REPORT OF
THE WORKING GROUP ON

AGRICULTURE RESEARCH AND EDUCATION

FOR
THE ELEVENTH FIVE YEAR PLAN
(2007-2012)

सत्यमेव जयते

GOVERNMENT OF INDIA
PLANNING COMMISSION

1. RECOMMENDATIONS

Crop Science

1. Strengthening the existing institutions in upgrading the infrastructure to changing technologies acquisitions in the field of agriculture, horticulture, animal and fisheries sciences to solve issues of national importance.

2. Investment in agricultural research and education be raised to provide one percent of the GDP of agriculture and allied sector to facilitate the development of basic and strategic research.

3. A nation wide programme needs to be launched for the conservation of plant, animal, fish and micro-organism resources in the country.

4. Science and Technology are the drivers of change in farm operations and output. New technologies which can help to enhance productivity per units of land and water are needed for overcoming the prevailing technology fatigue. Frontier technologies like biotechnology, information and communication technology, renewable energy technologies and nanotechnology provide uncommon opportunities for launching an ever-green revolution capable of improving productivity in perpetuity without ecological harm.
   In field of genetic enhancement, 10 premier institutions should be identified where breeding of specific crops should be carried out by integrating the tools of both conventional and molecular methods of plant breeding. Expedite marker assisted transfer of multiple traits into regional varieties and hybrids should be expedited. Both molecule markers and transgenic technologies need to be given equal and high importance.

5. The seed replacement in varieties should reach 40% and in hybrids touch 80% which will not only make demands on seed producing agencies but will also largely induce private entrepreneurs to invest in seed production. An orientation of public sector research in "hybrid development with commercial viability" has to be reintroduced on a mission mode at least in crops like Pigeonpea, soybean, wheat and mustard on priority. Good quality seed and disease free planting material are essential for crop productivity and security.

6. Development of district-wise crop-potential map district-wise to focus research on crop improvement and production management within the potential region for each crop. Block level agro-climatic, land use and socio-economic data collection and analysis should be carried out.

7. Focused research on hill-ecosystem to concentrate on low temperature tolerant and rainfed crops of rice, wheat, millets and temperate pulses. Under hill ecosystems, bio-fertilizer, zero-tillage and organic nutrient based crop improvement research has to be

initiated as priority since the region is compatible with such activities having small sized un tillable fields.

8. Agricultural Biosecurity covering crops, trees, farm and aquatic animals is of great importance. Bio-Safety Testing and Research at national and regional level be strengthened and facilities in the different agroecological regions is an absolute necessity if India intends to covert the transgenic development research to product development levels with commercialization prospects to quickly and safely reach the farmers.

Plant Protection

9. The overall concepts of crop health management have to be imbibed in order to focus on cost-effective crop production. This should have high priority for the XIth Plan period.

10. The evolution of national data base on pesticide residue status in commodities is another prime area of focus for the next five year plan period.

11. There is a need for interdisciplinary research in plant protection to elucidate basic issues of herbivory as well as to develop suitable mitigations.

12. Introduction of plant health management as a thematic emphasis on integrated pest management(IPM) in educational programmes of the country through broad-basing agricultural education; contextual fortification of extra-mural research; introduction for social needs to form para-agric team to practice plant health management similar to para-medical teams in human health care.

13. One of the major weaknesses in viral disease management is the poor understanding of vector relationships and their biology. Although there have been good strides in the case of aphids, plant hoppers and whitefly in crops such as potato, cotton or rice, many potential vectors such as thrips, bugs and mites are not studied for their exact role and biological association in viral transmission. Strong network programme on this is essential to make viral disease management in Indian crop health scenario through vector control.

Horticulture

14. Perishable commodities like fruits, vegetables, and flowers incur huge post- harvest losses due to poor handling, storage and processing. Post-harvest management and value addition of horticultural crops be dealt with separately.

15. North Eastern Region (NER) covering eight states (Assam, Arunachal Pradesh, Meghlaya, Nagaland, Manipur, Tripura, Sikkim and Mizoram) offers unique opportunity for development of horticulture industry. Rich germplasm, suitable agro-climate and farming practices are unique features of NER. Therefore, there is a strong need to establish a central research institute for horticulture for the NER focusing hill horticulture.

16. Improvement of water use efficiency and water productivity through multiple water use for diversified agriculture. Rain water management through equitable water harvest technology based on participatory approach.

17. The development of biofuel species such as Jatropha, Pongamia and other Tree Borne Oils (TBO's) based agroforestry systems for different agro-climatic conditions and to develop complete package of practices for cultivation of bio-fuel species.

Resource Conservation

18. Due to intensive use of nitrogenous fertilizers in the "Green Revolution" areas, large amounts of nitrogenous compound have built-up in the soil water, ground water, drainage water, water flowing in rivers and reactive N_2 in the atmosphere. The reactive N amount needs to be documented, methods to manage it need to be found, and better use of N-fertilizer needs to be formulated and the new knowledge needs to be spread to farmers, industry, extension workers and environmentalists.

19. There is a need to identify alternative cropping systems with higher and stable yields and/or profit in different agro-ecological regions. The integrated farming systems internalizing synergies of different components for enhanced resource utilization, income and livelihood generation and minimizing environmental loading need to be developed for different agro-ecologies. A more diversified food basket will provide better food and nutritional security to the people.

20. The effluents discharged into the sewage and irrigation water need to be catalogued and examined for the build up of toxicities in soil-plant-animal-human chain. There is a need to develop low cost pre-treatment technologies for waste waters and quick cheap and easy to handle testing tools for contaminants.

Climate Change

21. Development of appropriate methodologies employing GIS and remote sensing for detail soil resource maping and land use planning at watershed level. The exercise is desired for taking up priority treatment of 20 m/ha of degraded lands envisaged by the Planning Commission, Government of India. Developing blue prints for increasing crop production in low producing districts of the country having sufficient potential of irrigation water but low fertilizer use, employing remote sensing and GIS tools is required.

22. Timely and dependable advice on weather conditions will be very helpful to farm families to plan their sowing and other operations. Therefore, upgradation of weather based forewarning mechanism and provision of value added agromet advisory services are needed.

23. Impact of climate change on agriculture through experimental and modeling studies, assessment and maping of geographical shifts on crop and horticultural regions and

other vegetation due to climate change, need to be studied. A planned research programme needs to be undertaken to enhance understanding of N-cycle at eco-regional level due to climate change.

24. Maping of disaster prone areas, pest and disease hotspots using GIS and remote sensing technologies need to be taken up. There is an urgent need to establish a wide interlinked network of automatic weather stations with real time data dissemination across the country particularly in the eco-regions important for food security.

Rainfed Agriculture

25. A major programme for rainfed/limited irrigation suited crop variety development is the need of the hour to provide new technologies to nearly 55% of cropped area. In the rainfed crop production system, the most crippling factor in achieving the required crop growth rate. There is need to get to the root of the problem of yield limiting factors. These need to be identified crop, location wise and addressed genetically for physiological enhancement of the crop so that the stress related loss in production and quality are minimized. An integrated approach to use limited irrigation under rainfed situation is the better option than unpredictability associated with rainfed cropping alone.

26. Dryland horticulture, medicinal, aromatic and seed spices, fuel, oil and wood yielding tress and bushes have immense potential to augment the income of farmers in rainfed areas. Thus, concerted research efforts are required to improve the productivity of these crops both as sole crops and in different intercropping systems. Research strategies for areas receiving less than 500 mm rainfall should be primarily livestock based, 500-700 mm crop-livestock based, while areas between 700-1100, crop-horticulture-livestock-poultry based and those with > 1100 mm should have enterprises based on multiple use of water (water for inland fisheries, aquatic plants and irrigation of arable crops/horticulture).

27. Intensify the use of molecular biology tools by introducing biotic and abiotic stress tolerance and infusing organoleptic characters in rainfed crops. Indigenous plant types that inherently possess genes responsible for higher nutritive value (more protein, micronutrients etc) need to be identified and used for enriching nutrients in rainfed crops.

Agricultural Engineering

28. Agricultural engineering/technology interventions should aim to achieve sustainable growth in land, livestock and fisheries productivity; reduced production and processing cost; reduced production and post-harvest losses; upgrade value addition technology to achieve high quality products and develop technologies for economic utilization of production agriculture and processing byproducts and waste. Work stress, safety and comfort of workers, particularly of women, should receive proper consideration in the

design and development of hardware and processing farm mechanization and post-harvest processing.

Animal Science

29. Productivity Enhancement and Management of Animal Genetic Resources through development of methodologies and technologies for conservation and improvement of indigenous livestock and poultry breeds for high yielding strains for milk, meat and fiber through crossing and selection, fertility using newer embryo biotechnological tools, marker assisted selection to improve disease resistance (small ruminants – parasitic diseases) & fertility and buffalo genomics.

30. Designing of diagnostics and vaccines for major diseases of Cattle, Poultry and other domesticated animals and development of new generation vaccines against important diseases should receive high priority.

31. Studies on manipulation of rumen ecosystem for improving digestibility of low quality roughages, isolation of cellulose gene, rumen fungi and fungi from wild animals, bio-availability of nutrients and micronutrients, improvement and utilization of local feed and fodder resources should be strengthened.

Fisheries

32. Both coastal and inland fisheries provide employment and livelihoods to millions of families. Therefore, the thrust on fish production and productivity should be on responsible fisheries to achieve sustainability and optimum utilization of the resources in marine and coastal fisheries and aquaculture; marine biodiversity and conservation of resources; strengthening mariculture and coastal aquaculture activities; developing resources specific fishing techniques; post-harvest and product development using unconventional fish species; reduced post-harvest losses and developing technologies for mass culturing of fish feed organisms as compliment of aquaculture to generate additional income for women.

Education

33. There is a need for sweeping reforms in agricultural education for improving quality and standards because of emerging challenges of making Indian agriculture not only sustainable but also internationally competitive. Therefore, enhanced resources are required to initiate / strengthen research and facility / faculty development in new and emerging area such as Nano-technological applications in agriculture; Precision agriculture; Automation, Biosensors; Biotechnology and biosafety testing facilities; Micro-array and BAC resource center; High-tech horticulture especially floriculture; agri business; Modernization of libraries and farms; Establishing Centres of Distance Education and video-conferencing facility.

34. Human resource development holds the key to overcoming the stagnation in agricultural growth and productivity. An investment in the human resource development is crucial so that a balance between basic / strategic and applied research is maintained in such a way

that sufficient number of researchers are engaged in basic research to provide a high quality scientific information base for its conversion to knowledge and internationally acceptable strategy aimed to increase profitability of crop commodity through enhanced crop production and productivity.

Extension Education

35. The research in extension education is the weakest link in the growth of transfer of technology. The recent advances in the field of communication and information technology, behavioral sciences including management have great implications for improving research in extension education as well as development of models of technology generation, assessment and refinement.

Agricultural Economics, Agri-Business and Marketing

36. Demand and supply projections on a regular basis for all agricultural commodities at national and regional level, including nutritional implications of dietary diversification should be given the priority. Implications of Globalization, WTO and trade agreements; agricultural and rural markets and future trading should receive attention. Appropriate strengthening of departments of agricultural economics marketing and agribusiness (AEMA) in SAUs and ICAR Institutes should be done to improve the education and research in agricultural economics and agribusiness to enhance the output of well trained man power to suit future needs. The status of NCAP should be elevated to National Institute level.

Organization, Management & Finance

37. ICAR is a lead national organization with a global face in agricultural research and education. It should align all its activities and resources to become a truly global thought leader in cutting-edge agricultural research and innovations. ICAR should also envision a much greater role for itself in international agricultural research. It should in particular strengthen linkages with the NARS in Africa and Asia through appropriate mechanism, besides continuing partnership with the CGIAR system.

38. ICAR should increasingly focus on research coordination, networking and partnership to increase efficiency and effectiveness of agricultural research. ICAR should foster these institutional mechanisms, especially partnership with private sector in new IPR environment, and strengthen linkages between research, extension and farmers.

39. There should be a standing committee on gender-related issues in the Council and it should be headed by a deputy-director general level person. This committee should guide the Council on the policy matters, promote the schemes to empower women, and coordinate research programs.

40. ICAR should strengthen the efforts to integrate outcome of various programs undertaken by different ICAR institutes/schemes for greater visibility of research outcomes and impacts. A special Division may be established in the Council for this purpose which

should have close linkages with such units in the institutes. Monitoring and evaluation needs to be strengthened for better output.

41. Nearly one-third of plan funds of ICAR should be dedicated for competitive funding with well-defined objectives and research priorities, and only public institutions should be eligible to compete for these funds.

42. For externally-funded projects, ICAR institutes should charge an institution fee(20-40% of total budget) for maintenance of research infrastructure of the institute after completion of the project.

43. Management of intellectual property and transfer of technology through commercialization and public routes should be institutionalized in a sustainable manner. For this ICAR should have a Plan Scheme in XI Plan with a budgetary support to the tune of Rs. 200 crore. This scheme should develop an institutional mechanism for IP management with required expertise (in-house and outsourced) and eventually it should become self-sustaining over a period of time.

44. ICAR should develop some of its institutions as centres of excellence in cutting-edges science which should emerge as global leaders in their respective fields. These centres should have direct linkages with applied research programmes on the one hand, and on the other, these should attract foreign students and scientist for higher education and training. In order to encourage students from Asia and Africa, the option of offering fellowships should also be explored.

45. The different sub groups have recommended the establishment of large number of new institutes, national centres, coordinated/network projects, regional centres. There is need to consolidate the programmes to optimize output and enhance efficiency. Proliferation of projects/schemes results in spreading the resources thinly. However, depending upon the national priorities, the new establishments may be created in consultation with the stakeholders.

46. The financial health of SAUs is a cause of concern, hence, support to SAUs may be given to the tune of Rs.10,000 crore.

2. LIST OF INSTITUTIONS IN XTH FIVE YEAR PLAN

Following were the institutions engaged in research under Xth Five Year Plan :

NATIONAL BUREAU OF GENETIC RESOURCES

1. Bureau of Plant Genetic Resources
2. Bureau of Animal Genetic Resources
3. Bureau of Fish Genetic Resources
4. Bureau of Microbial and Fungal Genetic Resources
5. Bureau of Insect and Nematode Genetic Resources
6. Research Centre-DNA finger printing

CROP INSTITUTES

1. Central Rice Research Institute
2. Directorate of Rice Research
3. Project Directorate of Wheat Research
4. Directorate of Maize Research
5. Directorate of Sorghum & Millet Research
6. Indian Institute of Pulses Research
7. Indian Grassland and Fodder Research Institute
8. Indian Institute of Sugarcane and Sugarbeat Research
9. Sugarcane Breeding Research Institute
10. Central Institute of Cotton Research
11. Directorate of Oilseeds Research
12. Directorate of Research on Non-Traditional Crops
13. Central Institute for Research on Jute and Allied Fibres

PLANT PROTECTION

1. Directorate of Biological Control
2. Directorate of Research on Integrated Post Management

HORTICULTURE, VEGETABLE & FLORICULTURE

1. Indian Institute of Horticulture Research
2. Central Institute of Sub-Tropical Horticulture
3. Central Institute of Temperate Horticulture
4. Central Institute of Arid Horticulture
5. Indian Institute of Vegetable Research
6. Central Potato Research Institute
7. Central Tuber Crops Research Institute
8. Central Plantation Crops Research Institute
9. Indian Institute of Spices Research
10. Centre for Research on Orchids

NATIONAL RESOURCE MANAGMENT

1. National Bureau of Soil Survey and Land Use Planning
2. Indian Institute of Soil Science
3. Central Soil Salinity Research Institute
4. Central Soil and Water Conservation Research and Training Institute
5. Water Technology Centre for Eastern Region

CROPPING SYSTEMS/FARMING SYSTEMS

1. Central Research Institute for Dryland Agriculture
2. Central Arid Zone Research Institute
3. Cropping Systems Research Institute
4. Vivekanand Parvatiya Anusandhan Shala
5. Centre for Research on Weather, Climate and Agriculture
6. ICAR Research Centre for Goa
7. ICAR Research Centre for NEH Region
8. ICAR Research Centre for Eastern Region

AGRIUCLTURL ENGINEERING

1. Central Institute of Agricultural Engineering
2. Centre for Energy Management in Agriculture
3. Central Institute for Research on Cotton Technology
4. Central Institute for Research on Jute and Allied Fibre Technology

MULTIDISPLINARY INSTITUTE

Institute of Post-Harvest Science and Technology

ANIMAL HUSBANDRY AND DAIRYING

Project Directorate-Cattle Research and Management
Central Sheep and Wool Research Institute
Central Institute for Research on Goats
Central Institute for Research on Buffaloes
Central Institute on Animal Nutrition and Physiology
Central Avian Research Institute

FISHERIES

Central Marine Fisheries Research Institute
Central Inland Capture Fisheries Research Institute
Central Institute of Fresh Water Aquaculture
Central Institute of Brackish Water Aquaculture
Central Institute on Cold Water Fishes
Central Institute of Fisheries Technology

AGRICULTURAL STATISTICS & ECONOMICS

Indian Agricultural Statistics Research Institute
National Centre for Agricultural Economics & Policy Research

AGRIUCLTURAL EXTENSION

Institute of Agricultural Extension
Research Centre for Women in Agriculture

EDUCATION

National Academy of Agricultural Research Management
Central Agricultural University

NATIONAL UNIVERSITIES (RESEARCH & EDUCATION)

Indian Agricultural Research Institute
Indian Veterinary Research Institute
National Dairy Research Institute
Indian Institute of Fisheries Education

3. CONSTITUTION OF WORKING GROUP ON AGRICULTURAL RESEARCH AND EDUCATION FOR ELEVENTH FIVE YEAR PLAN (2007-2012)

I. Composition:

(i)	**Dr. C.R. Bhatia**, 17, Rohini, Plot No. 29-30, Sector-9A, Vashi, Navi Mumbai-400703 (MS) Tel: 022-27655178/27658504 Email: neil@bom7.vsnl.net.in	Chairman
(ii)	**Dr. M.C. Saxena***, A-22/7 DLF City, Phase I, Guargaon – 122002 Tel: Res: (0124) 510571 Email: m.saxena@cgiar.org	Member
(iii)	**Dr. G.S. Sekhon**, Professor of Soils, PAU, Ludhiana, A-6, Guru Ram Das Avenue *Ajnala Road* , C/O NIIT, Amritsar Centre, 38, the Mall, Amritsar-142001, Punjab Tel:0183-2592401 Email: drgurcharansekhon@hotmail.com	Member
(iv)	**Dr. S.S. Parihar*,** 136-D, Kichloo Nagar, Ludhiana-141001 (Punjab) Tel: 0161-2471378 Email: kpsingh123@satyam.net.in	Member
(v)	**Dr. A.M. Michael***,Ex. Director,IARI,Pusa,New Delhi, 27/78, B.P. Marichal Road, Vettekullam, Heppappally, North P.O. Cochin-682024 Tel: 0434-2543217	Member
(vi)	**Dr. S.N. Puri**, Vice Chancellor, CAU, Iroisemba, P.O. Box 23 , Imphal-795004 Manipur, Tel: 0385-2410414 Email: snpuri@rediffmail.com	Member
(vii)	**Shri S. Jayaraj,** Chairman, S. Jayaraj Research Foundation, No. 39, First Floor, Main Road, A.G.S. Colony, Velachery, Chennai-600042 Tel: (O) 044-22533806 email: prof_sjayaraj@rediffmail.com	Member
(viii)	**Dr. S.V.S. Shastri***, Ashoka, 202, Gautami Apartments, Barkatpura, Hyderabad-500027 (AP) Tel: 040-27551666	Member
(ix)	**Dr. E.A. Siddiq**, Ex-DDG (Crop Sciences), ICAR,Jasmine Plot No. 81, Happy Homes Colony, Upperpalli, Hyderguda, P.O. Hyderabad-500030 (AP) Tel: 040-24012695/24018625 Email: easiddiq@rediffmail.com	Member
(x)	**Dr. C.R. Bhatia**, 17, Rohini, Plot No. 29-30, Sector-9A, Vashi, Navi Mumbai-400703 (MS) Tel: 022-27655178/27658504 Email: neil@bomb7.vsnl.net.in	Member
(xi)	**Dr. J.C. Katyal**, Vice Chancellor, HAU, Hisar (Haryana). D-1/E-55, Bapu Dham, Saint Martin Marg, New Delhi Tel: 24675570	Member
(xii)	**Dr. Kirti Singh**, C-9/9766, Vasant Kunj, New Delhi-110070 Tel: 011-51767608 Email: kirtisingh1934@hotmail.com	Member
(xiii)	**Dr. Anupam Verma***, 253, Jaimaa Apartments, Plot No. 16, Sector-5, Dwarka, New Delhi-110075 Tel: 25072511 Email: anupamvarma@vsnl.net	Member
(xiv)	**Dr. I.C. Mahapatra***, Satya Bhavan, A-3/82, Janakpuri, New Delhi-110058, Tel: 25555043/4243	Member

(xv)	**Dr. S.M. Virmani**, 811 A Road No. 41 , Jubilee Hills, Hyderabad-500033, AP. Email: mail@ananthtech.com	Member
(xvi)	**Dr. R.L. Yadav**, Director, Indian Institute of Sugarcane Research (IISR), Lucknow Email: iisrlko@sancharnet.in	Member
(xvii)	**Dr. P.V. Dehadrai***, ex-DDG (Fisheries)ICAR, D-3/3403, Vasant Kunj, New Delhi-110070 Tel: 011-26899128 Email: pvdehadrai@yahoo.co.uk	Member
(xviii)	**Dr. M.L. Madan**, Anugraha, Madan Lodge, House No. 842/6, Urban Estate, Karnal, 132001- Haryana	Member
(xix)	**Dr. K. Pradhan**, ex-VC, RAU, Bikaner C-24/HIG, Housing Board Colony, Baraminda, Bhubaneswar –751003 Orissa.	Member
(xx)	**Dr. Rajendra Prasad**, C-309, Vardhman Apartments, Mayur Vihar Extension Phase-I, New Delhi-110091 Tel: 22712256/9810258485 Email: rajuma36@yahoo.com	Member
(xxi)	**Dr. K. Vijay Raghavan,** , ED, Sathguru Cornel Foundation, Hyderabad-500034 Email: vijay@sathguru.com	Member
(xxii)	**Dr. Jayati Ghosh***, Chairperson, AP Agriculture Commission Centre for Economic Studies and Planning School of Social Sciences, JNU, New Delhi – 110 067	Member
(xxiii)	**Dr. B.B. Singh**,** 18/529, Indira Nagar, Lucknow-226016, Tel: 05270-2359090/9415002010	Member
(xxiv)	**Prof. R.B. Singh,** Member, National Farmers Commission, (NCF), Office Block, IInd Floor, NASC Complex, opp. Todapur Village, PUSA, New Delhi-110012 Email: rb.singh@nic.in;rambsingh@hotmail.com	Member
(xxv)	**Dr. Mangala Rai**, Secretary , DARE & DG, ICAR, Krishi Bhavan, New Delhi-110001	Member
(xxvi)	**Dr. V.V. Sadamate,** Adviser (Agriculture), Planning Commission	Member
(xxvii)	**Dr. Rugmini Parmar***, Director (Plan Finance), Department of Expenditure, North Block, New Delhi-110001	Member
(xxviii)	**Mrs. Reema Nanawati***, Director (Rural Economics & Development), Self Employed Women's Association (SEWA), SEWA Reception Centre, Opposite Victoria Garden, Bhadra, Ahmedabad-380 001 (Gujarat)	Member
(xxix)	**Dr. K.S. Khokhar,** ADG(PIM), Room No. 330, ICAR, Krishi Bhavan, New Delhi. Tel: 23389526 Email: khokhar.icar@nic.in	Member – Secretary

* Could not participate in the Working Group meetings.

**Could not participate in the Working Group meetings but provided his inputs through mail.

4. TERMS OF REFERENCE

1. To make critical review of Xth Plan achievements in terms of agricultural research, animal improvement health and productivity, fisheries, transfer of technology, human resource development in contrast to the objectives and targets set during Xth Plan.

2. To identify critical gaps in scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as enable the nation to enhance its agricultural competitiveness in the context of WTO & IPR region.

3. To draw/suggest specific schemes/ programmes pertaining to agricultural research, education, animal & fisheries sector and frontline transfer of technology to address the problems of less privileged regions.

4. To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

5. To suggest thrust areas of research to curb degradation of natural resources (soil, water and climate) and for enhancement of productivity and input use efficiency and farm profit.

6. To critically review the status of post harvest management research, value addition and identify the priorities in terms of human resource development and institutional mechanism for attaining the desired results in this vital sector.

7. To identify institutional mechanism for strengthening, monitoring and evaluation system in agricultural research, and to suggest efficient measures for effective coordination of agricultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public-private partnership.

8. To critically examine strategies for reorienting of agricultural education at various levels to tend it towards agri-entrepreneurship, agro-industry friendly and sensitive to emerging challenges in agriculture and allied sectors.

9. To draw/suggest specific schemes/programmes/research area pertains to agricultural research, education, animal & fisheries sector and frontline transfer of technology including linkages with developmental departments.

10. The Working Group may co-opt any other official/non-official expert/representative of any organization as member (s), if required.

11. The Working Group may also examine and address any other issues which are important but are not specifically spelt out in the ToRs. The Working Group may devise its own procedures for conducting its business/ meetings.

12. The expenditure of the official members on TA/DA in connection with the meetings of the Working Group will be borne by their respective Ministry/Department as per the rules of entitlement applicable to them. . In case of non-officials, the TA/DA will be borne by the Planning Commission as admissible under SR 190(a).

13. The Working Group will be serviced by the Department of Agricultural Research and Education, Ministry of Agriculture.

14. The Working Group will submit its Interim Report by the end of June, 2006 and Final Report by the end of September, 2006 to the Planning Commission.

15. Dr.(Mrs.)Vandana Dwivedi, Joint Adviser(Agriculture)Planning Commission, Room No. 230, Yojana Bhavan, New Delhi-110001, Tel No. 011-23096730, Email: dwivediv@nic.in and FAX No. 011-23327703 will be the nodal officer of this Working Group and any further query/correspondence in this regard may be made with her.

5. INTRODUCTION AND PERSPECTIVE

About 70 per cent of the population lives in rural areas and the overwhelming majority of them depend upon agriculture as their primary source of income. The average farm size is becoming smaller year after year and the cost-risk-return structure of farming is becoming adverse, with the result that farmers are getting increasingly indebted. Marketing infrastructure is generally poor, particularly in perishable commodities. In a recent National Sample Survey Organizaiton (NSSO) survey, it has been revealed that nearly 40 per cent of farmers would like to quit farming, if they have the option to do so.

In the 1960s, India was deficient in foodgrain production and dependent on imports of wheat, financed under PL480 assistance from the United States. The focus of Indian policy in this period was to increase foodgrain production with a view to ensuring food security. This objective was successfully achieved due to the Green Revolution in the 1970s beginning with wheat and then expanding to rice.

In the 1980s, the agricultural focus shifted from food self-sufficiency to generating additional income in rural areas as a means of tackling the problem of poverty. Considerable success was achieved in growth of agriculture in the 1980s. Growth of agricultural gross domestic product (GDP) accelerated to about 4.7 per cent in 1980s, compared with only 1.4 per cent in the 1970s.

Average growth rate of 3.6 per cent in agriculture was achieved in the period 1990-91 to 1996-97. Actual performance since the mid 90s however, has been disappointing. Agricultural growth slowed to 2 per cent a year in the IXth Plan Period.

The Xth Plan targeted 8 per cent growth in GDP and 4 per cent growth in agriculture. The GDP growth averaged about 6.5 per cent, but agricultural GDP has grown by only 1.1. per cent during 2002-03 to 2004-05 and likely to achieve growth of about 2.0 per cent in remaining period of Xth Plan.

GDP growth in XIth Plan is targeted to 9.0 per cent for which agriculture must grow to 4.1 per cent.

The progress in the first three years of the Xth Plan assessed by the Planning commission shows that:

Current agricultural scenario:

The assessment of the progress in the first three years of the Xth Plan by the Planning Commission provides the best assessment of the current agricultural scenario. It has shown that:

- The GDP growth rate in agriculture and allied areas was only 1% per annum against the Xth Plan target of 4%.

- The growth rate of crop and livestock output after 1996-97 have averaged at 1.1.% and 3.6% per annum respectively.
- Within the crop sector, only fruits and vegetables grew at over 2.5% per annum.
- The trend of rice and wheat production was, less than the population growth rate.
- Import of pulses and edible oils/oilseeds have increased in recent years.
- Growth of input use in agriclulture decelerated after 1996-97 to about 2% per annum from 2.5% during 1980-97.
- The output prices began to fall relative to the input prices leading to lower profitability and slow increase in input use.
- Animal husbandry and fisheries sectors have shown higher growtrh rate.
- Sustainability of food production is threatened by depletion of water resources, soil health degradation, adverse environmental consequences, failure of extension and input supply and declining investment in agriculture.

The above facts show that the euphoria and the confidence that followed the green revolution with regard to the food security is vanishing. The recent import of wheat to meet the demand has brought back the view that the country may once again revert back to large imports of food grains. The opinions on the issue of food security vary. One view is that we should produce high value and processed commodities that give higher returns, and import basic commodities to meet the demand. The other view is that for inclusive growth, food security, higher income and gainful employment opportunities must increase for all, and the production cost should be lower to make adequate food within easy reach of the poor. Further, for a large country like India not having self sufficiency can impose a heavy cost in an increasingly violence prone world.

Thus the challenges before the Agricultural Research and Education system faces during the XIth Plan are enormous. The green revolution technology was rather simple, relatively easy to transfer and adopt. It provided immediate quantum increase in productivity. No similar technologies are presently available for sustainable increase in productivity, reduction of production cost, and enhancing income of the farmers at high productivity levels in irrigated, intesnsively cropped areas. The mean yield levels for all crops, and animal productivity are much lower than realized in other countries, and this provides an opportunity.

Broad Objectives Of XIth Five Year Plan

Agriculture has been and will continue to be the lifeline of Indian economy. Agriculture is the most important sector of the Indian economy from the perspective of poverty alleviation, and employment generation. This sector contributes close to a quarter of India's National Income and work force engaged in agriculture is about 60 per cent. The food security of the country is at risk once again due to the continuing increase in population, stagnation in crop yields, degradation of natural resources, diversion of land and water for other sectors of the economy, decreasing profitability, and continued fragmentation of land holdings, etc.

Despite having achieved national food security, the well being of the farming community continues to be a matter of great concern for the planners and policy makers in the country. The establishment of an agrarian economy which ensures food and nutrition to India's billion people, raw materials for its expanding industrial base and surpluses for exports, and a fair and equitable rewards system for the farming community for the services they provide to the society should be the mainstay of reforms in agriculture sector.

The National Policy on Agriculture seeks to actualize the vast untapped growth potential of Indian agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate the growth of agro business, create employment in rural areas, secure a fair standard of living for the farmers and agricultural workers and their families, discourage migration to urban areas and face the challenges arising out of economic liberalization and globalisation. Over the next two decades, it aims to attain:

- A growth rate in excess of 4 per cent per annum in the agriculture sector.
- Growth that is based on efficient use of resources and conserves our soil, water and bio-diversity.
- Growth with equity, i.e. growth which is widespread across regions and farmers.
- Growth that is demand driven and caters to domestic markets and maximizes benefits from exports of agricultural products in the face of the challenges arising from economic liberalization and globalisation.
- Growth that is sustainable technologically, environmentally and economically.

A major concern in foodgrain production arises from stagnation in production. Therefore, one of the major challenges of the XIth Plan is to reverse the deceleration in agricultural growth from 3.2 per cent between 1980 and 1996-97 to a trend average of only 1.5 per cent subsequently. This deceleration is undoubtedly at the root of the problem of rural distress that has surfaced in many parts of the country.

A Second Green / Everseen Revolution is urgently needed to raise the growth rate of agricultural GDP to around 4 per cent. This is not an easy task since actual growth rate of agricultural GDP was only 1 per cent per annum in the first three years of Xth Plan and even the projections for 2005-06 and 2006-07 would limit this below 2 per cent for the full five year period. This challenge, therefore, is to at least double the rate of agricultural growth as per Planning Commission.

The use of energy specially in the form of electricity and petroleum, will define the future growth of agriculture and, in turn, have implications for food security. The issues are what new technologies are needed to reduce the use of energy in agriculture. As fossil fuel costs grow, it becomes economical to use bio-fuels. The core issues related to energy and bio-fuels are : what technologies can help improve production and use of bio-fuels without adversely affecting food grain production and how can small holders benefit from producing bio-fuels ?

Therefore, to sustain growth rate of 9 per cent during XIth Five Year Plan, the pace of agricultural growth is to be accelerated from the current rate of around 1 per cent to 4 per cent. It would, therefore, need a dynamic approach oriented towards achievable strategy which is well planned, coordinated and monitored.

Meeting the Objectives

1) Investment in agriculture has suffered a decline over the past two decades. Capital formation in agriculture and allied sectors in relation to GDP started declining in the 1980s which has adversely affected irrigation and rural infrastructure development. Therefore, investment in agriculture particularly in irrigation needs to be increased.

2) The present day agricultural crisis can be converted into an opportunity for not only reversing the decline, but for taking the agricultural revolution forward by helping farm families to bridge the gap between potential and actual yields in all major farming systems to mutually reinforcing packages of technologies, services and public policies. Progress in agriculture should be measured by the growth rate in the net income of farm families, if the human dimension is to be added to agricultural policies.

3) Self-sufficiency, maintaining low food price, raising agricultural exports, investments for upgrading production potential in a cost-effective and sustainable mode are over-riding concern in agriculture. In the post-WTO era, both export and import of the country have increased substantially. However, increase in imports of food items is relatively higher than in export. This trend is adversely affecting self-reliance in agriculture which needs to be reversed.

4) Substantial public investment in infrastructure and supportive policies, involving agricultural marketing, production, processing, trade, etc. is needed to create a favourbale environment for the development of agriculture in the country. Increasing population, need to maintain self-sufficiency, national food and nutritional security and raising the income of farmers necessitate substantial increase in the agricultural output.

5) In order to achieve Ever-Green Revolution, emphasis is to be laid on rainfed agriculture so as to make these gray areas green. This is critical for sustainability, improved livelihood and income of resource poor farmers.

6) Agriculture marketing in the country is going through a phase of major transformation. The marketing reforms permitting setting up of competitive agricultural markets in private and cooperative sector, promote direct marketing and contract farming. This has opened the doors for farmers and for all scales of business to participate in areas such as setting up private agricultural markets, marketing infrastructure, supply chain and logistic, banking, finance and other Agri-marketing services.

Market driven diversification in global perspective has become the new paradigm driving future agriculture growth. Livestock, fisheries, horticulture, specialty enterprises (spices, medicinal, aromatic, organic) and value added products has great potential for export.

7) A new thrust in biotechnology, nanotechnology and information & communication technology (ICT) can contribute technologies to resolve key concerns related to agriculture. The key concerns include the need of energy for use in agriculture, enabling access to information, knowledge and skills through use of ICTs for agricultural communities, enabling food safety and control of animal and plant diseases and their spread, ensuring environmental safety and sustainable use of natural resources.

8) Post-harvest and value addition in agricultural and horticultural crops and livestock products should be given priority so that farmers can get additional employment and income. There is great scope for export of fruits, vegetables, flowers, meat and fish provided international standards with respect to quality and packaging can be ensured.

6. MANDATE, GOALS & OBJECTIVES OF THE X FIVE YEAR PLAN

The Department of Agricultural Research and Education (DARE) is responsible for governance, addressing agricultural research and education needs to the country, and all international matters relating to agricultural research and education. This responsibility is discharged through the Indian Council of Agricultural Research (ICAR), an apex and autonomous organization for agricultural research and education in the country. Since its establishment in 1929, ICAR has undergone several structural and functional changes to discharge its responsibilities. The focus of these changes has been on evolving the national research system for agriculture and providing a leadership role. Currently, ICAR has broadly organized its functions into promotion and coordination of agricultural research and education through a network of Schemes/institutes. In addition, ICAR has Schemes for technology assessment, refinement and demonstration of frontline technologies, besides training is also imparted to farmers/entrepreneurs for knowledge upgradation to augment the overall capacity. In 2006-07, there are 71 Schemes falling under eight Subject Matter Divisions and establishment at the headquarters of ICAR. These Schemes/institutes could be classified as (a) ICAR deemed universities and central agricultural university for conducting basic and strategic research and imparting higher education, (b) national institutes for upstream research, (c) bureaux for collection, conservation, evaluation, classification and documentation and strategic research support for resource management and effective utilization, (d) national research centres for basic and strategic mission-oriented research for feeding into the coordinated system, (e) project directorates to support research through coordinated programmes for location, situation and system specific technologies and (e) centres for frontline extension.

Goal

The Goal of ICAR is to promote sustainable growth and development of Indian agriculture by interfacing education, research and extension initiatives complemented with efficient and effective institutional, infrastructure and policy support, for ensuring livelihood security.

Mandate and Objectives

1. To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, animal science, fisheries, agro-forestry, home science and allied sciences.
2. To act as a clearing-house for research and general information relating to agriculture, animal husbandry, fishery, agro-forestry, home science and allied sciences through its publications and information system, and instituting and promoting transfer of technology programmes.
3. To provide, undertake and promote consultancy services in the field of research, education, training and dissemination of information in agriculture, animal science, fisheries, agro-forestry, home science and other allied sciences.
4. To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing co-operative programmes with other organizations such as Indian Council of Social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre, and the Universities.
5. To do other things considered necessary to attain the objectives.

7. ACHIEVEMENTS OF XTH FIVE YEAR PLAN

(A) CROP SCIENCE

- Developed, released and notified over 250 high-yielding varieties and hybrids of field crops for their commercial cultivation. Successfully developed improved varietal technology in various crops in the country for enhancing agricultural production/ productivity. Crop productivity increased in cotton, sugarcane, sorghum, pearl millet.

- India has been able to maintain the second largest producer identity for wheat and rice despite unprecedented abiotic stresses and natural disasters during the period.

- About 84 genetic stocks and 20 of barley registered with NBPGR and the germplasm was shared with cooperators across the country through nurseries. The germplasm was enriched specially in rice-wheat system in Eastern India and warmer regions of Central and Peninsular India. The donors for thermal tolerance identified and physiological parameters viz., canopy temperature depression (CTD), cell membrane stability, stem reserve mobilization were validated. Product specific varieties were classified for chapati, bread, biscuit and pasta making.

- In durum wheats, an export commodity from India, genetic stocks with high beta carotene (9.5 ppm), protein (13.5%) and 1000 kernel weight (60-65 g) were developed

- In hybrid wheat – initiatives through chemical male sterility inducing agents were undertaken. However, more economic approach of CMS based system was also put on the anvil during the period. In total, an infrastructure to produce over 10,000q of hybrid wheat seed has been created in coordinated programme.

- In barley, parameters for malting quality were identified and superior malt varieties of barley developed.

- Rice which is cultivated in diversified ecologies viz., irrigated (19.6 m.ha), rainfed lowland (16 m.ha.), rainfed upland (7 m.ha), deep water rice (6 m.ha.) etc., where yield levels fluctuated variedly. Thus, though significant increase in the averages from around 4.1 tons/ha under irrigated ecology of nearly 20 million hectare area was achieved during the X Plan, the same got lowered to 2.9 tons/ha on a national basis because of the fragile ecosystem. Under irrigated conditions, hybrids like PRH 10 achieved 9-10 tons/ha in farmers' fields within 110 days, and varieties like Pusa 44 achieve 10 tons in 145 days over the past several years in Punjab and Haryana.

- Improved varieties of sugarcane, rice, maize, sorghum, groundnut, mustard etc. through coordinated trials have helped the nation in an inclusive fashion to consider the ecological variations with respect to each crop. However, the productivity achieved in the field trials and that achieved at farms has not been the same in all these crops, the reason that led to shortage in achievement of the targeted production.

- Developed very promising single cross hybrids of maize as well as the QPM (quality protein maize) during the Xth Plan. This needs to be covered over all the zones with seed production targeted to reach the farmers.

- Headway in hybrid research in *Brassica juneca;* developed two cytoplsmic male sterility systems and introgressed a dominant fertility restorer gene.

- The period also saw the development of hybrid pegion pea with the use of cytoplasmic male sterility and restoration system through related species.

- Developed/ deployed the concept of new plant type in various crops/ plants to enhance yield potential.

- The improved, high yielding, resistant/ tolerant and short duration varieties/ hybrids in various crops have played catalytic role in crop insulation against biotic/abiotic stresses

- Awareness for multiple cropping systems in enhancing cropping intensity particularly of wheat, rice, maize, sorghum etc. was achieved to provide diversity and intensification.

- Transforming the mindset of farmers from conservative to technology-responsive one including the use of system of rice intensification (SRI) in rice in the southern part of India.

- The phenomenal increase from 0.8 million ha to 1.80 million ha this year (on the basis of seed produced and sold) of hybrid rice is an indicator of the potential of about 1-2 tons/ha additional yield in north India which was made possible through public-private partnership on hybrid seed production involving large groups of farmers in organized hybrid seed production.

- Transgenics in cotton containing Bt genes Cry 1Ac, Cry 1Aa3 and Cry 1F and rice by incorporating genes Cry 1Ac and Cry 1Aa for insect resistance were developed. They are in early experiments. The commercially available Bt transgenic hybrids of cotton have revolutionized cotton cultivation with unprecedented production levels over the Xth Plan period.

- In cotton, several intra- *G. hirsutum, G.arboreum* -hybrids and varieties were developed and deployed for cultivation. Hybrid seed production at commercial level competitively with the successful commercial private seed production system needs to be taken up. In hybrid cotton research, both CMS and genetic male sterility systems are being attempted for diversification with more than 400 CMS lines and 145 GMS lines. Triploid hybrids between *G. hirsutum X G. armourianum* have been made and are under experimentation.

- Developed/successfully deployed ready-to-use diagnostic kits to detect Bt transgenic cotton plants from normal ones.

- India is now among the five leading soybean producing countries of the world.

- In the National Gene Bank, one of the World's leading *ex situ* germplasm storage facilities for the long-term more than 2.5 lakh accessions belonging to over 180 crop species and their wild relatives including seed germplasm, other planting materials, plant tissue cultures, DNA and live perennial species in various ecologies have been conserved.

- Established a mechanism of registration and conservation of potentially valuable plant germplasm and registered 280 germplasm belonging to 54 plant species at NBPGR.

- Developed and deployed technology for DNA fingerprinting in 23 major crops and fingerprinted ~1800 released varieties and elite landraces of crops.

- Steady increase in breeder seed production resulting in enhanced supply of quality seeds to the farmers. About 30,000 q of breeder seed including 10,000q hybrid wheat seed being produced annually and supplied for the production of foundation seed and in turn certified seed.

- Established mechanism of IPR protection in the ICAR system - Patenting; logistics/ DUS testing support for the operationalization of *sui generis* Act on protection of plant varieties and farmers' rights.

- Laid emphasis, in Mission and Institutional Modes, on the use of improved, specific technologies to enhance the Household Food and Nutritional Security. Several improved varieties of nutritious minor millets, pseudocereals and pulses were promoted. The micronutrients mission focused priorities of research on pulses, oilseeds and maize to ameliorate protein energy malnutrition such as adaptability evaluation of Quality Protein Maize (QPM). Several hybrids well suited to harsh environments, particularly for arid zone, in crops like pearl millet (*bajra*) were released. Transgenic research with value added traits was encouraged to develop indigenous transgenic plants as a material for future.

(B) HORTICULTURE

FRUIT CROPS

- Under germplasm collection, 356 accessions comprising 28 mango, 273 banana, 11 grape, 15 guava, 2 papaya, 1 sapota, 5 macademia, 20 bael and 1 aonla accessions were added to field gene bank. Twenty eight different fruit varieties were better in yield and quality. In ADB-TFT Project, 125 accessions of mango, 68 of citrus and 30 of litchi were added to field gene-bank.
- In banana, a new species of *Ensete* from Kodaikanal hill of Tamil Nadu and a new sub species of *Musa acuminata* from Anaimalai hill of Western Ghats were collected. Further, 138 accessions were collected from Andaman and Nicobar Islands and North Eastern States. Sixty-one exotic collections were also added.

- For mango, two hybrids analysed for fruit characteristics, exhibited good fruit quality with more than 70 % pulp recovery. Molecular characterization of 45 mango, 24 papaya, 52 banana accessions was completed using RAPD markers as per IPGRI descriptors. Mapping of citrus genetic diversity was done with help of GIS. Under ADB-TFT Project, 194 mango accessions were documented and characterized.
- Drip irrigation method was standardized in mango, Nagpur mandarin and pomegranate. Drip irrigation coupled with mulching was optimum for increasing fruit production and water use efficiency in pomegranate and grape.
- IPM including bio-agents was tried out in mango, banana, citrus and grapes against important insect pests.
- Storage life was extended up to 30 days at 8°C by packing mango fruits individually in micro-perforated polyethylene or polypropylene films.
- Twenty mango and 2 papaya hybrids were evaluated for fruit characteristics. Three banana hybrids were evaluated for plant and fruit characteristics.
- In pomegranate, 860 hybrids from 26 crosses were evaluated for drought resistance. Cell membrane stability test was carried out in 10 pomegranate hybrids.
- Two promising hybrids in grape were identified.
- Two hybrids of rough lemon are promising for nursery characteristics and resistance to *Phytophthora.*
- Germplasm Information System was developed at IIHR, Bangalore for computerization of central accession register containing records of germplasm of different horticultural crops over last four decades. Separate database design structures were developed to store and retrieve information about fruit crops, vegetable crops, medicinal and aromatic plants and ornamental crops.
- Guava Rootstocks `Vellaikolumban' and 'Rumani' recorded maximum productivity/unit canopy volume and unit land area. Technique was demonstrated in guava that it was possible to grow up to 5000 plants/ ha at a spacing of 1.0 m x 2.0 m coupled with regular topping and heading.
- Studies carried out by using different fertigation levels under high density planting in Robusta, Rasthali and Saba cultivars of banana showed that paired row system (5200 plants /ha) gave better plant growth compared to other densities in all fertigation levels.
- In grape, Thompson Seedless and Flame Seedless scions showed maximum compatibility with Dogridge B and 99 R stocks respectively. Among different rootstocks, Thompson Seedless grafted on Dogridge B recorded maximum yield of 2.79 kg/vine.
- Post-harvest treatment with Prochloraz (0.1%) and hot water treatment at 52^{o}C for 10 minutes were the most effective for management of disease in mango.
- Botanical extract *Solanum torvum* spray at 50% concentration on banana fruits after harvest controlled anthracnose disease and also increased shelf life of banana to more than 26 days over control. Dot blot technique was developed for detection of BBTV.
- Citrus plants treated with Ledermycin 600 ppm + $ZnSO_4$ + $FeSO_4$, shows the highest reduction in greening disease.
- Preharvest treatment of grapes with chitosan alone or in combination with *Trichoderma* improved shelf life of grapes.
- XAD-16 resins was the best for removing bitterness in citrus juice.

VEGETABLE CROPS

- Fifty-two (52) varieties were notified by Central Varietal Release Committee in different vegetable crops.
- Promising ToLCV resistant tomato hybrids were evaluated for confirming resistance. Multiple resistant superior hybrid (TLBRH 1) was identified. Promising 81 lines were identified along with one joint less mutant and β-carotene rich tomato line. 300 IIVR collections and 163 exotic collections were evaluated and characterized. 124 crosses were developed for further evaluation.
- In tomato, two field resistant lines to leafcurl, H 88-78-1 and H 88-78-2 are identified. Putative transgenic plants in tomato cv. H-86 and in brinjal cv. IVBL -9 were developed using Cry 1Ab and Cry 1 Ac gene constructs. Haploids and double haploids in tomato, brinjal and cucumber through anther culture were produced.
- Promising varieties/ hybrids of cauliflower, cabbage, radish and carrot were evaluated. 200 lines of different groups of Indian cauliflower, 70 lines of radish and 50 lines of carrots were evaluated. 25 hybrids of cabbage are under evaluation stage. 40 F1, F2, F3, F4 and one population of 6 generation mean analysis were grown and data recorded in pumpkin. The beta carotene analysis of pumpkin in six generation population was analyzed plant wise.
- In ash gourd, 60 new F1 were developed. Segregating population was handled and seed of selected variety was multiplied. 128 germplasm selfed and maintained, 62 F1s and 41, 23, 14, 9 plant populations were evaluated. VRH-1 (F1) was selected. Germplasm of *Vicia faba* (4), *Chenopodium* (1), *Basella alba* (2), *Basella rubra* (1), Moringa (2) lines were collected.
- Important antioxidant phytochemicals viz., ascorbate, carotenoids, lycopene, lutein and phenols in promising 59 tomato lines and hybrids were estimated with help of HPLC.
- Very high anthracnose severity in chilli was recorded during October and varied between 58-70% in different treatments. Under pathogenic and molecular characterization of *A. solani*, isolates Va-3, Va-5, Dh were the most virulent. Screening by PCR is in progress for maximum polymorphism. A total of 575 kg *Trichoderma* was prepared and 434 kg was distributed among 612 farmers. A total 7 IPM training and farmers meetings were conducted in Mirzapur, Chandauli and Varanasi districts.
- Fruit fly population dynamics were studied. Screening of cultivars and botanicals were conducted. Population dynamics of jassid and influence of organics were studied.
- Drying onion seeds to 6 % moisture content, packaged in laminated pouches along with silica gel increased storability to 18 months under Varanasi conditions.
- Technology for producing quality tomatoes under green house was standardized with marketable fruit yield of 171t/ha in the medium of soil : compost : saw dust (2:1:1) and fertigation with commercial fertilizer, indicating possibility of reducing production cost due to fertilizers. Average fruit weight was 80 g/fruit and on an average 74 fruits were harvested from each plant.
- Evaluation of *Cynadon dactylon* for management of disease complex of tomato (validation of ITK) by spraying extract fortnightly, resulted in reduced incidence of wilt, leaf curl, early blight, and increase in harvest of healthy fruits in *Cynadon* treated plots as compared to untreated control.
- Technology for production of quality capsicum was standardized. The highest marketable yield of 113.8 t/ha was harvested under growing medium of Soil: Compost: Saw dust

(2:1:1) and fertigation with water soluble fertilizers. French bean line IIHR 220 x Arka Komal 12-B with pod yield of 18-21 t/ha and resistance to rust was released and named 'Arka Anoop'.

- In potato, six hybrids viz. JW-160, MS/92-2105, SM/87-185 and HT/92-621 were recommended for release. Hybrid HT/92-621 is heat tolerant, resistant to leaf hopper and mites.It posesses high dry matter and is the most suitable for French fries. Hybrid JW 160 possesses wide adaptability and excellent keeping quality and can be stored under ambient temperatures. Integrated use of vermicompost and inorganic fertilizers gave 290 and 362 q/ha in Kufri Chipsona-1 and Kufri Anand, respectively besides improving tuber dry matter, specific gravity and chip colour in Kufri Chipsona-l. A total of 161.621 t nucleus seed and 2523.544 t breeders' seed was produced in plains and hills.
- A total of 2.2305t potato breeders' seed was supplied from plains and hills to state departments and other seed producing agencies.

COCONUT, ARECANUT, CASHEW AND COCOA

- Genetic base of coconut was further strengthened by adding large number of collections from various sources.
- Integrated approaches for management of major diseases like root (wilt) disease, stem bleeding and insect pests like eriophyid mite, rhinocerous beetle, red palm weevil in coconut and yellow leaf disease in arecanut were developed.
- Fertigation technique to save water and nutrients in coconut was developed.
- Soft wood grafting was standardized in cocoa.
- Coconut based cropping systems suitable for different regions were developed.
- In cashew, high density planting and canopy management were standardized.
- Technologies for management of cashew stem and root borer were developed.
- Value added products like coconut chips and snowball tender nuts were developed.
- Vermicomposting technique using coconut and farm wastes was standardized.
- Remote sensing and GIS techniques were successfully employed for identification of root (wilt) diseased palm.

TUBER CROPS

- A total of 5578 accessions of tuber crops are conserved *ex situ* at CTCRI. About 30% are maintained in *vitro* .
- High yielding varieties of cassava, sweet potato and taro were developed.
- A high carotene sweet potato hybrid, Sree Kanaka is developed which gives an yield of 10-15 t/ha in 75-85 days after planting.
- Two triploid hybrids of cassava having high and stable starch yield (29-32%) and high tuber yield (>36 t/ha) were developed for Tamil Nadu.
- Two superior hybrid selections in Amorphophallus with higher tuber yield (38-42 t/ha) were identified for release.
- Virus elimination through meristem culture was standardized.
- Integrated disease management against taro blight was developed.

MUSHROOM

- About 935 mushroom specimens were collected and taxonomically described and characterized using RAPD technique.
- A high yielding strain of *A. bisporus* with better quality and tolerance to fly was developed. Four high yielding strains of *A. bitorquis* with tolerance to false truffle were identified.
- Developed indoor compost production technology and rapid composting using thermophillic fungi.
- Cultivation techniques of famous edible and medicinal mushroom, Shiitake (*Lentinula*), Reishi (*Ganoderma luciolum*), Flammulina and Agrocybe were standardized.

SPICES

- 110 accessions of black pepper and 49 of cardamom were characterized based on IPGRI descriptors. Collection 1041 was registered as field tolerant to foot rot disease.
- High yielding varieties of black pepper, cardamom, ginger, turmeric and cinnamom were released for commercial cultivation.
- Black pepper lines OPKm, HP-728, HP-1411 and HP-780 are promising.
- Accession HM-444, 372 and 376 of fenugreek recorded the highest yield. HM 444 is resistant to downy and powdery mildew diseases.
- A technique 'Serpentine layering ' was developed to produce healthy planting materials of black pepper.
- IPM/IDM technologies with emphasis on biocontrol agents were developed for all major diseases and pests.
- Diagnostic kits for detecting viral infection in planting materials is under way.
- Rhizome solarization is highly promising for management of bacterial wilt in ginger.
- Organic farming in spice crops is attempted.

FLORICULTURE

Rose

- HT rose 'Pusa Gaurav' and floribunda rose "Arunima" performed well at majority of centers.
- For loose flower production, varieties "Neelambri", and Arunima" were promising while "Banjarani" was the best for garden display.

Gladiolus

Arka Kesar, Swarnima and Shagun performed better at many places.

Carnations

The cvs Impala, Superstar, Veleta and Fantasia provided with 4 hrs extended light resulted in maximum flowering stem length and early flowering.

Chrysanthemum

Newly developed varieties viz Arka Ravi, Punjab Gold, Mother Teresa, CO.2, Indira, Yellow Gold, Ratlam selection, Sonali Tara, Sunil, Baggi etc were promising at different locations.

Orchid

Coconut husk was the best suitable media for Dendrobium cv Sonia**.**

Tuberose

Prajwal and Vaibhav performed outstandingly.

Gerberas

Gerbera cvs grown under low cost polyhouse performed better than those grown under shade net and open field conditions.

MEDICINAL AND AROMATIC PLANTS

- Germplasms of various medicinal and aromatic plants were enriched.
- Digitization of germplasm is in progress.
- Good Agronomic Practices for these crops are being standardized.
- Ashwagandha MWS 133 gave maximum root yield (1091 kg/ha) and MWS-212 seed yield (1905 kg/ha). Alkaloid content was maximum in MWS-100 (0.56 %)
- In isabgol, the maximum yield (1232 kg/ha) was recorded in G-1-2 genotype at Faizabad.
- High yielding genotypes of safed musli, opium poppy, kalmegh, satavari, lemongrass, palmarosa, chandraasur, mentha etc were identified.

(C) NATURAL RESOURCE MANAGEMENT

Soil Survey and land Use Planning

- The digitized soil maps of 15 states (Madhya Pradesh, Maharashtra, Chhatisgarh, West Bengal, Rajasthan, Himachal Pradesh, Goa, Delhi and NEH states) on 1:250,000 scale were developed. Soil series have been identified and mapped for prospective land use planning.
- The soil series mapped at district level were for Pauri Garhwal and Almora districts of Uttaranchal, Meerut and Etah districts of Uttar Pradesh, Purulia district of West Bengal, Medak district of Andhra Pradesh and Tumkur district of Karnataka. Land use maps for Kamrup, Nalbari and Barpeta districts of Assam and soil landscape model for suitable cropping pattern for 4 districts of Tripura were prepared.
- Digitized maps of salt affected soils of the country (1:1million scale) and eight states (1: 2,50,000 scale) were prepared.
- Soil erosion maps (1:250,000 scale) and bulletins were prepared for West Bengal, Assam, Maharashtra, Madhya Pradesh, Gujarat, Uttar Pradesh, Himachal Pradesh, Tripura, Bihar, Chhatisgarh and Rajasthan .
- Database on Indo-Gangetic plain, and desertification map of southern part of western Rajasthan have been published.

- The water logged and salinity areas in irrigated semi-arid alluvial plains of Indira Gandhi Nahar Pariyojana in north -west Rajasthan were delineated and mapped.
- Soil resource inventory of major watersheds of Tista basin in Sikkim, namely, Ranikhola watershed and Rangit watershed was carried out and soil maps were prepared.
- The integrated watershed development programme in a participatory mode in Bundelkhand region was developed and implemented. It has increased the cropping intensity and crop yields (67-105%). The tribal dominated Kokriguda watershed was developed as model watershed for Eastern Ghat high land zone of Orissa.
- Studies on the impact of watershed management revealed that Peoples' Participation Index (PPI) in 15 DPAP watersheds of Coimbatore district of Tamil Nadu was 55, 44 and 27 per cent at the planning, implementation and maintenance stages, respectively suggesting, medium, low and very low level of peoples' participation. Benefit-cost (B:C) analysis of the project considering 10 years life at 10 and 15% discount rate gave a B:C ratio of 1.53:1 and 1.28:1 with 28% of internal rate of return (IRR). The credit utilization and repayment capacity improved as a result of watershed programme.

Soil Management :

- Sloping Agricultural Land Technology (SALT) – An appropriate technology for restoration of degraded lands proved to be most suitable for restoration of *Jhum* fallow/degraded lands in eastern Himalayas.
- Effectiveness of conservation furrows in moisture conservation and run-off management was demonstrated in10 on-farm trials in 5 villages of Nalgonda district of Andhra Pradesh. The area with conservation furrows stored 8-35% more moisture, thereby, resulting in 16-17% higher yield of castor and pigeonpea.
- The soil loss due to water erosion in the coastal belt of peninsular India worked out to be 5-40 t ha^{-1} yr^{-1}. The growth of cashew plants was better under bio-engineering measures than under vegetative barrier alone on the sea coast of Goa.
- Bed planting has been found to save time, labour, energy and water and, thereby, reduce cost of cultivation in Indo-Gangetic Plains (IGP).
- The zero-tillage technology for seeding wheat increased wheat yield by 7-8% in western U.P. with an additional return of Rs. 4355 ha^{-1}. The zero tillage also proved its worth on several other winter crops besides wheat after rice.
- Direct Seeded Rice (DSR) technology found to have a potential for improving the water productivity by 15-18% and system profitability by 10-15%.
- A technology package for amelioration of 25 million ha of critically degraded acid soils has been developed. Liming @ 2-4 q/ha along with the recommended fertilizers has potential to increase food grain production by 25 million tonnes per annum.
- Laser land leveling technology standardized for increased water productivity, nutrient use efficiency and crops yields in western Uttar Pradesh.
- A cost effective amelioration technology with reduced dose of gypsum (@ 25 % of gypsum requirement) and growing of sodicity tolerant varieties (rice- CSR 13 and wheat - KRL 19) developed to ensure higher crop productivity in sodic soils.
- Fungal inoculants were identified for bioremediation of heavy metals like lead, cadmium and chromium.

Cropping & Farming Systems

- Rice yield after berseem, chickpea and field pea was 9.3, 12.3 and 13.5% higher, respectively, than after wheat. This offers substituting wheat by legumes in rice-wheat cropping systems.
- Under sodic water irrigated conditions, rice-wheat cropping system was found to be better than rice-mustard, sorghum-wheat, sorghum-mustard and *Sesbani*a-wheat.
- Rice-potato-wheat cropping system was found more remunerative than rice-wheat cropping system.
- A single pre-emergence application of clodinaps (TOK) @ 60 g ha^{-1} 3-4 weeks after sowing effectively controlled wild oat in wheat at Jabalpur (M.P.).
- Inclusion of high yielding genotypes of finger millet and barnyard millet in the cropping system, increased the cropping intensity and total production in the rainfed north-west hilly region of the country.
- Crop diversification with maize, groundnut and pigeon pea in rainfed upland rice regions of eastern India fetched net return of Rs. 15,000/ha/annum.
- Sorghum + pigeon pea and castor + green gram intercropping proved highly remunerative even under situation of delayed monsoon for south-eastern Rajasthan.
- Intercropping of green gram-castor (4:1) doubled the net return in Agra region.
- A fish-pond-cum secondary reservoir was developed and constructed for economical and multiple uses of irrigation water in agricultural production system. Results revealed that dissolved oxygen level at 1.6 m below water level decreased continuously upto 6 days after water exchange and stabilized thereafter. For proper growth of fish, water has to be changed after every 5 days.
- A run-off recycling system was evaluated for multiple use for third year. It was found that an integrated farming system involving crops, fish, and horticultural crops can be developed around this system. The benefit-cost ratio with crops alone was 1.89 and increased to 2.27 with addition of horticultural crops and to 2.80 with addition of fisheries. It could be further raised if duckery was added as an additional component.
- A model farming system has been developed for NEH region introducing agri-silvi-horti-pastoral system at different hill slopes integrating fishery, piggery, duckery, poultry, apiculture and mushroom cultivation.
- Evaluated rice, coconut and rabbit based integrated farming systems for Western Ghats region.
- Evaluated multi enterprise farming system models for better livelihood in Sunderbans under Coastal agro-eco system
- Palm rosa (*Citronella martini*) was found to be a potential aromatic plant for sodic soils.
- A variety of plant species (131) comprising of herbs, shrubs and trees identified for herbal farming in arid region.
- Contingent crop-planning under delayed monsoon situations for rainfed areas was formulated.

Water Management

- Standardized alternate raised & sunken bed system to diversify crops in lowlands of eastern region. The system increased annual productivity of lowlands from 3.2 to 21.6t/ha, irrigation efficiency from 26.6 to 212.9 kg/ha-cm and net return from Rs 1,552/- to Rs 57,710/- per ha.

- Aquifer characteristics (depth, thickness, discharge, transmissivity and storavity) of Balasore, Mahanadi delta and Kathajodi river basin of Orissa were studied.
- A pressurized irrigation system fed through a reservoir in adjunct to the canal system for irrigation either by pumping or by gravity was developed with benefit-cost ratio of 2.6. The system can act as a gravity-fed surface irrigation system during monsoon and as a pump based drip cum sprinkler irrigation system during post-monsoon season.
- An improved design of *khadin* for water harvesting and moisture conservation in arid lands formulated.
- A comprehensive land and water management system devised for super cyclone affected coastal districts of Orissa.
- Devised drip and sprinkler irrigation systems to save water (30-50%), labour (50%), fertilizer (30-40%) and increase yields (12-76%).
- Developed a model of rotational delivery schedules of canal water. The 7 and 15 days rotational scheduling during *rabi and kharif* seasons, respectively saved more water compared to prevailing continuous delivery schedule.
- Recharge filters of one metre thickness with coarse aggregate and sand were found to be effective in recharging sediment free runoff water in open and tube wells.
- Recharge from the Shingave percolation tanks in Maharashtra has been studied since 1992-93. The influence of percolation tanks was upto 750 m. The recharge due to percolation tanks was estimated to be 89% of inflow, while the average recharge over the period of 7 years was 86%. The total inflow based on the curve number technique was computed as 216 ha-m.
- Developed a database on water resources of Bihar & Jharkhand containing surface water and ground water including crop area, crop production, meteorological information using MS-Access.
- The norms for recycling of saline water for irrigation were developed. Application of FYM @ 20 t ha^{-1} decreased build up of salinity in soils irrigated with chloride and sulphate dominated waters.
- Dorovu technology for skimming fresh water overlying the saline water perfected.
- Integrated water management was developed for chestnut cultivation in shallow water-logged areas of coastal and tribal dominated districts of Orissa.
- A single life saving irrigation to cotton 21 days after sowing on a deep alluvial soil of Agra doubled the net income from the crop.

Nutrient Management

- The soil carbon stocks under different land use systems of the country documented.
- Digitized soil fertility maps (N,P,K) for Andhra Pradesh, Maharashtra, Orissa, Punjab, Chhattisgarh, Haryana , Karnataka and Himachal Pradesh were prepared.
- Delineated and mapped micronutrient deficiencies in the states of Punjab, Haryana, Bihar, Gujarat, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Uittar Pradesh and Uttaranchal.
- Sulphur deficient areas in the country were delineated. About 41 percent of 60,000 soil samples from different parts of the country were found deficient in sulphur.

- Developed ready reckoners for soil test based fertilizer recommendations for given yield targets of crops for different agro-ecological regions (AERs) of the country.
- Integrated nutrient management packages for major cropping systems in different AERs of the country compiled and passed on to respective states to promote balanced fertilization.
- Conjunctive use of inorganic and organic fertilizers improved the soil quality of Vertisols reflected in the build up of soil organic C, increase in microbial biomass and improvement of soil structure.
- Wheat residue incorporation/surface retention along with supplementation of 28 kg N ha^{-1} through FYM/poultry manure was more profitable than the practice of residue burning for subsequent soybean crop in wheat-soybean cropping system.
- Integrated Plant Nutrient Supply System packages for soybean-wheat and rainfed cotton on Vertisols and clusterbean-pearl millet cropping systems in arid zone were developed.
- Integrated nutrient management employing sulphitation press mud and FYM with sub-optimal NPK application increased the annual productivity of rice-wheat system.
- Incorporation of humic acid (2%) as an additive to lignite and vermiculite carrier based cultures improved the shelf life of bio-fertilizers.
- In situ incorporation of rice residue along with application of N-enriched phosphocompost 3 weeks before the sowing of wheat improved wheat yield, soil organic matter and availability of other nutrients.
- A technology of co-composting of poultry litter with rice straw, pyrite and rock-phosphate along with inoculation with cellulytic micro-organisms was developed to reduce ammonia volatilization losses by 40% during decomposition of poultry litter.
- Leaf Colour Chart (LCC), a simple device for nitrogen management, saved 15 kg N/ha in rice.
- Developed mixed Biofertilizer formulations with nitrogen fixers and phosphate solubilizers
- Green manuring with sesbania and crotolaria spp. increased the yield of rice - wheat system by about 24%.
- Granular penta borate, a new boron source, found efficient for correcting boron deficiency in major crops in different agroecological zones**.**
- A rapid rice straw composting technique developed employing pre-treatment with aqueous salt solution for 48 hours (to break lignocellulosic complex) followed by composting for 21 days.
- Quality standards of biofertilizers and rural/urban composts formulated .

Agroforestry

- A comprehensive on-line database on agroforestry entitled "Agroforestry BASE" generated.
- Agroforestry systems viz. agri-silviculture, agri-horticulture, horti-pastoral and silvi-pastoral have been developed for rainfed and irrigated conditions.
- *Chironjee, Lasora, Bael, Ber and Aonla* have been successfully domesticated on degraded lands. Vegetative propagation techniques for these have been standardized.
- In situ moisture conservation practices conserved 10-15% higher moisture and favoured tree growth in aonla (*Emblica officinalis)* based agri-horticultural system.

- Nineteen provenances of *Acacia nilotica* were collected from central India. In addition, 21 tress having good tree form and 5 trees having high gum yield were also collected.
- The black gram yield in deep ploughed inter-space between 9 year old Shisham (*Dalbergia sissoo)* trees was 12.7% higher than normal ploughing.
- Ridge method of planting was found better than flat for survival and growth of trees. The maximum survival of 95.7% was recorded in menhdi (*Lawsonia inermis*) followed by agave (*Agave sisalana)* and Karonda *(Carissa carandus)*
- The planting of guava (*Psidium guajava)* alongwith a leguminous fodder *(Stylosanthese hamata)* in trenches gave a better performance of fruit component in degraded hillocks of eastern ghats of Orissa.
- The performance of fruit-based (*Karonda, aonla, bael)* agro-forestry system was satisfactory with saline water even on highly saline and calcareous degraded lands of Haryana.
- Under tree improvement programme, 247 accessions of *Jatropha*, 302 of *Neem*, 32 of *Shisham,* 63 of *Babul*, 16 of *Kardhai* and 138 of *Karanj* have been collected from various parts of the country for evaluation of productivity under different agroforestry systems.
- The teak based agri-silvicultural system sowing pigeon pea as an inter crop was most suitable for the first five years at Parbhani. After five years turmeric and ginger were better as inter crop.

Climate Change

- A network project on Impact, Adaptation and Vulnerability of Indian Agriculture to climate change has been initiated at 16 centres in the country with an outlay of Rs.10 crores.
- A website "Crop Weather Outlook" for agromet and weather based agro-advisories made operational at CRIDA, Hyderabad.
- Technical Bulletin on "Cold Wave 2002-03 and Heat wave 2004 depicting impact on agriculture brought out.

(D) AGRICULTURAL ENGINEERING

- Large number of machines were developed. Some of the important machines are Light weight power tiller (140 kg) operated by 3.5 kW engine; Animal drawn raised bed former and seed cum fertilizer drill for cultivation of vegetables on raised bed; Development of tractor operated Plastic Mulch laying machine; Tractor operated Lugged Wheel Puddler (185 cm); Self Propelled Rice Ridge seeder operated by 5 hp diesel engine; Tractor operated inclined plate planter with bed forming attachment and bed former for sowing of inter crops on broad/raised beds; Self propelled chopper type combine harvester for sugarcane; Indigenous laser guided land leveler; Tractor operated Orchard Sprayer.
- Technology for Mechanized transplanting of rice including nursery raising. Technology for minimum tillage dry seeded rice in wheat straw fields; Technology for minimum tillage cultivation of wheat after combining harvested rice were developed. Tractor operated till plant machine. Self propelled Biasi cultivator operated by 5.5 diesel engine. Technology for direct seeding of wheat. 4-row sprouted manual rice seeder.
- Precision Irrigation under precision farming developed.
- Biogas slurry filtration unit was modified and installed for field evaluation

- Five units of 10 kW CIAE natural draft gasifier fabricated for multi-location trials.
- A 20 kW producer gas cooling and cleaning system was designed, developed and tested for tar absorption.
- A tar cracking unit has been developed for cleaning the producer gas for use in the biofuel cells.
- A power operated 350-400 kg/ h groundnut decorticator for seed and snacks industries has been developed.
- Osmotic-cum-heated air drying technology for vegetable like cauliflower, green pea and mushroom has been developed.
- A pilot plant for making oil free potato puffed product (20-25 kg/ day) has been developed.
- An upgraded dal mill to enhance dal recovery and to increase the capacity of mill was developed along with a dust free type cleaner.
- A fruit grader (3 t/ h) for round shaped fruits has been developed.
- Technologies have been developed to produce soy-shrikhand and amrakhand in which mango is an ingredient, sugar-free salted and sweet biscuits.
- Suitable processing approach has been developed for elimination of heat stable anti nutritional constituents in soybean and sunflower.
- Soy milk based rasogulla and Producing phytate and galactoside free soy products developed.
- A total of 479 women and 357 potential entrepreneurs were trained in soybean processing for food uses and soy products.
- Commercial prototype developed involving manufacturers for 15 CIAE prototypes.
- 10,235 prototypes were produced.
- 2539 persons including Extension Officers, Government Officials and Entrepreneurs were trained during the last four years.
- Post harvest management of peach and Post harvest management of ber developed.
- Developed cycle rickshaw for fish transportation.
- Developed integrated paddy dryer.
- Developed technology for debittering of kinnow juice.
- A non-destructive method to measure maturity and sweetness of mango developed.
- CIPHET low cost storage technology for fruits and vegetables developed.
- Enhancement of oil recovery using mechanical extraction for mustard seed developed.
- Developed low cost green house for cold desert region and Evaporative cold room.
- Developed Mustard seed grinder for higher oil recovery and Mustard by-products.
- Methodology including DNA isolation, PCR protocol, etc. has been standardized for lac insect characterization through RAPD profiles for reliable characterization of lac insect germplasm.
- Descriptors have been developed for the three major lac hosts, *palas* (*Butea monosperma*), *kusum* (*Schleichera oleosa*) and *ber* (*Zizyphus mauritiana*) for characterization.
- Modified *kusmi* lac production technology was transferred through regular training programmes of the Institute.

(E) ANIMAL SCIENCE

Animal Genetic Resources Evaluation, Conservation and Improvement

- Established National Informatics Centre on indigenous farm animal genetic resources and programme on characterization, evaluation and conservation of animal genetic resources through surveys.
- In-situ conservation of animal genetic resources on organized farms and under sustainable production systems in the field conditions and Ex-situ conservation of farm animal genetic resources using genetic markers.
- Technologies developed for improvement of the indigenous sheep breeds through selection using both natural breeding and artificial insemination.
- Developed technologies to preserve ram semen (liquid/frozen) and fertility trials conducted by use of preserved liquid and frozen semen.
- Technology has also been perfected for collection and transfer of embryos for quick multiplication of superior sheep germplasm.
- Quality of wools available from different indigenous and crossbred sheep evaluated with regard to their physical attributes and their physio-mechanical properties. Suitable blend formulations recommended for manufacture of different products.
- Carpets made from different types of indigenous and imported wools and from their blends and blended with wollenized jute evaluated for different quality characteristics.
- Developed superior genetic stocks of layers, broilers, quails and guinea fowls and development of package of practices relating to nutrition, management and health care to optimize growth, production and reproduction of the above avian species in tropical environment.
- Improvement of existing layers and broilers populations to achieve performance comparable to commercials through revised selection methodology on large population size with high selection pressure undertaken. In broilers the traits of economic importance such as feed efficiency, number of settable eggs, fertility, hatchability, less abdominal fat, better immunocompetence, livability etc., given importance in selection programmes. Similarly, in layers, in addition to egg weight and egg number the traits such as feed efficiency, heat tolerance, shall strength, shell thickness, livability etc will be given importance while formulating selection programmes
- Exotic and indigenous pigs and their crosses evaluated genetically and phenotypically for various economic traits. Package of practices developed for raising the exotic, indigenous and crossbred pigs under optimal managemental conditions.
- Developed synthetic broiler male line with white colour plumage was undertaken. Commercial test cross (KRISHIBRO) from coloured pure line attained body weight of 1339g without any finisher ration with a feed conversion ratio of 1.96 and mortality of 2.62 percent at six weeks of age.
- A new synthetic coloured control broiler population developed to measure the environmental trend for the selected lines.

- Parents of VANARAJA chicks selected with special emphasis on colour combination besides other traits of economic importance. Seven strains of poultry especially suitable for backyard farming released to institutional farms for performance testing.
- Genetic polymorphism was absent in Indian Yak
- 4,10,989 fertile eggs, day old chicks and grown up birds of Vanaraja and Gramapriya supplied to the farming community of rural and tribal areas.

Livestock Improvement

- Developed a data base information system on feed and animal resources available in the country The programme developed enables working out the nutrient requirement (DM, DCP and TDN) for different categories of livestock and give information on surplus / deficit of feed resources in different states for different years.
- Protected these fat supplements for incorporation in higher levels (5% and above) for achieving higher energy density in the ruminant rations developed. Protein supplements like silk worm pupae meal (de-oiled), chilli seed cake (expeller), chilli seed cake (solvent extracted), soybean extraction, sunflower extraction and maize gluten meal are good sources of bypass protein.
- Supplementing the ruminant diet with bentonite or activated charcoal reduces aflatoxin secretion in milk. Feeding of small quantity (1% DM) of either sodium bentonite or activated charcoal was able to reduce the secretion of aflatoxin in milk.
- For laying quails, a dietary provision of 75 mg Zn per kg and 3.0% calcium was found optimum and that no interaction between the two nutrients was evident.
- Supplementation of diet with fungal phytase improved remarkably the dietary phosphorous utilization with a concomitant decrease in phosphorous excretion. In another study, it was found that growing quails performed optimally on diets containing upto 8% crude fibre.
- Detoxification of linseed meal (autoclaving + Vit. B6 10 ppm) and use of activated charcoal in insecticide affected diets had a beneficial effect in enhancing the growth and reducing the severity of lesions in different organs of broilers.
- Poultry wastes biodegradation and its recycling are important to contain growing pollution menace. Anaerobic biodegradation of poultry droppings in presence of high cellulosic material like the dry grass and or tree leaves, left a bio-mass of high manureal value for increasing crop yield.
- Supplementation of Zn to practical diets from 0-320 ppm did not influence any change in growth, feed intake, feed conversion efficiency. Zn available from the basal diet (29 ppm) was adequate to support the performance of broilers during initial growth period of 5 weeks.
- Feeding of spineless prickly pear cactus alongwith roughage *Cenchrus* can serve as the sustenance ration for short term scarcity feeding of sheep. The soybean cake and cotton seed cake had higher amount of undegraded dietary protein (UDP) than those of mustard, groundnut, rapeseed and til cake.
- Sperm cells were found to synthesize steroid hormones during their maturation, under the influence of gonadotrophins. This synthesis is probably necessary for sperm

maturation, besides the hormone dependent protein synthesis of testis and epididymis to support sperm maturation.

- For the assessment of incidence of infertility in goats under farm as well as under field conditions major causes of reproductive constraints have been identified and their appropriate lines of treatment suggested automization of semen freezing protocol for higher post thaw motility and fertility in goats is in progress. A field technique of semen preservation has been developed and perfected for adoption under field conditions and is ready for commercial exploitation.
- Modulation of peripheral catechnolamines to control stressed moulting, loss in body weight and metabolic processes in white leghorn hens provided a strong basis of modulating certain physiological aspect favorably.
- Studies on haematological and biochemical parameters of Mithun, thermo-adaptability, immunoglobulin pattern, different mineral and enzymes studies, reproductive behaviour and induction of lactation using 17 ß estradiol and progesterone in yak were initiated.
- More than 40 non-conventional feeds identified and technology for their use in complete feeds developed. More than 100 complete feeds using locally available ingredients developed and recommended for growing and milch animals.
- The technology for cryopreservation of camel semen perfected
- A serum based sandwich ELISA test developed for early pregnancy diagnosis in equines.
- A highly sensitive enzyme immunoassay (EIA) for GH determination in mithun blood plasma developed and validated.
- Gene for Lysozyme, an antimicrobial protein, has been cloned and sequenced from the mammary gland and stomach tissues of buffalo and sheep, and native protein purified from buffalo colostrum.
- A sensitive ELISA procedure developed to estimate prostaglandin metabolites (PGFM) in mithun plasma and PGFM concentration has been estimated in mithun during different stages.
- National Research Centre on Pigs established at Rani, Guwahati, Assam.

Livestock Products Technology

- Development of milk based probiotic spray dried food formulation.
- Manufacture of probiotic Edam cheese containing *B. bifidum*.
- Development of low fat cheddar type cheese.
- Production of milk protein concentrates using ultra-filtration technology and their utilization.
- Development of platform test for detection of adulteration directly in milk with foreign fats & oils.
- Development of technology for dried carrot milk food.
- Technology of manufacturing delipidized whey protein concentrate employing membrane processing.

- Technology for Mozzarella cheese from skim milk microfiltration. Low cost processed cheese preparations developed.
- Microfilteration of milk for extended shelf life. Technology of long life soft drink from butter milk.
- Process for continuous hydrolysis of whey lactose.
- Dehydration of Paneer for enhancement of shelf life.
- Development of prototype equipment for continuous manufacture of paneer.
- Pesticide residues: Package of practice has been standardized / developed for the analysis of Organic Chloro Pesticide Residue(OCPR) in milk.
- Meat production potential & carcass quality evaluation of Sirohi weaner kids, Marwari kids, Malpura, Garole, Malpura & Garole crosses evaluated.
- Appraisal of broiler rabbit potential as an alternate source of meat (Soviet Chinchilla, New Zealand White, White Giant, Grey Giant and Black Brown breeds).
- Technologies for convenience & value added meat products such as nuggets, patties, sausages, meat balls, restructured rolls, kebabs & tandoori developed from buffalo meat, mutton, chevon, chicken meat, broiler rabbit meat.
- Egg- crust pizza formulation developed.
- National Research Centre on meat established for development of meat sector at Hyderabad (A.P.).
- Indian wool suitable for blending with angora rabbit hair and mohair specialty fibers has been identified on the basis of their fiber.
- Harshil wool of Uttaranchal was found promising to replace imported Merino wool for blending with Angora rabbit hair.
- A process based on osmotic dehydration developed for production of ready-to-reconstitute Ras Malai.
- An eco-friendly earthen pot using special clay and shellac coating developed for packaging of dahi to prevent shrinkage and increased shelf life.
- Blended yarns of Mohair with Chokla and 50% Gaddi Synthetic have been made in the blend ratios of 20 / 80, 30 / 70, 40 / 60 and 50 / 50 using woven system.
- Blended yarns of Angora rabbit hair with 50% Bharat Merino and 50 % Merino have been made in the blend ratios 20 / 80, 30 / 70 and 40 / 60 on a woolen system.
- New German Angora rabbit have been introduced, which produces about 1 Kg. of wool per annum with 2% guard hair. The wool is of good quality and shawls could be produced locally by blending with Gaddi synthetic wool.
- A process for Herbal Ghee with functionalities like resistance against heart diseases and blood pressure regulating properties developed.
- Mozzarella type cheese developed using buffalo skim milk and vegetable fats employing direct acid method.
- Method for making cottage cheese from Yak milk standardised.
- The leather produced from mithun hides was found to be of excellent quality with huge export potential.

Animal Health

- Rinderpest and other important diseases of livestock & poultry diagnosed and controlled by precise and timely diagnosis. Freedom from Rinderpest achieved.
- Molecular epidemiology of various serotypes of FMD along with nucleotide sequence have been determined and compared by the partial/ full sequence of the 1D gene of FMD virus field isolates of serotypes O, Asia 1 and A.
- The ***Non-structural (NS) proteins*** of FMD viruses are conserved across the serotypes. Antibodies to the NS antigens persist in the animals for long periods (up to 3 years) following infection. The protective antibody status following vaccination in ***Liquid Phase Blocking ELISA (LPBE)*** was further evaluated and standardized for screening large number of serum samples.
- A disease simulating forecasting model based on computer application has been developed and a national data base based on eco pathological zoning have been developed. Disease simulation models have been developed for the critical epidemiology, which are the tools, that relate/simulate the pathogenic performance of the disease in relation to the conditions that change either deterministically or randomly.
- Pharmacodynamics and pharmacokinetics of the drugs have been analysed and efforts have been made for utilization of indigenous medicines for the treatment of livestock and poultry disease.
- The presence of heat stable antiviral and immunopotentiating activity in the extracts of *Ocimum sanctum* (Tulsi) leaves and seeds were demonstrated.
- It was also shown for the first time in the country that dogs could be used as effective bio-monitors of lead and cadmium pollution in the urban and industrial areas.
- The antigenic variation and characterization of antigenic profile of purified antigens have been developed in terms of dot ELISA for the diagnosis of Johne's disease. For protozoal infections diagnostic tests involving molecular biological techniques have been developed and chemotherapy for the treatment of theileriosis have been investigated.
- An exclusive hybridoma laboratory for the production of N and H protein based monoclonal antibodies to RPV and PPRV have been developed for use in the ELISA kits for national sero monitoring and sero surveillance programmes.
- Polymerase chain reaction (PCR) assay was standardised for the diagnosis of trypanosomosis, a dreaded protozoan disease caused by *Trypanosoma evansi* in domestic and wild animals.
- A mapping of tick population responsible for transmitting diseases was undertaken.
- A newly designed linear skeletal fixator provided better and stable fixation of fractures in large animals than conventional fixator.

Diagnostics/Vaccines/Technologies developed

- Various diagnostics and vaccines developed and technologies transferred for commercialization.
- The immuno diagnostic kits for FMD, Blue tongue, brucella, IBR and IBT were prepared and released for the field application.
- Equine influenza vaccine was produced and made available for commercial utilization.

- ELISA kit in form of strip/ immuno dipstick for equine influenza was developed. Inactivated oil emulsified Inclusion Body Hepatitis-Hydro pericardium Syndrome (IBH-HPS) vaccine, prepared from the virus propagated in SPF-chicken embryos, which afforded complete protection to the chicks from one week to 6 weeks against the disease.
- Monoclonal based highly sensitive and specific Avidin- Biotin ELISA test was developed for comparative sero epidemiological monitoring of livestock diseases.
- An indigenously developed cheaper monoclonal antibody (Mab) based competitive-ELISA kit was for sero-surveillance against rinderpest.
- Complement fixation test based diagnostic kit COMPLEMENT FIXATION FOR EQUINE BABESIOSIS (COFEB) has been developed which would be helpful in saving foreign exchange and detection of infection within 4 hours against about 10-12 hours by conventional methods.
- A milk based bovine brucellosis ELISA kit has been indigenously developed for screening the milk samples collected from the village milk producer's cooperative societies to identify infected village and to develop strategies for its control/eradication.
- Powerful veterinary epidemiology software **India.admas Epitrak** has been developed for the first time, which is exclusive to the livestock disease scenario in India.
- Two new isolates of bluetongue virus, which was characterized as Type 23, were added the inventory of Centre for Animal Disease Research and Diagnosis. Rose Bengal colored antigen was developed for Serum Agglutination Test (SAT) for diagnosis of Caprine pleuropneumonia for field application.
- A dot ELISA based on soluble antigen of *Brucella mellitensis* biovar –1 isolated from goat was developed which was found to be very sensitive.
- A test to diagnose Bovine Immuno-deficiency virus in cattle and buffaloes, a condition similar to AIDS in human beings developed.
- Ingress of highly pathogenic animal influenza in the country checked by timely disease diagnosis and preventive measures.
- Molecular epidemiology of FMD has been carried out to assess the extent of infection and prevalence of virus in the country. The full-length cDNA of the second most common serotype of FMD virus Asia 1 has been constructed and nucleotide data deduced by sequencing.
- Avian influenza (Bird flu) virus detected in the samples from Maharashtra and more than 45,000 samples tested for Avian Influenza after outbreak of Bird Flu.
- Monoclonal antibody developed against six equine rota virus strains used for detection of foal rota virus in stool of more than 50 diarrhoeic foals.
- Surface antigen used for sensitive and specific detection of *Theileria annulata* infection.
- A novel multifunctional protein identified from *Haemonchus contortus* and gene coding for this protein cloned, expressed and the recombinant protein analysed. The cloned protein shows great potential for futuristic vaccine for control of gastro-intestinal parasites.
- Truncated fragment of EMA-2 gene of *Babesia equi* was expressed in pGEX T-1_ expression vector. ELISA was standardized using the GST –tagged purified recombinant protein for detection of *B. equi* antibodies. No cross reactivity was observed with reference to *B.cabbali* or *T. evansi* positive serum samples.
- An inactivated vaccine against Avian Influenza developed.

(F) FISHERIES

Development in Marine Fisheries

Developed a Mass Balance Trophic Model of the Arabian Sea ecosystem which can forecast the impact of change in effort on marine resources. Analysis based on trophic level of 707 species revealed that Fishing Down Marine Food Web occurs along southeast coast of India at the rate of 0.04 trophic level per decade. The National Marine Fisheries Census – 2005 was carried out in all the maritime states covering 7.56 lakh fishermen households, 3202 fishing villages. The historical time series data on biological aspects and landings of selected species analysed and published as "Marine fish Landings in India 1985-2005-Estimates and Trends".

Brackishwater Aquaculture

Captive brood stock development and domestication of kuruma shrimp *Marsupenaeus japonicus*, a candidate species for diversification was achieved. Culture of *M. japonicus* was successfully carried out in brackishwater pond with a survival of 83% and a production of 1018 kg /ha/4 months.

Developed captive land-based brood stock of Seabass, L*ates calcarifer* and produced F_4 generation. Standardised technology package for hatchery seed production or seabass and established a model marine finfish hatchery.

Freshwater Aquaculture

Giant Freshwater Prawn, *Macrobrachium rosenbergii* was bred in captivity using inland saline water and post-larvae raised with suitable ionic amendments without the use of sea water. Successful breeding of yellow catfish, *Horabagrus brachysoma* and freshwater eel *Mastacembelus aculeatus.* Through selective breeding technique, growth enhancement to the tune of 17% per generation in rohu *Labeo rohita* was demonstrated and **Jayanti** rohu given to farmers. Location and altitude-specific composite carp farming technology has been developed for hilly areas.

Management of Small Reservoirs

High fish production levels of 220 kg/ha/year have been achieved from small reservoirs as against the national average of 20 kg/ha/year.

Mariculture Technologies

Larval rearing protocols were developed for honey comb grouper *Epinephelus merra* and one seed production trial was successfully completed.

In vitro marine pearl production through tissue culture technique was successfully carried out in Indian Pearl Oyster *Pinctada fucata* and abalone, *Haliotis varia.* Make-up pearl production where *Pinctada fucata* pearls were colour - modified to mercurial blue and mercurial pink using heavy metals like iron and manganese.

Two species of sand lobster (*Thenus orientalis, Scyllarus rugosus*) were successfully bred in captivity and larval cycle completed in three to four weeks time.

Captive spawning of three varieties of damsel fishes namely *Dascyllus trimacultus, Pomacentrus coelestis* and *Dascyllus aruanus* was achieved.

Twelve hundred juveniles of sea cucumber, *Holothuria scabra* (mean size 25 mm) bred in captivity were sea ranched.

Duplex PCR Kit for the detection of white Spot Syndrome Virus commercialized.

Fish Harvest and Post-Harvest Technology

Developed designs of eco-friendly and resource - specific demersal trawls, V form otter boards, Turtle Excluder device (TED), square mesh cod ends, FRP sheathed, untreated rubber wood canoes, prototype of a 5.22 m LOA aluminum alloy boat for inland sector, Monoline fishing (long lining) for reservoir fisheries. Designed and constructed fuel-efficient 15.5m steel trawler, "Sagar Kripa', consuming 20% less fuel compared to conventional trawlers of the same size.

Standardised production of several value-added products from cuttlefish, squids, threadfin breams, Tilapia and Catla and carps. Developed a method of packaging system for cooked products in retortable flexible pouches, providing seal integrity, toughness and puncture resistance to maintain and preserve quality of cooked products for more than a year. Developed a method for detection of White Spot Disease in shrimp as also RT-PCR technique for detection of Yellow Head Virus.

Fish Genetics and Biotechnology

Sperm cryopreservation technique for endangered red tailed barb, *Gonoproktopterus curmuca* was standardized. Cryopreservation of eggs of rohu, *Labeo rohita* at the stage of blastomere achieved.

A probiotic preparation for the control of luminescent bacteria in the hatchery has been developed.

Polymorphic microsatellite and allozyme markers developed for fifteen fish species and *Macrobrachium rosenbergii.* Microsatellite enriched genomic libraries for *Chitala chitala* and *Pangasius pangasius* constructed.

Developed a database 'Fish Chromosome World', containing karyomorphological information on 126 finfish species from 34 families and 9 orders. Stock structure analysis of *Labeo rohita, Catla catla, Cirrhinus mrigala, Labeo dero* and *L. dycheilus* from different riverine system in Indo-Gangetic plains using allozyme and microsatellite completed.

Fish Conservation and Management

Diagnostic capability for exotic OIE listed pathogens by PCR was developed. Guidelines for introduction of Aquatic Exotic and Quarantine in support of national strategic plan were developed and published.

Fisheries Education

The CIFE continued to offer doctoral, masters and post-graduate diploma and certificate courses in fisheries through its headquarters and research/education/training centers. The CMFRI,CIFT and CIFA continued their M.F.Sc. and Ph.D. programmes in Mariculture, Post-harvest Technology and Aquaculture in collaboration with CIFE. During the period, the CIFE produced 190 M.F.Sc. students, 49 Ph.D. students and 93 P.G. Diplomas.

(G) AGRICULTURAL EDUCATION

Accreditation: Established Accreditation Board and accredited 14 Agricultural Universities to assure quality of education

- ***Niche Area of Excellence:*** With the objective of building global visibility in research and education, total 22 Niche Area of Excellence sanctioned with an allocation of Rs. 36.39 crores.
- ***Experiential Learning:*** With the objective of providing skill oriented hands on training to the students, 91 Units established in 35 Universities with an allocation of Rs. 30 crores
- ***Strengthening and Development of Agricultural Education:*** Financial and professional support given to State Agricultural Universities (SAUs), Central University (CU) and Deemed-to-be-Universities (DUs) for modernization and strengthening of academic facilities and updating infrastructure and faculty improvement.
- ***Girls Education:*** Construction of 57 girls hostels costing Rs. 42.15 crores supported
- ***International Hostel:*** Construction of 12 International Hostel costing Rs. 11.76 crores (ICAR Shares) supported. Foreign students from 25 developing countries admitted. Excellent academic programmes to attract foreign nationals.
- ***Refreshers Courses:*** 2000 scientists trained in emerging subjects areas through 91 summer / winter schools
- ***Reduction of inbreeding in education:*** Filling of 15-25% of total seats through common entrance test.
- ***Advanced Trainings:*** Competence and Research capability of 2975 faculty members improved through Centers of Advanced Studies by organizing 154 trainings.
- ***Drudgery Reduction:*** Improved implement, tools and house hold gadgets developed for farm women
- ***Curricula revision:*** IV Deans Committee constituted to address quality and relevance of education by reorienting course curricula and syllabi for employability of agricultural and allied science graduates.
- Scholarships and fellowships are provided to meritorious students
- Trained scientists and research managers for management through NAARM.

- NAARM assisted in development of policy interventions for enhancement of performance of NARS and review of ICAR progrmmes.
- Institutionalized basic research through National Professors and National Fellows.

(H) AGRICULTURAL EXTENSION

The Government of India has decided to establish one Krishi Vigyan Kendra (KVK) in each rural district (578). Thus, the ICAR has already established 503 KVKs in the country and remaining are likely to be completed during 2006-07. The activities of the KVKs includes technology assessment and refinement through on-farm trial in order to identify the location specificity of technology under different farm system, frontline demonstrations to establish the production potential of improved agricultural technology on the farmers field, training of farmers to update their knowledge and skill, and training of extension personnel to orient them in the frontier areas of technology development. 200 KVKs have been targeted for e-connectivity to facilitate exchange of information and upgrade the technology during the year 2006-2007. This facility will enable the farmers to get information quickly on new technologies.

In addition to KVKs, there were 76 Institution Village Linkage Programme (IVLP) centres and 44 Agricultural Technology Information Centres (ATICs) for technology assessment, refinement and transfer. The ATICs provided technological products, diagnostic services and technology information to farmers and end-users. Kisan melas, disussion fora, advisory services and film source were arranged to accelerate the process of dissemination of technologies. A large number of demonstrations of production technologies on various aspects of crop production in oilseeds, pulses, cotton, other crops and dairy, sheep, goats, poultry, piggeries, etc. were organized. The KVKs also organized about 2 lakhs training programmes benefiting about 20 lakhs farmers and farm-women, 5 lakhs rural youths and 4 lakhs in-service personnel. At KVKs about 15,000 tonnes of seeds of major crops and 10 million saplings / seedlings of fruits and plantation crops were produced for availability to farmers.

The KVKs also organized skill development training to farm-women to set-up different enterprises in agriculture. About 10 million farm-women and rural girls were given training on crop production, horticulture, home science, livestock production / management, etc.

8. CONSTITUTION OF SUB-GROUPS

Agricultural Research and Education is not only a very broad area but very vital for creating a knowledge base and developing technologies that should result in enhancing contribution of agriculture and allied sector to the national economy while maintaining and preserving natural resources for the posterity. Since agriculture includes varied subjects, the Chairman constituted the following Sub-Groups chaired by eminent scientists. The sub-groups were as follows :

	Sub-Group	Chairman	Member Secretary
1.	Climate Change, Risk and	S.M. Virmani	Y.S. Ramakrishna Disaster Management
2.	Natural Resource Management	G.S. Sekhon	P.D. Sharma
3.	Rainfed Agriculture	J.C. Katyal	P.S. Minhas
4.	Mechanisation, Post Harvest & Energy	B.S. Bathak	Pitam Chandra
5.	Crop Science	R.B. Singh	K.V. Prabhu
6.	Animal Science	M.L. Madan	Lal Krishna
7.	Horticulture	Kirti Singh	K.V. Ramanna
8.	Fisheries	T.J. Pandian	A.D. Diwan
9.	Biotechnology	Deepak Pental	N.K. Singh
10.	Education	S.L. Mehta	H.S. Nainawatee
11.	Agricultural Extension	T.S. Sohal	Rajinder Prashad
12.	Economics and Marketing	S.S. Acharya	Ramesh Chand
13.	Organization, Finance & Management	Pritam Singh	Suresh Pal
14.	Plant Protection	S.N. Puri	T.P. Rajendran

All Sub-Groups discussed the various issues and came up with their reports which are included as a part of this report.

9. ISSUES IDENTIFIED

1. The Planning Commission envisages a growth rate of 9 per cent in GDP to which agriculture sector would be required to have a growth rate of 4.1 per cent in XIth Plan.

2. Investment in agriculture has suffered a decline towards the past two decades which has adversely affected irrigation and rural infrastructure development.

3. The adoption of new and improved technologies remained unsatisfactory in most of the regions due to weak linkage between research and extension; low seed replacement rate; soil degradation/fatigue due to improper and inadequate nutrient application; increasing abiotic and biotic stress; low level of farm mechanization; limited credit access; and insufficient market related infrastructure.

4. Biotechnology and genetic engineering in crops, animals, fishes, etc. are emerging new tools for improvement and management of crop and livestock productivity. The emerging technologies like biotechnology, nanotechnology, and information and communication technology needs to be given priority in future research.

5. The future agricultural strategy must be oriented towards agricultural diversification and post-harvest processing. New concepts of alternative agricultural production system i.e. multi-enterprise farming systems, organic farming, crop diversification, conservation agriculture, site-specific input management and precision agriculture should be addressed.

6. Water is a critical constraint to raise agricultural productivity. The water use efficiency is very low – around 25 to 40 per cent instead of the 65 per cent that should be attainable.

7. About 60 per cent of India's cultivable area will remain dependent on dry farming even after all irrigation potential is fully exploited. Productivity growth in these areas is essential for rural income growth and poverty alleviation. Emphasis on watershed productivity enhancement based on land capability farming and alternate land use including multiple farming systems involving SAUs, KVKs, and ICAR Institutes is required.

8. Efficient delivery of inputs required for increasing agricultural productivity is necessary. The quality of seed and planting material needs to be greatly improved. Seed replacement rate in most parts of the country are only one-third to one-half of what they should be.

9. Lack of knowledge of micronutrient deficiency in the soil is a serious problem. Efficiency of soil nutrients like NPK, also needs to be improved due to poor application of balanced nutrients.

10. The average farm size is going down and nearly 80 per cent of the farm families belongs to the marginal and small farmers category. Per capita availability of land is 0.28 ha. which demands input intensive highly productive precision farming system.

11. A greater R&D effort is required on aspects of snow melt harvesting, production of off – season vegetables and aromatic and medicinal plants, green-house production, pasture development, agro-forestry, livestock, agro-processing and value addition, etc. A center of CAZRI recommended in cold arid region.

12. Climate resource characterization for managing climatic variability and change, climatic risk and disaster management; weather-based agro-advisories; agro-meteorological instrumentation; and expansion of agromet and R&D Network.

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14. Agricultural research system should be more results oriented.

15. Deterioration of the extension services makes it difficult in transfer of new technologies.

16. Human resource development to meet the new challenges in agriculture research and management needs priority.

10. ISSUES TO BE ADDRESSED

1. Identify Projects / Programmes, which should continue and their approximate budgetary support.

2. Identify Projects / Programmes that needs to be dropped.

3. Identify Projects / Programmes that need to be merged with other Projects / Programmes.

4. Identify Projects / Programmes which should be taken up in view of the national need and international demands, particularly in view of WTO and galongwith their proposed plan budget.

5. How Public and Private Sector participation could be more interactive and complementary for meeting the needs of the country?

6. How agricultural research and education could address the problems of rural development?

11. PROPOSED PLAN REQUIRMENT (IN CRORES)

Crop Science	2760
Plant Protection Research and Education	360
Horticulture & Protected Cultivation	755
Natural Resource Management	1800
Climate Change, Risk and Disaster Management	170
Rainfed Agriculture	950
Mechanization, Post Harvest processing & Energy Management	300
Animal Science	3705
Fisheries and Aquaculture	300
Biotechnology, Genetic Engineering & Bio-Security	2050
Agricultural Education	4900
Agricultural Extension	2500
Agricultural Economics, Marketing and Agri-Business	922
Organization Finance & Management (For IPR Management)	200
Support to SAUs	10000
TOTAL	**31672**

12. REPORTS OF THE SUB-GROUPS

1. CROPS SCIENCE

Review of Xth Plan

Over the last four decades, India has developed one of the largest agricultural research systems in the world. Investments in agricultural research and extension accounted for nearly three-fourths of this growth in productivity. Much of this growth was the result of the new technology that was disseminated throughout India during the Green Revolution. During the Xth Plan, however, the idea that the returns to agricultural research may be declining has received some currency. Though this period experienced economic liberalization and budget constraints did exist in public sector agricultural research to an extent that still keeps the recurring question intact if the public investment in agricultural research was appropriate during the period.

The performance of the sector during the Plan is summarized as follows : Currently, about 70 percent of the area planted with rice, 90 percent of the area planted with wheat, and 50 percent of the area planted with coarse grains were sown with modern varieties. Many other crops have also been improved, including cash crops such as cotton. Productivity gains from improved rice continue to rise, but wheat gains have slowed.

Concerns are, however, being expressed if the production increases can keep pace with the demand of the continued population increases. The per capita rice-**wheat** growing areas have shrunk from 1200 m2 in 1961 to less than 700 m2 by 2000. Considering the fact that many of the current areas are double and even triple cropped, intensification is not a possible option for many areas. **Yield increase is the only remaining option to cope up with the growing demand**. In the XIth Plan it should be a multi layered approach integrating the genetic enhancement, resource management and crop protection tools for economic betterment of farmers.

Achievements and Gaps during the Xth Plan

- Developed, released and notified over 250 high-yielding varieties and hybrids of field crops for their commercial cultivation. Successfully developed improved varietal technology in various crops in the country for enhancing agricultural production/ productivity. Crop productivity increased in cotton, rice, sugarcane, sorghum, pearl millet.

- India has been able to maintain the second largest producer identity for wheat and rice despite unprecedented abiotic stresses and natural disasters during the period.

- About 84 genetic stocks of wheat and 20 of barley registered with NBPGR and the germplasm was shared with cooperators across the country through nurseries. The germplasm was enriched specially in rice-wheat system in Eastern India and warmer regions of Central and Peninsular India. The donors for thermal tolerance identified and physiological parameters viz., canopy temperature depression (CTD), cell membrane stability, stem reserve mobilization were validated. Product specific varieties were classified for chapati, bread, biscuit, pasta.

- In durum wheats, an export commodity of wheat from India, genetic stocks with high beta carotene (9.5 ppm), protein (13.5%) and 1000 kernel weight (60-65 g) were developed

- In hybrid wheat – initiatives through chemical hybridizing agents were undertaken. However, more economic approach of CMS based system was also put on the anvil during the period. In total, an infrastructure to produce over 10,000q of breeder seed has been created in coordinated programme.

- In barley, parameters for malting quality were identified and superior malt varieties of barley developed.

- Rice which is cultivated in diversified ecologies viz., irrigated (19.6 m.ha), rainfed lowland (16 m.ha.), rainfed upland (7 m.ha), deep water rice (6 m.ha.) etc., where yield levels fluctuated variedly. Thus, though significant increase in the averages from around 4.1 tons/ha under irrigated ecology of nearly 20 million hectare area was achieved during the X Plan, the same got lowered to 2.9 tons/ha on a national basis because of the fragile ecosystem. Under irrigated conditions, hybrids like PRH 10 achieved 9-10 tons/ha in farmers' fields within 110 days, and varieties like Pusa 44 achieve 10 tons in 145 days over the past several years in Punjab and Haryana.

- Improved varieties of sugarcane, rice, maize, sorghum, groundnut, mustard etc. through coordinated trials have helped the nation in an inclusive fashion to consider the ecological variations with respect to each crop. However, the productivity achieved in the field trials and that achieved at farms has not been the same in all these crops, the reason that led to shortage in achievement of the targeted production.

- Developed very promising single cross hybrids of maize as well as the QPM (quality protein maize) during the Xth Plan. This needs to be covered over all the zones with seed production targeted to reach the farmers.

- Headway in hybrid research in *Brassica juneca;* developed two cytoplsmic male sterility systems and introgressed a dominant fertility restorer gene.

- The period also saw the hybrid pegionpea development with the use of cytoplasmic male sterility and restoration system through related species.

- Developed/ deployed the concept of new plant type in various crops/ plants to upgrade genetic ceiling of yield potential.

- The improved, high yielding, resistant/ tolerant and short duration varieties/ hybrids in various crops have played catalytic role in crop insulation against biotic/abiotic stresses

- Opening up awareness for multiple cropping systems and in enhancing cropping intensity particularly of wheat, rice, maize, sorghum etc. was achieved to provide diversity and intensification.

- Transforming the mindset of farmers from conservative to technology-responsive one including the use of SRI (system of rice intensification) in rice in the southern part of India.

- The phenomenal increase from 0.8 million ha to 1.80 million ha this year (on the basis of this years seed produced and sold) of hybrid rice is an indicator of the potential of about 1-2 tons/ha additional yield in north India which was made possible through public-private partnership on hybrid seed production involving large groups of farmers in organized hybrid seed production.

- Developed experimental transgenic in cotton containing Bt genes Cry 1Ac, Cry 1Aa3 and Cry 1F and rice by incorporating genes Cry 1Ac and Cry 1Aa for insect resistance. The commercially available Bt transgenic hybrids of cotton have revolutionized cotton cultivation with unprecedented production levels over the Xth Plan period.

- In cotton, several intra- *G. hirsutum, G.arboreum* -hybrids and varieties were developed and deployed for cultivation. Hybrid seed production at commercial level competitively with the successful commercial private seed production system needs to be taken up. In hybrid cotton research, both CMS and genetic male sterility systems are being attempted for diversification with more than 400 CMS lines and 145 GMS lines. Triploid hybrids between *G. hirsutum X G. armourianum* have been made and are under experimentation.

- Developed/successfully deployed ready-to-use diagnostic kits to detect transgenic cotton plants from normal ones.

- India is now among the five leading soybean producing countries of the world.

- In the National Gene Bank, one of the World's leading *ex situ* germplasm storage facilities for the long-term for seed and other planting materials more than 2.5 lakh accessions belonging to over 180 crop species and their wild relatives including seed germplasm, other planting materials, plant tissue cultures, DNA and live perennial species in various ecologies have been conserved.

- Established a mechanism of registration and conservation of potentially valuable plant germplasm and registered 280 germplasm belonging to 54 plant species at NBPGR.

- Developed/ deployed technology for DNA fingerprinting in 23 major crops and fingerprinted ~1800 released varieties and elite landraces of crops.

- Steady increase in breeder seed production resulting in enhanced supply of quality seeds to the farmers. About 30,000 q. of breeder seed being produced annually and supplied for the production of foundation seed and in turn certified seed.

- Refined/ deployed seed production technologies for various crops, particularly with reference to hybrid seed production.

- Developed/ released/ deployed practices and guidelines for crop breeding and varietal selection, strongly inter-related with regulations and procedures governing identification, verification and release.

- Established mechanism of IPR protection in the ICAR system - Patenting; logistics/ DUS testing support for the operationalization of *sui generis* Act on protection of plant varieties and farmers' rights.

- Laid emphasis, in Mission and Institutional Modes, on the use of improved specific/ integrated technologies to enhance the Household Food and Nutritional Security. Several improved varieties of nutritious minor millets, pseudocereals and pulses were promoted. The micronutrients mission focused priorities of research on pulses, oilseeds and maize to ameliorate protein energy malnutrition such as adaptability evaluation of Quality Protein Maize (QPM). Several hybrids well suited to harsh environments, particularly arid zone, in crops like seed pearl millet (*bajra*) were released. Transgenic research with value added traits was encouraged to develop indigenous transgenic plants as a material for future.

Gaps identified :

During the Xth Plan, the performance of crops growth rate average of 1.1% did not match with the nearly 1.5% growth rate in Agricultural GDP which indicated there was immediate scope and need for increased growth rate attainment in the crops sector. While the crops were most important commodity of the agricultural production scenario, the slower rate of growth indicated a need for higher emphasis on achieving the potential growth in the crops. Wheat has suffered the most in terms of factor productivity considering the huge area and the number of farmers associated. The first limiting factor is the non-availability of any replacement to the currently grown variety PBW 343 in more than 6 million hectares which has become susceptible to diseases and has its productivity and quality reduced. A focused activity in this area was possibly found wanting in the research on crop improvement in the NARS. If the proposed growth rate of 4% in total agriculture was to be achieved during the next Plan, what is required is to facilitate pro-active proposals to make crops sector reach excess of 2.5% growth rate. It was recognized that increased cost of cultivation caused by increased input cost was the major reason confounded by lowering trends in the returns caused by reducing productivity. The factor productivity was the key that had not increased aided by poor resource management on seed, soil & water and extension of production technologies. The Xth Plan priorities generally stressed on enhancing productivity in cereals, pulses and oilseeds but did not have categorical distribution of resource by quantifying or targeting the growth expected. An example would be the success in rice achieved in China where 25% of the budgetary allocation is directed towards rice alone having declared rice as the major staple food source.

Major gaps existed in seed production crop-wise, manpower/infrastructure in key areas of extension, resource management, basic research in genetics/physiology of crops. The total food production has been hovering around 200 million tons during the Plan mostly because the target in most areas have not been achieved basically because the growth range required to meet such targets were about 1.8% in cereals and 3.5% in pulses and oilseeds. The factor productivity had to be made stable which did not happen due to poor implementation at farmers levels the improved technologies. The major gap that centers around the genetic improvement realization in the form of increased productivity is the largely neglected priority to "seed replacement" by farmers. The approximate figures are about 8-10% in varieties and about 40% in hybrids. These gaps alone if covered are likely to make productivity improvement in all ecologies record major gains. An example is the nearly 80% seed replacement in cotton in the last two years (due to the Bt cotton) which saw the cotton production go to a high of unprecedented growth and volume which normally should have been achieved during 2030s.

Strategies for the XIth Plan

IIA. General recommendations for crops *(An outlay across crops of about Rs 3610 crores}*

a. Establishment of three institutions such as

i. Institute for crop genetics, genomics and physiology

ii. Centers in different crops research foci such as Hyderabad, Bangalore, Nagpur, Cuttack or Patna under one National Phytotron Facilities and

iii. National Biosafety Testing and Research Institution

b. **Strengthening the existing institutions in upgrading the infrastructure to changing technology acquisitions in the agricultural sciences. A priority has to be placed on immediate infrastructure upgradation and renovation with new structures in aging institution IARI, New Delhi.**

c. The important general areas across crops that need to be addressed during the XI Plan taking into account the reasons for being able to achieve the targeted production by some regions, for being able to achieve 50% of the target by some regions and complete lack of any achievements by some regions of the country, are the following :

i. **Target seed production** as a major responsibility of stake holders such as States seed production agencies, SFCI somewhat on the lines of immunization campaign to see seed replacement is not seen by poor farmers as an unnecessary investment but as a major source of gainful profit achievement even if other resources were constrained. The seed replacement in varieties should reach 40% and in hybrids touch 80% which will not only make demands on seed producing agencies but will also largely induce private entrepreneurs to invest in seed production. An orientation of public sector research in "**hybrid development with commercial viability**" has to be reintroduced on a mission mode at least in crops like Pigeonpea, soybean, wheat and mustard on priority. A grant of Rs 50 crores need to be placed for targeted seed production technology development and application.

ii. **Benchmark soil fertility-nutrient, water status** in different production systems to optimized levels and employ location specific technologies to reach the optimum levels so that targeted soil health and water levels are achieved to enable cropping system research such as wheat-rice-pulses combinations to make best use of the situation (Rs 20 crores). Although this is not direct cropscience based research, the area is important to bring under-utilized and unutilized areas under cultivation to economically viable ends.

iii. **The genetic potential** of each crop in the agriecological zone has to be not only enhanced through quantitative improvement but the varieties need to be packaged with value addition to enable processing and profitability through minimized resource utilization. For this purpose, a programme for QTL identification for each of the value traits in combination with yield need to be launched under one umbrella of a programme, QTL identification for yield and value addition in crops at an estimated expenditure of Rs 50 crores in major crops like wheat, rice, maize, pearl millet, sorghum, mustard, pigeonpea, soybean.

iv. **An investment in the human resource development** is crucial so that a balance between basic/strategic and applied research is maintained in such a way that sufficient number of researchers are engaged in basic research to provide a high quality scientific information base for its conversion to knowledge and internationally acceptable strategy aimed to increase profitability of crop commodity through enhanced crop production and productivity (An increase in basic science manpower by 20% to existing level in all institutions is proposed)..

v. **Improved infrastructure** to cope up with the booming new technologies developed was a need which cannot be achieved with the current levels of about 0.8% in science and research, about 2/3rd of which is spent on defence research and space. Agriculture has to be prioritized at the same level and the investment in agricultural research be raised commensurately to facilitate the development of strategic research. Institutes like IARI need to be provided with at least Rs 100 crores for major over haul and all institutions including IARI which were formed before 1965 need to be provided an additional grant of Rs 10 crores/every 10,000 m^2 covered building area an year for maintenance.

vi. **Networking with links** among physiology, biochemistry and stress management in crop improvement projects is the need of the hour to regain the advantages harnessed during green revolution to achieve an all-round gain in crop production. As an exception, for networking projects involving cross-cutting disciplines linking basic sciences with crop improvement need to be started as special programmes to induce "high quality strategic research". A dedicated grant of Rs 50 crores should be allocated for this programme alone.

vii. **A major programme for rainfed/limited irrigation suited crop variety development** is the need of the hour to provide new technologies to nearly 55% of cropped area. In the rainfed crop production system, the most crippling factor in achieving crop growth rate required, there is a need to get to the root of the problem of yield limiting factors. These need to be identified crop-location-wise and addressed genetically for physiological enhancement of the crop such that the stress related loss in production and quality ware minimized. An integrated approach to mix limited irrigation with rainfed situation is the better option rather than unpredictability associated with rainfed nature alone. A sum of Rs 200 crores has to be dedicated to pool scientific breeding projects integrating this fragile ecosystem to categorically develop varieties with specific crop stage identities that respond best for critical irrigation with quantified irrigation requirement.

viii. Time has come to convert the production into products with marketability. This could be achieved by instituting "product development" as one of the post-genetic improvement activities before the variety itself is released for cultivation. This means investing exclusively to breed varieties with industry orientation for specific products with maximized critical component amenable to processing for extraction. This would be high grade designer approach which may be allocated a sum of Rs 50 crores for exploratory and targeted product improvement potential.

ix. In all crop institutions, a priority should be placed on maintenance breeding and prebreeding so that no time is lost in developing the basic genetic stocks labeled with specific production features, quality traits, disease/pest resistance status and characterized yield potential. This is very important in the XI Plan in view of the restricted germplasm exchange from CGIAR or other such Institutes. An exclusive investment for developing storage facilities and protected maintenance field facilities like chain-fencing or nethouses need to be provided (Rs 30 crores in all major crop Directorates and National Institutions).

x. **There was a need to prioritize on the 69 of 140 backward districts in different states like Uttar Pradesh, Zharkhand, Bihar, Madhya Pradesh and Chattisgarh by "desegregation of agricultural production zones" analysis**. The production limiting factors in these areas have to be identified the concerned KVKs in the zone need to be strengthened on immediate prioritization such that they become sourcing centers for knowledge-based crop production, product development and marketable options base. This will also mean employment generation avenues within locations.

xi. A major incentive proposed/recommended is to induce state governments invest in SAUs. **It is proposed that apart from the estabishment expenses which is shared by the ICAR with State Govts., a working contingency for crop research of "X" amount be funded by the state**

government on an annual plan layout basis which will be matched by the ICAR as supportive grant. This is a key to make the SAUs to budget their research activities and inventively source their research.

xii. **It was appropriate to distribute the budgetary allocation on the basis of crop commodity/priority (like rice in China) so that the grants flow into intensified crop improvement research as per need rather than on an equitable basis across crops.** If the Plan visualized oilseed productivity has to be increased, attempts need to be made to allocate and utilize maximized allocation of grants in that area. This needs to be facilitated by reprioritizing research projects in SAUs, national institutions and crop-based institutes of ICAR.

xiii. A focus identified in the rice-wheat belt under irrigation production system was to optimize water use in rice to reduce water consumption by 60-70% by rice intensification techniques and by breeding varieties with high water use efficiency and tolerance to water deficit under irrigation system. The vulnerability and precautionary wastage of huge amount of water can be reduced for the water to be available for timely planting of wheat if varieties are bred to be capable of germinating with slightly deeper planting in lands with minimal moisture. This will be rewarding in drylands also where most pulses and oilseeds are targeted. The genetic component responsible for hypocotyls development and the seed survival, germination emergence under packing need to be identified and explored to help crops like cotton, groundnut etc. (Rs 10 crores)

xiv. **Develop a crop-potential map district-wise to focus research on crop improvement and production management within the potential region for each crop. This will possibly get the best agricultural production of a given geographical region. This may be taken on priority by investing Rs 50 crores on a national basis involving geneticists, physiologists and crop-modelers..**

xv. **In view of a slack in basic genetics & plant breeding research, understanding of crop yield limiting factors in view of changing global Abiotic and biotic stresses, there was an urgent need to establish a National Institute on Crop Genetics, Genomics and Physiology with the sole aim of working out the genetic bases behind all yield limiting factors and genetic means to making breeding methodologies precise, focused and target oriented**.

xvi. **Establishment of facilities like National Phytotron Facility in at least four other places to facilitate increased number of indigenous transgenic events, gene isolation, construct development and event testing is a necessity if we want to take full advantage of the science of plant biotechnology and trained manpower in India. (Rs 50 crores for establishment with Rs 2 crores for annual maintenance is proposed).**

xvii. Focused research on hill ecosystem to concentrate on low temperature tolerant and rainfed crops of rice, wheat, millets and temperate pulses. Under hill ecosystems, biofertilizer, zero-tillage and organic nutrients based crop improvement research has to be initiated as a priority since the region is compatible with such activities having small sized tillable fields. **The total investment estimated is Rs 300 crores including conservation & utilization of biodiversity, biofertilzer**

research from rich organic hill ecologies, IPM technologies and human resource dedicated for difficult hill ecologies.

xviii. **Establishment of a National Biosafety Testing and Research Institute with six or seven regional isolated field testing facilities in the different agroecological regions is an absolute necessity if India intends to convert the transgenic development research to product development levels with commercialization prospects to quickly and safely reach the farmers. This is a biggest limiting factor that has been making public sector and Indian industries not compete with the multinational agencies. The MNCs network internationally to generate data on their transgenic events on toxicological and allergenicity aspects with sufficient information on environmental biosafety before testing or introducing these technologies in India. An expected investment for this purpose would be about Rs 400 crores for infrastructure and equipment.**

II B. Crop-wise recommendations

a. Rice (An outlay of Rs 200 crores)

i. Hybrid rice development, seed production and distribution as a major national goal. This will mean identification of new male sterility and restoration systems as the current CMS lines are not favoured by the southern and eastern part of the country. The aim is to bring down the profitable cost of hybrid seed production from the current levels of about Rs 175 to less than Rs 80 per kilogram. This will ensure larger quantum replacement by farmers and make up for profits through larger volumes to seed producers.

ii. New plant type for better productive tillers having high grain number like the "super hybrids" with sturdiness to support the crop under adversities including untimely floods and rains.

iii. Stress resistance breeding through markers assisted selection to incorporate genes with known ability and transgenic rice improvement for nutrient enhancement and insect resistance

iv. Quality improvement of rice for different targets such as export, products and purposes (medicinal like nivara)

v. Basic research at the CRRI to be strengthened with emphasis on diversification of sources of male sterility/restoration system, genetic manipulation for rainfed+upland rice productivity improvement since about 23 million ha land is currently grown under this production system with not more than 2 tons/ha average production.

vi. Have a mission mode research group with a single objective of "bran oil" yield-enhanced rice and alternate uses of industrial value

b. Wheat (An outlay of Rs 150 crores plus Rs 260 crores for an upgraded central wheat institute)

i. Breaking yield barriers in wheat through hybrids (CMS based) should be priority of highest order and it is recommended that a focused program on a mission mode should be attempted with open ended goal of either identifying new sources of CMS and restoration, or particular cytoplasmic source with high restoration to gainfully exploit even 25% heterosis.

ii. On priority develop a replacement for all major area covering varieties especially the variety PBW 343 in the north western plains zone. Value addition to PBW 343 may be taken up on a target mode by some institutions with capability to take up the job like IARI, PAU and DWR to overcome the risks of disease epidemic proportions by large area under the variety and improved grain and nutritive quality in the variety.

iii. Broadening genetic base through revival of winter X spring hybridization, synthetics, buite & Chinese germplasm should be taken up with cytogenetic and cytological interventions to make best progress in prebreeding activity.

iv. Biotechnological intervention by gene pyramiding through markers, transgenics. Integrate rice-genome information for functional genomics and trait based genetic modification

v. Developing product specific varieties for protein quality, grain hardness, protein content, biofortification

vi. Upgrade Directorate of Wheat Research to an institute level like Central Wheat Research Institute for full-fledged basic/strategic and applied research on wheat

c. Maize (An outlay of 80-120 crores)

- Revitalize the single-cross hybrid development
- Full-season hybrid with inbreds specifically developed for multiple disease resistance
- Develop mission mode projects for baby corn, sweet corn and pop corn
- Research on metazenia technology for increased oil
- Quality protein maize research, specialty maize and oil based corn
- Reorientation of maize with multi-enterprise based agriculture to broaden the production base of different ecosystems, supported by market intelligence.
- An exclusive project on developing India-specific “heterotic gene pools” to explore higher heterosis with single cross hybrids for normal, QPM, baby corn and sweet corn.

d. Oilseeds (An outlay of 300 crores)

i. Intensified hybrid development for safflower and diversify CMS / restoration systems so that larger areas can be grown to safflower with profitability and healthy oil popularization theme since safflower is suitable to India.

ii. Castor success in Gujarat needs to be duplicated in other areas and focused breeding for value addition by improvement of quality and stability to changes in temperature.

iii. The protein-rich byproduct from soybean needs to be targeted as a main product which can be done by breeding soybean for quality improvement.

iv. In soybean, the initial reports of successful hybrid development by China needs to be immediately taken to cognizance and kept pace with. A focused exploratory programme has to be launched for hybrid soybean development taking both heterosis documentation and hybrid seed production technology in this wonder pulse/oilseed crop.

v. Renewed effort to make use of increased production of cotton seed, rice-bran and corn to produce edible oil from each of these.

vi. Groundnut breeding to focus on resistance to viruses and low aflatoxin content

vii. In oilseed mustard, preliminary successes achieved in hybrids through CMS and biotechnology routes need to be strengthened by dedicating at least three to four research networks on *B. juncea* and *B. rapa.*

viii. Successes in quality oil (single zero) need to be multiplied with intensified research for double zero and hybrid double zero in Indian mustard.

ix. Losses due to Alternaria, rusts and aphids in mustard has not be tackled on a mission mode so much so that even proper information on the pathogen/pest strains or biotypes is not available in the country. This is a priority and has to be taken as foremost researchable focus.

e. Pulses (An outlay of 180 crores)

i. Breeding for drought tolerant pulses is the most important activity that needs to be focused during the XI Plan by harnessing the modern biotechnological tools (transgenic and non-transgenic) integrated with genetic improvement since 87% of pulses are grown under rainfed conditions

ii. Crop intensification with short duration varieties where these can find a place also in irrigation-available situations (example : Chickpea in Andhra with 100 days maturity with few irrigations yields upto 1100 Kg/ha compared to 150 days maturing chickpea in Punjab with not more than 900 Kg/ha).

iii. Lentil as a major pulse crop needs to be bred as specifically suitable to NEPZ since it is well suited to the area

iv. Short duration pegionpea with increased yield for northern zone is very important in wheat growing areas.

v. Biotechnology against pod borers in chickpea and arhar should become priority pooled with wilt resistance as these are the two most limiting biotic factors in the two crops

vi. Hybrid pigeonpea development with new CMS / Restorer system is a potential area and has to be given a special consideration during the plan with basic research inputs.

f. Cotton and cash crops (An outlay of Rs 250 crores)

i. Success in cotton hybrids and BT cotton needs to be given a higher pedestal looking at the commercial prospects by intensifying public domain research for transgenic development

ii. Novel genes for enhanced productivity, quality as fibre and seedoil, nutritive value of oil cake and oil

iii. Most of the indigenous materials are yet not fingerprinted and in view of the economic outputs involved which therefore need to be fingerprinted.

iv. Farmer usable diagnostics for evaluation before marketing of the produce and detection of spurious seed etc such as BT cotton are to be emphasized

v. In cotton, research on desi species of G. arboreum and G. herbaceum for heterosis exploitation in the interspecific F1s is of immense potential because of better yield and adaptability potential.

vi. Transgenic diploids is another important area in cotton which will be India-specific and needs to be initiated with location specific varieties for insect resistance and drought tolerance.

vii. In sugar crop, a new emphasis has to be placed in intensified research with sugar beet which has far great commercial, ecological and economical advantage over sugarcane. The sugarbeet with higher sugar content than sugarcane has no more than 3-4 months of growth compared to 12-18 months of sugarcane. Nor there is the requirement of resources like water as demanded in the case of sugarcane. An industry-linked product development oriented research has to be focused during the Plan to see how best can this be taken up to better the quality of life of sugarcane farmers who are bound to investment for prolonged periods of agriculture without gainful activity during the 12 month growth of the crop and under severe pressure of marketing their cane in a very short period after harvest with no power on controlling the economics of the product.

ix. A large support on use of coarse fibre crops like jute, flax and coconut has to be placed to research for their quality improvement for diversification of their products base and strengthening the fibre quality. An industry linkage potential has to be attempted by quality diversification at genetic enhancement levels in these crops.

Summary Budget Estimate for the Crop Science Research XI Plan

S. No.	Particulars	Estimated budget (Crore Rs)	Remarks
1	Targeted seed production research with commercial viability	150.00	
2	Development of targeted cropsystem suitable varieties in fragile ecosystems below benchmark of optimum nutrient and water status	20.00	
3	Genetic potential enhancement programmes through QTL identification	50.00	Wheat,rice, maize, bajra sorghum, pigeonpea, mustard, chickpea, soybean
4	HRD for basic and strategic research	20.00	
5	Improved infrastructure in aging institutions like IARI	200.00	Institutions prior to 1965
6	Network research for High quality strategic research	50.00	
7	Crop improvement for rainfed + limited irrigation system	200.00	
8	Designer crop development for product oriented varieties	50.00	
9	Maintenance breeding programmes	30.00	All crop directorates
10	Crop breeding for fragile low productivity eco-systems	200.00	In 69 of the 140 backward districts in UP, Rajasthan, Zharkhand, M.PChattisgarh, Bihar
11	Development of crop-potential map of India	10.00	
12	Establishment of Crop Genetics, Genomics and Physiology Research Institute	400.00	

13	Establishment of National Phytotron Systems in 4 regions	70.00	Northeast, South, West and Central Zone
14	Establishment of National Biosafety Research and Testing Institute	400.00	
15.	Crop Improvement in fragile but high resource based hill ecosystems	300.00	
16	Rice improvement	200.00	
17	Wheat improvement	410.00	(inclusive of Rs 250 to upgrade DWR to Central Wheat Res. Instt.
18	Maize improvement	120.00	
19	Oilseeds improvement	300.00	
20	Pulses improvement	180.00	
21	Cotton and other cash crops	250.00	
	TOTAL	**3610.00**	

2. PLANT PROTECTION RESEARCH AND EDUCATION

Existing issues in biotic stresses of crop plants, when analysed, provide a satisfactory solution to major problems in very few cropping systems as well as groups of pests. By pests, we define all the organisms such as insects, pathogens, nematodes and weeds in addition to vertebrate pests in different agro-climatic regions of the country. Indian plant protection strategies have been hand-in-glove with the farm production strategies that the government pursued over the last few five year plan periods. These have apparently evolved over time in accordance with the contextual challenges and demands. Upheavals in crop health management have been the order of the day in the late eighties and nineties of the last century. The Xth five year plan period witnessed intensification of crop production for apparent reasons shared the threats and risks of crop loss due to intense herbivory and consequent heart-burn of severe crop loss to farmers. The quest for enhanced production using high yielding varieties that were with dubious tolerance to various biotic stresses led to the increased indulgence of agro-chemical use in irrigated system as well as in assured rainfall areas of the country. The escalation in cost of protection resulted in non-profitability under swinging market prices of the commodities. Misadventures as well as overzealous approaches of chemical pest management led to strong ecological lessons that revived the biological balancing in agro-ecosystems. The frustration of crop failure coupled with poor farm-gate profitability to Indian farmers paved the way for enormous economic burden in villages.

Emerging scenario of biotic stresses also is not so heartening since the impact of climate changes, new cropping patterns and practices as well as intensification of horticultural cropping in uplands and midlands has a predictable upheaval towards development of suitable environment towards build up of newer pest complexes. There is demand for more agricultural commodity production for both domestic consumption and for sustaining enhanced trade demands in the globalised scenario of world trade order (WTO). Challenging herbivory of nature has been the major effort of plant protection in agriculture and allied sectors.

The XIth five year plan period should witness higher growth in agriculture for which the various measures that are contemplated to integrate and co-ordinate the good developments of the past in this area are examined by this Sub-group. A thorough analysis as well as discussion with all stakeholders including private industry associates in crop protection endeavour made the directions and suggestions to be developed succinctly. This report could be a land-mark document to steer various measures of the government to, pro-actively, face challenges that are expected to arise under the ongoing changes in global climate, trade and economic power struggles. Asynchrony that has set in between the Indian population growth rate and the growth rate of productivity of food grains and other commodities could be corrected in the XIth five year plan period, if only biotic stress management is directed towards attaining 4% growth rate in agriculture.

Securing health of crops and damage of commodities from pestilence shall be addressed with extremely careful planning. Effective measures to prevent excess herbivory that bring about excessive crop loss, both on-farm and in storage are the themes of research in plant protection.

These have been pursued contextually over the previous five plan periods in order to harvest logically cleaner and safer commodities in sufficient quantities to meet the growing demand from our population. The role of plant protection efforts in sustaining high growth in agricultural productivity have been highly appreciated and recorded. Investment in various plan periods to enhance suitable infrastructure for research and training plant protection aspects has been justifiable.

This Sub-committee, constituted as part of the Working Group on Agricultural Research and Education of the Planning Commission (*Annexure I*) examined materials provided by Indian Council of Agricultural Research (ICAR) institutes, State Agricultural Universities, private pesticide industry as well as the Concept Note from the Member Secretary of this ICAR Subgroup to finalise this report.

INTRODUCTION

The challenges for plant protection research and education are, therefore, to be viewed in the context of the demand for the demand for increased agricultural growth in the XIth five year plan period. Consumers' demand for cleaner and poison-free food and commodities for daily life is growing. India produces crops / commodities worth US $ 38677 million. Out of these, about 13% is lost in crop fields and in storage, worth approximately Rs. 231,193 million (US $ 4919 million) (Agricultural Information Sciences, UK, 2006). The pressure on the plant protection researchers to address these is quite intense. The directions in which mitigation measures are pursued by all the stakeholders decide the actual saving of commodities from pestilence. The awareness, sensitization as well as implementation of all protection strategies holistically with the co-ordination and networked efforts of all the concerned research and development organizations at the production level could save all commodities from avoidable destruction and crop loss. The costly crop production process gets wasted when effective strategies to protect the fruits of such labour of farmers are left unattended. Securing the safety and quality of agricultural commodities for consumption by the nation to ensure the energy and nutritional requirements of its people is to be considered paramount attention in planning and execution. Progress in trade and economic developments of the country are guided by the available surpluses of various commodities in our agrarian society. While there is intense struggle to achieve higher production of all farm products to satiate the growing population needs in the country over the last few five year plan periods, the emphasis for securing these from herbivory and pestilence in storage and handling needs to snatch immediate attention during the XIth five year plan period. This could reduce the government's struggle to ensure adequate availability of energy and nutrition to its masses.

Rural development has been given significance by the government to achieve overall hike in gross domestic product of the country and contain inflationary tendency. The rural development that is expected to contribute to overall national GDP during the eleventh five year plan depends on farmstead productivity of crops, animal products as well as entrepreneurship. Ensuring crop and animal health can contribute to attaining better rural growth. As a major component of crop production system, crop health management is considered by this Sub-group for clear attention of the planners and policy makers. An introspective analysis of the current research and development programmes in DARE-ICAR set up as well as their implementation by the Department of Agriculture and Co-operation (DAC) show that the gap between planning and execution of available know-how and skills for effective management of all biotic stresses in agriculture lie in grass-root level timely reconnaissance and comprehension of the arising problem, effective mobilization and implementation of the mitigation measures by all concerned agencies as a team. Many attempts, in the past, through imaginative approaches to enlarge farmers' skills to successfully reduce biotic stress issues in crops, such as through 'lab to land', 'training and visit system,' 'frontline demonstrations' etc., or even through many sponsored operational research projects (ORPs) ended only as government sponsored programmes and not as a farmer-driven approach in most of the states. Currently, a number of private agencies as well as self-help groups and non-governmental organizations have come into this fray and provide yeomen service to farming community in different parts of the country, especially in the supply chain management of high-value and processed commodities. Contract farming and participatory production systems have been set into an evolutionary path, over the Xth plan period to address some of these inadequacies.

The Plant Protection Division of Department of Agriculture and Cooperation has envisaged as well as implemented suitable enabling procedures of pest risk analyses, post entry quarantine as per Schedule V and XI of Plant Quarantine Order, 2003 and monitoring of agro-chemical residues in commodities. These pre-emptive measures are directed towards enhanced export-oriented trade opportunities so as to make the farmers' income to grow. The cost of plant protection in the overall crop production costs is to be appreciated and every step to reduce and contain it to the minimum through effective and rational plant-health management strategies and protocols shall enhance scope for harvesting commodities competitive farm gate costs. The country shall have to rely in a big way on the major chunk of agricultural land in assured rainfall areas and dry lands for the spiked production of coarse cereals, cotton, pulses, oilseeds, commercial crops and horticultural crops etc. that should form the hub of economic boom in Indian agriculture. The irrigated land mass of the eastern states of the country shall have to be converted into food bowl of the country in the wake of various non-sustainable issues that have cropped up in the conventional north western states in recent times. While a balancing amelioration of agro-ecosystem in intensively cropped area is to be followed, exploitation of the nascent, protected area is to be followed. This throws different challenges upon Plant Protection research and education to crop health management in these two diabolic fronts.

The Sub Group on Plant Protection as part of the Planning Commission's Working Group for Agriculture, was constituted by the Indian Council of Agricultural Research with the following Terms of reference (*Annexure I*).

(i) To make critical review of Xth Plan achievements in terms of Crop Protection research, in contrast to the objectives and targets set during Xth Plan.

(ii) To identify critical gaps in scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as enable the nation to enhance its agricultural competitiveness in the context of WTO & IPR regime.

(iii) To draw/suggest specific schemes/ programmes pertaining to crop protection research to address the problems of less privileged regions.
(iv) To critically examine the on-going programmes specific to farm women, small, marginal, and tribal farmers and outline the R&D priorities.
(v) To identify institutional mechanism for strengthening, monitoring and evaluation system in plant protection research, and to suggest efficient measures for effective coordination of agricultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public-private partnership.
(vi) To draw/suggest specific schemes/programmes/research area pertains to crop protection research and frontline transfer of technology including linkages with developmental departments.

The Sub-group met on 28 August and 7 15 & 16 September in order to deliberate and finalise its report. Further, the Working Group on Agricultural Research and Education for the XIth five year plan in its meeting on 30th October 2006, six inclusive guideline points were developed. This report encompasses these guideline points. Strategic fund-based research in few critical areas such as pheromone research, indigenous synthetic process of botanical pesticides, development of microbial strains and their formulations against insects, microbial phyto-pathogens and nematodes.

REPORT

The committee considered the significant achievements in plant protection research under various schemes of the ICAR during the Xth plan period (Annexure II). It looked into the extensive information that has been generated through the high quality research in various institutes and AICRPs / AINPs as well as in the crop protection divisions of crop institutes and National Research Centres.

XIth plan requirements of crop health management are:

1. The anticipated enhancement in crop production and intensity as well as a strong accent on horticulture development through the National Horticultural Mission has been in place in all potential states. This could alter the agro-ecological situation, resulting in new challenges of pestilence, particularly, for diseases and nematode infection. Perennial ecosystems need careful rhizosphere management that may have to be specially engineered for long-term, sustained crop production.

2. The enhancement of production of required quantity of cereals, oilseeds and pulses in addition to fibres necessitates varieties and crop cultivars that offer moderate resistance to various pests (insects, diseases and nematodes) that form major biotic stress factors deterring optimal harvest. Recent upsurge of Brown plant hopper in east coast and Tamil Nadu due to suspected resistance against neo-nicotinoid pesticide molecules. Increased pestilence due to

soil-dwelling insects and pathogens are anticipated in the wake of extension of agriculture into fringing forest area.

3. Enhanced nematode damage in unconventional crops such as pomegranate, citrus and many other vegetable crops has thrown up challenges demanding holistic approach for rhizosphere management.

4. The thrust that is to provide in the next plan period shall be for reduced cost of cultivation. In order to achieve that, maintaining pestilence at low key as well as designing new holistic strategies that could reduce extra-expenditure to farmers have to be designed.

5. The change in climate and weather patterns that is currently experienced has to be viewed as pre-cursors of alterations in the pattern and intensity of biotic stresses in agriculture. Intelligent and strategic approaches of research are now warranted in order to mitigate impending pestilence in mono-cropped, intensively cultivated crops. The existing infrastructure of research and education for plant protection research and education have to be restructured, strengthened, augmented or even amalgamated to achieve desired goals of deriving appropriate outcome.

With this background, the following terms of references were deliberated upon by this Sub-group.

TR: 1 – To make critical review of Xth five year plan achievements in terms of Crop Protection research, in contrast to the objectives and targets set

The major achievements during the Xth five year plan period are given below:

1. The introduction of genetically modified cotton cultivation reduced the incidence of *Helicoverpa armigera* all the three zones and crop loss due to this pest is minimised. However, pet problems such as Mirid bugs on flowers, Grey mildew disease, cotton leaf curl disease etc. have accentuated in cotton crop.
2. The favourable climatic conditions as well as intelligent deployment of tolerant genotypes and deployment of suitable integrated management tactics reduced large-scale pestilence such as that of Sugarcane Woolly Aphids, Brown plant hopper, tissue borers in rice, maize, sorghum and vegetables.
3. There has been tremendous impact of integrated pest management and good agricultural practices to reduce pestilence in rice, wheat, paddy, maize, sorghum, vegetables such as tomato, okra, brinjal, chillies etc. A number of major diseases causing wilts, blights and rots in most crops could be managed using biological options (antagonists and PGPR organisms), phyto-sanitation and tolerant cultivars in target crops.
4. The bio-control of insects and disease-causing organisms has been popularized by massproduction of relevant formulations of organisms (microbial bio-pesticides, antagonists, and plant growth promoting organisms) to the farmers.

5. There have been consistent efforts to reduce the cost of protection by infusing judiciousness as well as timing of the synthetic chemicals or bio-pesticides and other pest management options. Reduction in pesticide residues in food, feed and fodder could be possible.
6. Enhanced research on honeybees enabled development of suitable techniques and skill for successful commercial apiculture for achieving better crop productivity through migratory beekeeping along with harnessing various bee products to the country. The concept of crop productivity enhancement through commercial bee keeping was promoted in rapeseed-mustard, apple, litchi and vegetable crops. Technologies to utilise beneficial insects such as lac insects, silkworm etc. were extensively multiplied in homestead situations to enable rural population to earn ancillary income.
7. The major plant parasitic nematodes that have been identified to inflict damage in various crops across the country are root-knot nematodes infecting cereals, vegetables, pulses, oilseeds, fibre, fruit and plantation crops; Cysts nematodes (*Heterodera* Spp.) in wheat, maize, pigeonpea, cowpea, potato, guar etc.; Wheat seed gall nematode in wheat and barley; rice root nematode in rice; citrus nematode in citrus growing areas of the country; lesion nematode in vegetables, pulses, oilseeds, fruit and plantation crops; Reniform nematodes in vegetables, oilseeds, cotton, pulses and fruit crops; lance nematode, stunt nematode and spiral nematode in sugarcane, sorghum, vegetables, oilseeds and fruit crops. Hot spots of root-knot nematode, *Meloidogyne graminicola* in rice growing areas of Karnataka, Orissa, Assam, West Bengal, Kerala and Haryana; for white tip nematode, *Aphelenchoides besseyi* in Madhya Pradesh and Tamil Nadu; for *Anguina tritici* in Madhya Pradesh, Bihar and Rajasthan; for pigeonpea cyst nematode, *Heterodera cajani* in Gujarat, Tamil Nadu and Maharashtra; for lesion nematode, *Pratylenchus thornei* on chickpea in Rajasthan and U.P. and for root-knot nematode infecting citrus in Gujarat and pomegranate in Maharashtra were identified. Cropping systems and soil fertility are the two most important factors influencing the community structure in population dynamics of plant parasitic nematodes as well as other soil inhabiting nematodes. Under different eco-systems and cropping systems, the application of a part of nitrogen dose to the extent of 25-50% in *kharif* season through organic sources as crop residues, farm yard manure, green manure and blue green algae reduced the rate of growth of plant parasitic nematodes population and increased the populations of beneficial and saprozoic nematodes. Low cost, eco-friendly and practically feasible integrated nematode management technologies have been developed and demonstrated against economically important nematode populations at farmers' field due to the efforts of the All India Coordinated Research Project on Plant Parasitic Nematodes.
8. The various diagnostic techniques and suitable kits for major bacterial diseases such as bacterial wilt in cotton have been developed. Similar kits for diagnosis of viral diseases in potato and many crops have been developed. There is good outcome due to serological field diagnostics for providing virus free nucleus planting materials for further multiplication.
9. More than 15,000 germplasm accessions / varieties in rice, pulses, vegetables, cotton, groundnut, jute, citrus and grapevine etc. have been screened for recording resistance / tolerance against key nematode pests, enabling to identify and confirm a few sources of resistance against key pests in different crops.

CROP VARIETIES IDENTIFIED/DEVELOPED RESISTANT TO PLANT PARASITIC NEMATODES

CROP	NEMATODE	RESISTANT VARIETIES
Tomato	Root-knot nematodes (*Meloidogyne javanica/M. incognita)*	PNR-7, NT-3, NT-12, Hisar Lalit
Chilli	Root-knot nematodes (*Meloidogyne javanica/M. incognita)*	NP-46A, Pusa Jwala, Mohini
Cowpea	Root-knot nematodes (*Meloidogyne javanica/M. incognita)*	GAU-1
Mungbean	Root-knot nematodes (*Meloidogyne javanica/M. incognita)*	ML-30 and ML-62
Cotton	*Meloidogyne incognita*	Bikaneri narma, Sharda, Paymaster
Grapevine	Root-knot nematodes (*Meloidogyne javanica/M. incognita)*	Khalili, Kishmish Beli, Banquabad, Cardinal, Early Muscat, Loose Perlett
Potato	Potato cyst nematode (*Globodera rostochiensis & G. pallida*)	*Kufri Swarna*

The ICAR launched Network Project on Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS) with five themes: i) microbial diversity and identification, ii) Nutrient management, PGPR and bio-control, iii) Agro-waste management, bioremediation and microbes in post-harvest processing iv) microbial genomics.

The major threats of pestilence, in anticipation, during the XIth five year plan period are as follows:

1. With the change in climate and weather, there is perceptible change in pest status on several crops. Introduction of new crops like Jatropha and Pongamia in large areas is prone to new pests. There are reports of Cerambicid borers on Jatropha in different parts of Andhra Pradesh. Increased incidence of sugarcane wilt due to white grubs in the same state is also of a great concern during this phase of intensification in agriculture. Cerambicid beetles species are also causing intense damage in cashew, coffee.
2. *Locusta migratoria*, Indian sub-species invasion in Chingtang valley in Leh district and in Zanskar valley of Kargil district was reported on 11 August, 2006. Pasture lands, field crops such as barley, wheat and pea have been damaged. The Jammu and Kashmir government officials as well as the high-level central team that visited Chintang valley have reported about the movement of this insect from Chinese-occupied territory along the banks of Indus. This insect was reported to be active in the summers for the last three years.
3. In cotton, mirid bug (*Lygus* Spp.) damage flowers, inducing sterility, has been reported, especially in GM cotton hybrids. There is an increased susceptibility of GM hybrids to various sap sucking insects. Most of these hybrids have also enhanced susceptibility to grey mildew and

bacterial blight. Many of these hybrids have potential susceptibility to cotton leaf curl disease in northern states.

4. Intermittent dry periods in the months of August and September caused invasion of Sesbania Stem borer (*Azygophleps scalaris* Fabricius), in certain cotton fields of Vidarbha.
5. A recent report of *Meloidogyne graminicola* infestation was there in rice crop of Mandya district in Karnataka. A new root-knot nematode species *M. iriticoryzae,* is noted to damage rice and wheat in the north-western plains with rice-wheat cropping system. A new cyst nematode species *Heterodera swarupi* has been found infecting chickpea in Rajasthan.
6. Sugarcane woolly aphid damage to sugarcane fields took the country by surprise in Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu and caused damaged in a big way while in northern states, the incidence was mild. The focus of research about its pestilence to reduce sugar content and brix value is being done.
7. Tobacco streak virus infection in cotton, reportedly transmitted by thrips in Telengana and Adilabad areas of Andhra Pradesh is another example.
8. While older biotic problems such as mildews, rusts and wilts haunt crop production, many viral diseases also provide constraints in plant health in farmers' fields.
9. Recent episodes of rodent outbreak in North eastern hills, associated with solitary and gregarious bamboo flowering have damaged crops to the extent of bringing out famine in two districts of Arunachal Pradesh, one district of Mizoram and few locations in Nagaland and Tripura.

The various schemes were in progress during Xth five year plan for developing mitigating measures against pestilence in various crops and agro-climates could achieve satisfactory progress so as to provide suitable solutions to farmers. The major highlight has been the elucidation of herbivory in crops such as cotton and rice with which new approach to regulate the same for modulating insect population in crop plants were developed. The genesis of non-chemical farming that graduated into 'organic farming' in crops such as cotton is classically exemplified during the Xth plan period. India has become the world leader in organic fibre production with 14,000 MT during the current year, as per the recent ICAC Recorder.

The following aspects need attention of planners of the country in order to gauge the enormity of the crop health management task in the five year plan period in Indian agriculture.

Changing scenario of biotic stress

In the recent years, the need to increase food production to meet the demands of rapidly increasing population from a limited land resource, necessitated the use of intensive farming systems, with the inputs like narrow genetic base, high fertilizers, irrigation, multiple cropping etc., which favour disease and pest development. The intensive agriculture, especially the introduction of new high-yielding genotypes were susceptible to the pests and the pathogens and changing cropping patterns including cultivation in non-traditional areas have resulted in a spurt of pests and diseases in crop patho-systems, remarkably changing the scenario of biotic stresses. It is not only that those new pest problems emerged, but also the minor pests assumed major status and vice-versa. The intensification of cropping systems has led to increase in biotic stresses on account of: a), introduction of new pest problems (e.g. cotton leaf curl, type B of white fly, spiral white fly); b) increased intensity of the existing pests (e.g., white rust of mustard, leaf blight of wheat, sheath blight of rice); c), development of resistance to pesticides (e.g. American bollworm, whitefly).

The pesticide use pattern has been lop-sided mainly due to the commercial and market-driven status of the commodities in question. Although the farmers seldom got the real benefits of higher production of clean commodities, there has been overall enhancement of net return of farm productivity. In money-terms, this could not be translated into asset build-up of farming families; however, it enhanced the village-level prosperity. The private credit chain and money-lending system in villages was bolstered by input manufacture chain for up-linking farmers with latest agro-chemicals as well as other inputs. Macro-level failure in increasing accurate knowledge about all aspects of crop health management has been visible in those villages that were far-fetched in connectivity from the rest of the country. The flow of knowledge and inputs for modernized farming to these villages has been quite limited. The wisdom and experience along with weather and market fluctuating conditions made these farmers risk-avoiding and risk-averse.

Plant disease epiphytotics have been a major cause to change agricultural patterns and even food habits in many parts of the world. For example, cereal rye was replaced by potato due to ergot (*Claviceps purpurea*) disease, and potato was replaced by wheat due to late blight (*Phytophthora infestans*) in Europe. Some other similar devastating diseases which had far reaching impact on agriculture were: wheat rust in Mexico; coffee rust in Sri Lanka and Brazil; southern corn blight in the USA; cassava mosaic and maize rust in Africa; panama disease (*Fusarium oxysporum f. sp.cubense)* of banana in South America and Liberia; bunchy top of banana in Australia; swollen shoot of cocoa in Ghana; bacterial *(Pseudomonas solanacearum*) rot of potato in Kenya and many others. In India, the brown spot of rice (*Cochliobolus miyabeanus*) caused the great Bengal famine in 1943; red rot of sugarcane caused severe ephiphytotics in Uttar Pradesh and Bihar in 1938-42; wheat rust in Uttar Pradesh and Madhya Pradesh in 1946-47; Helminthosporium blight of wheat and barely in Uttar Pradesh, Bihar in 1979-81 leaf curl of cotton in Punjab and Rajasthan in 1994-95; tungro disease of rice in Punjab in 198-99; and necrosis disease of sunflower in Karnataka are just a few examples of the serious problems caused by plant diseases. Ironically most of these diseases have caused destruction in crops grown under rain-fed agriculture, indicating vulnerability of such cropping systems.

In wheat, rusts were the most serious problems until the mid-seventies, but currently with the wide use of rust-resistant varieties (although there is overwhelming evidence of the yellow rust resistant wheat variety, PB 343 appear to be susceptible to this dreadful disease in the 'green revolution area' of the country), a minor disease of the past, namely, Karnal bunt has assumed serious-proportions. The rice tungro virus and the bacterial leaf blight of rice are the most devastating diseases in the new varieties. Sheath blight has become serious on rice in the non-conventional areas. Maize and millets are now devastated by downy mildews. Blight of cotton became a major problem when the indigenous diploid cottons were replaced by exotic cotton tetraploid cottons. The new exotic cotton varieties are also highly susceptible to a new disease known as 'parawilt of cotton' of unknown etiology. During the past few years the viruses of cotton (particularly whitefly transmitted leaf curl) has become dangerous and required special efforts to check the spread to different areas. Such examples of changing disease scenario are available for pulses, oilseeds, vegetables, fruits, etc. i.e. the crops in which productivity has increased tremendously. Certain diseases of complex or unknown etiology, e.g., parawilt of cotton, coconut root wilt, citrus, mango malformation, crown rot of oil palms, brown-bast disease of rubber, etc. need special efforts to develop management practices to minimize the losses.

Plant parasitic nematodes, the unseen enemies of the farmer, have been recognized as serious perpetual problems in agricultural production all over the world. Favourable weather and almost continuous availability of host crops in the tropical and subtropical regions including India favour their build up. Being soil-borne and with wide host range nematodes are one of the toughest pests to control. International estimates have put crop losses due to nematodes at over $100 Billion (Sasser, 1988). The root-knot nematodes cause intense pestilence problem in vegetables, fruit crops, rice, pulses, fibre and oilseed crops.

Extensive nematode quarantine and control efforts in developed countries have paid rich dividends. India suffers heavy quantitative and qualitative losses in various food, fibre and commercial crops due to nematodes. A number of new nematode problems have emerged in the intensive cropping systems.

Heterodera schachtii; soybean cyst nematode, *H. glycines*; coconut red-ring nematode, *Rhadinaphelenchus cocophilus;* pine-wilt nematode, *Bursaphelenchus xylophilus* etc. can cause havoc if they gain entry into India. Nematode infestations and contaminations in export commodities can be serious limitation in international trade in agricultural commodities; this aspect has gained even greater significance with globalization. Proper pest risk analysis, quarantine, phytosanitation procedures, surveillance and are essential for consideration in the next five year plan period.

A few useful species of nematodes like entomopathogenic nematodes, *Steinernema* and *Heterorhabditis* species can also be used as bio-control agents of insect pests, while some other bacterial and fungal feeding nematodes play beneficial role in maintaining soil health.

The insect pest scenario was more influenced by the introduction of new agricultural production technology based on high yielding varieties and increased use of inputs like irrigation water, fertilizers and pesticides during the last four decades have changed the scenario of Indian agriculture. Many ecological attributes, which are favourable for plant growth, also favour multiplication of pests. Basic principles of herbivory were highlighted in several pestilence episodes. Most of these intense pestilences in various crops could be mitigated through regulated plant nutrition system. The quality of plant nutrition is the determinant of the intensity and build-up of agricultural pests, which are capable of adapting to large changes in the environment. Consequently, there is a change in the insect pest scenario and pathogens in almost all the crops due to changes in agro-ecosystem. The *desi* tall varieties of rice were found to suffer from only five insect pests, viz. yellow stem borer, hispa, rice bug, rice grasshopper, and surface grasshopper. Following the introduction of high yielding dwarf varieties and many river command-area projects, and also the associated chemical intensive technology, there has been a considerable increase in area under rice. Extensive sole cropping of rice is very common in many river and tank command areas, which favoured the development and multiplication of multitude of pests and diseases. Rice revolution in the country has brought about many second-generation insect pest problems such as a new root-knot nematode species *M. iriticoryzae*, which damage to rice and wheat in the north-western plains with rice-wheat cropping system. *Meloidogyne graminicola* infestation was intense in rice crop of Mandya district in Karnataka.

Similarly, leaf folder has emerged as a serious pest in Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Punjab and Haryana. Gall midge has been observed to occur during *rabi* in Godavari delta of Andhra Pradesh and coastal Maharashtra. Gundhi bug, which was earlier confined to north and north-eastern States of India, has been frequently causing serious damage to rice in parts of Tamil Nadu and Andhra Pradesh. Karnal bunt in some wheat growing states, *Molya* nematode disease in wheat in Haryana and Bihar, break down of resistance in PB 343 variety for yellow rust race, 78 S 84. There is a need to cultivate mosaics of varieties of crop plants in monocropping systems in large geographic tracts to prevent generation and invasions of various pests as a tool to avoid enormous biotic stresses.

TR:2 - To identify critical gaps in scientific infrastructure and frontier areas of technology and to suggest the ways to bridge the gap, so as enable the nation to enhance its agricultural competitiveness in the context of WTO & IPR regime

CURRENT INADEQUACIES

1. There is a lack of understanding and knowledge of processes of herbivory in crop cultivation *vis-à-vis* that in nature.
2. The tri-trophic interactive processes between plants, herbivores and their natural enemies in food-chain/food-web system of agro-ecosystem need better elucidations.
3. 'Fire-fighting' approaches of plant protection (including integrated pest management – IPM tactics), that has been in vogue over several decades, have led to only insufficient and inadequate effective crop protection. Often these have been very tentative and led to higher crop production costs. Contingency planning was the practice although IPM, theoretically, was to design medium-term measures in annual cropping period to reduce pestilence effectively through imaginative and dynamic interventions. More than escalating costs, the lack of faith of farmers for ecosystem management due to short-sighted prescriptions over long standing and pragmatic measures resulted in crumbling protection of crops from key pests and diseases that limited productivity as well as enabled destruction of commodities after harvest too.
4. No major attention is given in designing IPM for post-harvest commodity preservation and protection from pestilence.
5. In the event of large-scale retirement of personnel in the coming two years, a severe manpower crunch will be felt to effectively service various research programmes and develop contextual crop health management strategies.
6. One of the major weaknesses in viral disease management is the poor understanding of vector relationships and their biology. Although there have been good strides in the case of aphids plant hoppers and whitefly in crops such as potato, cotton or rice, many potential vectors such as thrips, bugs and mites are not studied for their exact role and biological association in viral transmission. Strong network programme on this is essential to make viral disease management in Indian crop health scenario through vector control.

7. Karnal bunt of wheat, rice tungro, soil biology and rhizosphere engineering in regard to citrus decline, termites ins groundnut and sugarcane, white-grubs in hill agriculture and rain-fed areas, nematodes in various crops, elaborate studies on vectors such as thrips, mites, bugs and nematodes to develop management approaches of viral diseases in groundnut, sunflower and vegetables, root wilt of coconut, eriophyid mites in pigeonpea and coconut, arecanut yellows, mango malformation, Black Sigatoka (*Mycosphaerella fijiensisi*) Morelet [anamorph: *Paracercospora fijiensis* (Morelet) Deighton], Apple scab, interactive pestilence of viruses in crops, sugarcane red rot, white stem borer of coffee. A budget of Rs. 5-10 crore of funding for each area is essential.
8. Strategic research in various aspects of key areas, in the event of the possible introduction of various genetically modified crop varieties as well as many such innovative approaches to mitigate abiotic and biotic stresses in crop plants, could be prioritized.

a. **Vertebrate Pests**: Rodents, large mammals and birds

Field crop loss and that in post-harvest situation has been bothering Indian agriculture in the last few five year plan periods. The role of rodents in the outbreaks of various contagious and communicable diseases such as *Leptospirosis,* plague etc. has deepened the threats to rustic and peri-urban life. The research support in this sector brought about tangible baiting-based and trapping-based recommendations in order to suppress crop and commodity loss, which warrants community approach. Modern research tools could be put in place for tracking the population build up to manage vertebrate pests in human living systems. Bird depredation of strategic crops such as cereals and oilseeds need innovative strategies to prevent quick adaptation by target organisms. Since bird fauna is part of agro-ecosystem, delicate balancing is called for to reduce such large-scale depredation while capitalising on the insectivorous habits of certain species of these animals in field crops.

b. **Impact of climate change**

The effect of changing global climate, particularly of sharp increase in temperature, through the last century on the intensity of pests and diseases is largely unknown. It now appears that the southern Asia will become warmer and unseasonably much wetter. The major changes in global temperature and climate are expected to be mainly due to atmospheric CO_2, methane and chlorofluorocarbons. Initial experiments have already shown that an increase in atmospheric CO_2 concentration from the current level of 330 ppm to 670 ppm, increases the susceptibility of plants to pathogens and pests. There are practically no data on the effect of the ongoing climatic variability on disease and pests. Most of the studies have been more concerned with the influence of day-to-day weather conditions rather than with year-to-year climatic variability on pest and disease appearance and build up. Climatic variability can affect any part of the life-cycle of the pathogen, insects, nematode as well as the interaction between or among these organisms. The integrated pest management (IPM) and Integrated disease management (IDM) strategies strongly rely on natural controlling factors such as weather and natural enemies of various pest organisms. Based on physiography, soil, climate and growing period, 21 agro-ecological regions (AERs) have been identified. Most of the major disease problems in rainfed agriculture occur in sub-humid and semi-arid conditions which represent 72 per cent of the total geographical area (329 m ha) of the country. The other AERs have relatively fewer serious disease problems. Utilising the current scientific tools, appropriate information on the biological transportations that the herbivorous organism undergo in crop fields shall be studied.

c. **Indiscriminate Use of Pesticides**

There are serious problems due to indiscriminate use of pesticides, of which insecticide resistance, fungicide resistance, pest resurgence, secondly pest outbreak, and minor pests becoming major pests are of great concern. In many cropping systems, such problems are becoming more serious, rampant and evident. There is manifold increase in the kinds of insect species recorded and the numbers of some them have increased, creating imbalance, leading to development of serious pests. The indiscriminate use of insecticides in the cropping systems of cotton, rice, vegetables, fruits, storage etc., had resulted in resurgence of insects like whiteflies, aphids, thrips, and mites in cotton, gall midges, leafhoppers and plant hoppers in rice. The indiscriminate use of insecticides had also resulted in problem of insecticide residues and other safety hazards. The residue levels of insecticides monitored in the vegetables, fruit and milk samples indicate that in many cases these levels are far above the maximum permissible limits set by WHO. Evidences of fungicide resistance in various pathogens of potato, apple, rice etc are also emerging field of research.

9. IPM in protected horticulture, development of suitable IPM for contract farming and large-scale farming, ageing horticultural plantations rejuvenation programme for integrated technology, Crop IPM with all plant protection disciplines, rejuvenation of crop protection research in national institutes and main IARI Insect genetics, insect molecular biology and biotechnology, conservational bio-control NPV tolerant to UV.

10. Research in weed sciences through National Research Centre (NRC) for Weed Science and the AICRP on weed science is one of its kinds in the world. The main objective should be to cut cost, to increase productivity and to maintain sustainability in crop production. The excellent infrastructure should be under PP Section of Crop Science Division to develop suitable research programmes in all cropping systems and to meet the emerging challenges.

11. Strengthening by deploying need-based manpower trained in the required areas concerning weed management including Sanitary and Phytosanitary (SPS) issues is of paramount significance. Weed seed collection with expertise and facilities for weed seed identification, cataloguing and developing their herbaria of native and alien weed species are significant steps to strengthen the knowledge to aid the National Plant Protection Organisation (NPPO). A radio tracer laboratory and phytotron facility for studies on weed biology and ecology in addition to studies on herbicide dynamics in simulated agro-ecosystems is also

required. At present co-ordinated programme is operating at 22 SAUs. Among these, the active centres should be identified centres should be provided with the facilities for herbicide residue analysis.

12. SPS related issues in the country to develop of suitable infrastructure to meet the enabling requirements of the SPS Agreement for international trade in agriculture. There is a growing concern that certain SPS measures impede the export of agricultural produce due to lack of appropriate infrastructure to address various issues related to SPS Agreement. The factors that put us in disadvantageous position are:

- Lack of PRA on the pests of interest.
- Lack of understanding on the SPS measures of other countries
- Lack of infrastructure on the SPS measures of other countries
- Lack of infrastructure for scientific research, testing, conformity assessment and equivalency.
- Non-participation of well informed experts to effectively participated in the international standard-setting process.

We must plan suitably to correct the present situation so that SPS measures are used to the advantage of Indian agriculture. For this, the overall infrastructure for plant protection will have to be reorganized and strengthened. Pest risk analysis including delineation of pest-free areas, effective diagnostic tools and techniques for post-entry quarantine monitoring as well as for enforcement for stringent domestic quarantine, suitable research support in plant protection for the implementation of all the legislations in agriculture such as Insecticide act, Seed act, Plant variety Protection and Farmers' Right Act, Plant Quarantine Order etc. as well as for development of mitigative measures to remove pestilence in targeted exportable commodities. The next five year plan period shall have to address these issues in order to make a leap into cost-effective pest management approach that ultimately influence crop harvest at reduced cost of production.

In the XIth plan period, the ICAR institutes and main campuses of SAUs should be supported to intensify / initiate strategic research that will enable solving some of the key national pest and diseases problems. Some of the examples of priority areas are given below:

1. The plant protection research suitable for this sector is expected to be boosted. One of the far-cry in dry land agriculture is the poor plant stand of all the candidate crops due to poor seed germination, arising out of poor seed health and vigour. Research on seed health management techniques in various crops at planting has to be focused. Suitable seed dressing agents (both chemicals and natural products), to prevent internal and external infections of diseases and insects, have to be researched upon.

2. Field crops suffer major damage from the insects, plant diseases, mites and also nematodes immensely. Poor biodiversity in the soils has enabled the magnified spurt in crop loss due to various species of nematodes and root infecting pathogens. The effective principles of agriculture in qualified land mass having high organic carbon shall be the basic focus of

research in plant protection to mitigate several soil-borne crop damage issues and for pest avoidance.

3. Yet another strong role that the Entomology research in the country has been playing from the period of development of Indian agriculture has been the studies on pollinators as enhancers of crop productivity. The increased relevance of this field in the ensuing five year plan period has to be paramount to attain the high targets of crop productivity in both field and horticultural crops. A strong inter-disciplinary research group has to be carved out to research on the palinological and pollinator-behavioural studies in different agro-climatic regions. Enabling processes for pollinator build up through intelligent agro-forestry and silvipasture tactics in addition to enhanced thrust on apiculture is to be focused.

4. Development of tools and techniques, methodologies as well as analytical approaches for assessing the impact of various recommendations, practices as well as *ex-ante* analysis of potential impacts of such recommendations shall be given major thrust. Various UGC funded universities as well as institutions shall be ideal for such networked programmes. The major areas of research shall be on rhizosphere engineering, management and related crop health issues. Ideal nutrition of crops for their metabolic satiation and effective productivity insurance shall be blended with studies on intensities of herbivory (by insects, pathogens nematodes and others) under different weather profiles.

5. The pollinators as enhancers of crop productivity are to be recognised. The increased relevance of this field in the ensuing five year plan period has to be paramount to attain the high targets of crop productivity in both field and horticultural crops. The under-privileged regions of the country shall be infused to get into the seed production entrepreneurships through deployment of potential pollinators for the production of seeds of cross-pollinated crops which are aided by insect and other pollinators. Enabling processes for pollinator build up through intelligent agro-forestry and silvipasture tactics in addition to enhanced thrust on apiculture is to be focused. Apiculture products with true value addition shall be the one of the few by-products in these underprivileged areas of the country to sustain the population that have no direct involvement in agriculture-based activities of the communities. The social up-thrust in economics shall empower the people in such areas to realize economic independence.

6. Plant health management, employing tools and techniques, methodologies as well as analytical approaches could be translated into entrepreneurship-based (PPP) input production and supply system to regional needs under skill monitoring and efficient production systems of biological pesticides and antagonists. Research results from various UGC funded universities as well as institutions shall be ideal for such networked programmes. The major areas of research shall be on rhizosphere engineering, management and related crop health issues. Ideal nutrition of crops for their metabolic satiation and effective productivity insurance shall be blended with studies on intensities of herbivory (by insects, pathogens nematodes and others) under different weather profiles.

7. The domestic quarantine should receive attention of the policy planners as the spread of nematodes through infested seeds/planting material from one State to another State is increasing. Pest risk analysis to address phyto-sanitary needs of international trade of agricultural commodities.

8. There is a need to carry out researches on use of diazotrophic, rhizobacteria and other bio-agents for their antagonistic role against plant parasitic nematodes. Role of nematodes in decomposition organic matter. designing nematode management technologies for organic farming systems, role of friendly nematodes such as entomopathogenic nematodes (EPN), predatory and saprophagous nematodes which constitute the sizeable nematode biomass and play an important role in soil health should receive due attention need appropriate attention.

The Plant protection research shall address the under-mentioned areas in the next five year plan period and some of them could attract competitive grant mode.

1. biodiversity and bio-systematics of all organisms of agro-ecosystems
2. Soil biology and rhizosphere engineering
3. crop health care modelling
4. components of host plants resistance, gone identification, multiple and durable resistance, transgenic induced systemic resistance biosystematics and biodiversity
5. tri-trophic relationships in cropping systems
6. insect genetics and breeding to improve efficiency of beneficial insects
7. development of better natural products and stable formulations
8. IPM for storage pests and pathogens; pre- and post-harvest management of myco-toxins; grain quality management and food safety
9. Synthesis of safer agro-chemicals

TR 3 - To draw / suggest specific schemes / programmes pertaining to crop protection research to address the problems of less privileged regions.

- Four PP **Centres of Excellence** in four different parts of the country under SAU system should be developed, which shall be inter-institutionally networked under the National Centre of Integrated Pest Management. All PP research programmes of the country shall be networked through inter-ministerial networks. There should be a master control at DAC-DARE (ICAR). This would ensure direction, accountability/responsibility, review/monitoring as well as collective wisdom. All professional societies shall be accountable for brainstorms on contextual PP issues as well as provide both solutions and advice R & D programmes for fellow scientists to take up through their institutions. Specific PP research programmes should be interlinked with national funding agencies such as DBT, DST, APPEDA, DoE and International agencies such as CGIAR and others. Good collaborations for research work shall be established with foreign universities/ research organizations in the areas under different sub-disciplines of Entomology, Plant Pathology, Nematology and vertebrate pest management as well as other relevant plant protection fields. The professional societies through its members shall identify such potential departments, faculty and institutions.

- In some of the States and KVKs Subject Matter Specialist having Nematology background should be provided wherever nematode has assumed significant proportions as pests of crops. For disseminating the knowledge and technologies to the farmers' good quality documentaries film on nematode symptoms and their management should be prepared and shown to the farmers during Kisan Mela, farmers' meeting and farmer's awareness programmes.

- Development of adequate infrastructure to train farmers of this region to produce biological products such as bio-fertilizers, bio-pesticides, pesticides of botanical origin and bioremediation products in locally available resource regime. Non-conventional energy sources, local skills and ingenuity as well as innovations for the best mode of production of these critical inputs shall be encouraged. Public-private entrepreneurship shall be encouraged to make a strong foot-hold of these technologies in underprivileged regions of the country.

Science of Plant protection needs sharper knowledge development at UG and PG level for which there shall be adequate refresher courses for the faculties on frontier areas such as molecular biosystematics, advanced knowledge in herbivory, host plant interactions with various herbivores, natural balance in agro-ecosystem, post-harvest management of commodities including modern storage systems, trade-related plant protection issues including all the international agreements under World Trade Order as well as all the relevant protocols for which India is signatory and relate these to the current plant protection scenario, application of nanotechnology for enhanced targeting of pesticides, increased plant defence systems etc. Suitable task-force for development of robust curriculum so as to incorporate such modern cutting edge techniques may be undertaken. The ICAR should launch specific HRD programmes for strengthening its work force that can contribute in both private and public institutions for undertaking this mission-oriented research. Appropriate steps to generate texts and reference books on these subjects of inter-disciplinary nature shall be patronised through competitive grant projects. The ICAR and SAU scientists also shall be refreshed in these aspects for which separate curricula could be framed and designated institutions shall be given this responsibility. The first year of the next plan shall put in place this task into operation with a major revamping of curricula and course content, in consonance with the recommendations of the National Knowledge Commission (NKC) and other relevant bodies for hiking academic standards.

Strengthening of R&D in Plant Protection in existing organizational set up is the need of the hour. Over a period of time, some of the ICAR institutes and SAUs have been specialising in certain areas of plant protection and have excelled in these fields. They have become leaders in their own areas of research. Many centres of Advance studies, Centres of Excellence etc. are essentially to be established. In view of the great emphasis given to strategic and basic research that will enable finding solutions to certain key national pestilence, the Sub group recommends identifying certain centres in different areas of plant protection research for further development as Centres of Excellence. These centres shall do advance research, train manpower through post-graduate programmes and medium and long-term training of scientists and share the processes and products develop by them across the country. Private-public partnerships shall invigorate this process more effectively.

The main deficiency was the absence of training of PP scientists in core and frontier scientific areas. Quarantine and Sanitary Phyto-sanitary capabilities are the weakest. Homozygous test organisms for bio-efficacy testing, AICRP in various crops and commodities could not progress well in identifying resistant sources against key biotic concerns in crop production due to inadequate screening protocols for multiple pest episodes. Biotechnology applications in PP research were resorted to only to harness alien genes instead of fortifying the tolerant genes from the wild relatives of crop plants. Imaginative application of suitable molecular tools for gaining better understanding of the tri-trophic association of pests on crop plants shall provide better opportunity to work for mitigative measures in agriculture.

TR:4 - To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

The indigenous knowledge and practices in general agriculture of knowledge-challenged and input challenged regions of the country has to be studied and compared with the modern practices that have been put to practice elsewhere in the same state through socio-economic and environmental analyses. The risk assessment of both these systems shall be made. The risk assessment of the relevant package of practices of profitable crop production shall be inherent, *a priori* to their recommendation and practice.

Enabling farm women to involve in pollination-based seed production enterprise, sericulture as well as entrepreneurship-based production for local needs of various bio-pesticides and antagonists, as per CIB & RC guidelines, could be the apex programme mediated through various Krishi Vigyan Kendras of such regions where focused emancipation of tribal, marginal and weaker sectors of land-ownership exist.

Decision-making in terms of development of farm activities is generally vested with women in our rural fabric. It is worthwhile to undertake realistic assessment of their sociological, economic as well as market acceptability *in toto.* The knowledge and skills, that have to be accrued by them to orient their thought process for enabling robust decisions in crop healthcare during each season across various crops the family raises, shall be such as that on agro-ecosystem analysis-based decision making for crop health care is significantly achieved.

The indigenous knowledge and practices in general agriculture of knowledge-challenged and input challenged regions of the country has to be studied and compared with the modern practices that have been put to practice elsewhere in the same state through socio-economic and environmental analyses. The risk assessment of both these systems shall be made. The risk assessment of the relevant package of practices of profitable crop production shall be inherent, *a*

priori to their recommendation and practice. Production by masses over mass-production of bio-pesticides and good quality seeds (pathogen-free) could enlarge rural economy substantially.

TR:5 - To identify institutional mechanism for strengthening, monitoring and evaluation system in plant protection research, and to suggest efficient measures for effective coordination of agricultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public-private partnership

The national research agenda in plant protection shall be focused to address the constraints that are given ahead in this report. The plant protection research suitable for this sector is expected to be boosted. One of the far-cry in dry land agriculture is the poor plant stand of all the candidate crops due to poor seed germination, arising out of poor seed health and vigour. Research on seed health management techniques in various crops at planting has to be focused. Suitable seed dressing agents (both chemicals and natural products), to prevent internal and external infections of diseases and insects, have to be researched upon.

Cropping intensity enhancement, being one of the tools for maximizing the efficiency of land use, crop diversity aspects along with rhizosphere engineering and management are to be specialised approaches of plant protection research for the next five years. Field crops suffer major damage from the insects, plant diseases, mites and also nematodes immensely. Poor biodiversity in the soils has enabled the magnified spurt in crop loss due to the excessive build up of various species of nematodes and root infecting pathogens. The effective principles of agriculture in qualified land mass having high organic carbon shall be the basic focus of research in plant protection to mitigate several soil-borne crop damage issues and for pest avoidance. This has to be taken up as a mission in all plant protection research.

The basic tenet of crop protection has to be put upon enhanced reliance on plants' capability to sustain invasion of various herbivores, but also through an enabled metabolic enhancement for compensation of crop loss. The age-old reliance on such attributes of plants to sustain their life. Compensation measures through such attributes have to be researched upon in all the crops cultivars under intensive farming, so as to elucidate their prowess suitably to harness them for enabled reduction of herbivory. There is a strong need to revamp the direction of research in plant protection in order to acquire better understanding of the internal processes of each crop species alone and in combination with others of a cropping system and in sequence. This could be best addressed through a discovering a new paradigm of crop health management. As in the case of the successful and glorified achievement in animal husbandry of the country, agrarian husbandry has to be made more meaningful with crop health management in which defined health attributes of the crops have to be pursued.

Having currently a national pool of around 1000 plant protection scientists (in Entomology, Plant Pathology, Nematology, Acarology, Apiculture, vertebrate organisms etc.) in DARE (ICAR and SAU systems), reorganization of resources has to be rationalized to involve effectively in the prioritized research programmes in plant protection.

DISCIPLINE	TOTAL SANCTIONED POSTS AS PER REVISED CADRE STRENGTH IN ICAR INSTITUTES			
	Scientists	Senior Scientists	Principal Scientists	Total
Plant Pathology	203	92	35	330
Nematology	50	16	04	70
Agricultural Chemicals	33	10	03	46
Entomology	184	71	29	284
TOTAL	470	189	71	730

There is equivalent number of Plant Protection scientists in the SAUs, making the total strength to about fifteen hundred.

The sub-group addressed the following key research programmes in the country in the following areas through institutional structure of ICAR's plant protection institutes (NCIPM, PDBC and NBAIM) as well as nine AICRPs / AINPs.

1. biosystematics research to study the biodiversity as well as bionomics of all organisms (insects, nematodes, pathogens, mites etc.) that cause pestilence (herbivores) and their natural enemies in agricultural ecosystems of the country with an aim to develop robust catalogue of these bio-resource inventories shall enable better planning of agriculture for the posterity
2. soil health management for pest avoidance through defining apt roles of bio-fertilisers, bioremediation as well as microbial antagonists.
3. plant health management from invasion of insects, plant pathogens including through vectors, nematodes, mites and vertebrate organisms
4. post-harvest commodity management for both consumption and for seed
5. development research for agro-chemicals including pesticides of botanical origin, synthesis of pheromones, juvenile hormones etc. of insects, evaluation of residue of all agro-chemicals in crops and commodities
6. biosafety and phytosanitation issues, appliances engineering, host resistance, natural products etc.
7. pest risk analysis including delineation of pest-free areas, effective diagnostic tools and techniques for post-entry quarantine monitoring as well as for enforcement for stringent domestic quarantine, suitable research support in plant protection for the implementation of all the legislations in agriculture such as Insecticide act, Seed act, Plant variety Protection and Farmers' Right Act, Plant Quarantine Order etc. as well as for development of mitigation measures to remove pestilence in targeted exportable commodities.
8. to undertake benefit-cost and risk-benefit analyses of plant protection recommendations for all agro-climatic conditions.

The following suggestions for reorganisation of Plant Protection Research during the XIth plan period are proposed by this Sub-group to bring in holism in crop health management.

1. Reorganisation of AICRPs/AINPs

The laudable system of AICRPs under ICAR was modulated to accommodate some of the existing schemes as All India Network Projects in Plant Protection (PP) disciplines. The tenth plan period witnessed erosion of the tenacity and grip of some of these PP schemes, due to lack of national exposure in regard to the pest problems and poor interaction with crop institutes and departments of SAUs and other stakeholders in agriculture. The width of performance narrowed in this process. The Co-ordinators of AINPs were co-opted scientists from amongst the group. It was felt that directly recruited Coordinators have to lead these AINPs. This would garner better confidence and professional acumen to lead the team towards the desired goals of such AINPs.

Since there is need for consolidation of research work, it is also recommended to upgrade the AINP on Pesticide Residues into an AICRP looking into the global need for national data base in agro-chemicals of the country. It is also felt that the AINP on Ornithology shall be merged with AINP on rodents to be designated as AICRP on Vertebrate Pests. The AINP on Agricultural Acarology as well as that for White grubs and soil arthropods management seem to have outlived their roles for breeder issues in biology of these pests. Since the current problems due to these pests in field and horticultural crops are addressed by respective crop institutes as well as by concerned SAUs, this project could be terminated at the end of Xth plan period.

The pollinators as enhancers of crop productivity are recognised by this Sub-group. The increased relevance of this field in the ensuing five year plan period has to be paramount to attain the high targets of crop productivity in both field and horticultural crops. A strong inter-disciplinary research group in network-mode has to be carved out to research on the palinological and pollinator-behavioural studies in different agro-climatic regions. Enabling processes for pollinator build up through intelligent agro-forestry and silvipasture tactics in addition to enhanced thrust on apiculture is to be focused. The present AICRP on Honeybees Research and Training has to enlarge its scope through providing ideal impetus to study the potential pollinators in all cross-pollinated crop species.

Biological control of pestilence is a recognised component of integrated pest management (IPM) in order to revitalise biodiversity of agro ecosystem as much as attaining suppression of target pest build up. Hence, the AICRP on Biological control shall be changed to AICRP on Integrated Pest management (IPM), with all the ICAR crop research institutes as well as SAUs as centres.

2. National Animal and Plant Virology Research Institute (NAPVRI)

The intense crop loss in field and horticultural crops due to phyto-pathogenic viruses was considered by this Sub-group as an important area that needs strong intervention in the XIth five year plan period. The **National Animal and Plant Virology Research Institute** is recommended during the XIth plan period in order to address the enormous number of Viral disease in field and horticultural crops. This was also suggested during the X^{th} five year plan period too. A proposition to establish the National Institute on Virology with emphasis on research on virus diseases of animals and plants is under active consideration of the Government of India. This shall be the opportune step to intensify research in the designated phytopathogenic viral diseases. A concept note on the structure of this institute is given in *Annexure II*. The institute is expected to reach international scale of quality research in all sectors of this field of science such as vector studies, tri-trophic relationships and the reaction of plants to phyto-pathogenic viruses. This institute shall also be responsible to undertake research on viruses infecting animals including pest organisms such a insects, mites, nematodes etc.

3. NATIONAL PLANT HEALTH RESEARCH INSTITUTE (NAPHRI)

Integration of resources is the call of the day for ideal optimizations. Research manpower, infrastructure utilization including laboratory tools and equipments, field facilities, mobility to farmers' fields etc. have to be integrated for ideal optimisations. Common facilities and technical manpower could be designed so as to reduce number of posts and provide inter-disciplinary approach for focussed research in critical areas that have left wide gaps in all areas of plant health management. **It is recommended to merge National Centre for Integrated Pest Management with Project Directorate for Biological Control to conceptualise NAPHRI.**

In the XI^{th} plan period, the main ICAR institutes and main campuses of SAUs should be supported through basic and strategic research that will enable solving some of the key national pest and diseases problems such as Wheat of Karnal bunt, rice tungro, soil biology and rhizosphere engineering in regard to citrus decline, termites in groundnut and sugarcane, white grubs in hill agriculture and rainfed areas, nematodes in various crops, vector-virus studies in field and horticultural crops, root wilt and eriophyid mites in coconut, arecanut yellows, mango malformation, Sigatoka in Banana, Apple scab, interactive pestilence of virus, sugarcane red rot, white stem borer of coffee etc.

The mandate of the **NATIONAL PLANT HEALTH RESEARCH INSTITUTE (NAPHRI) are:** i) be an umbrella organization for basic and strategic research projects in its own ambit as well as network all applied inter-disciplinary research effectively, ii) Satisfying the national needs emanating out of Sanitary and Phytosanitary issues, Codex Committee for Pesticides Residues (CCPR) / Joint Monitoring Pesticides Residues (JMPR) of *codex alimentarius* as well as Plant Protection Quarantine issues of National Plant Protection Organisation (NPPO). Various departments/divisions of plant protection disciplines of ICAR institutes and State Agricultural Universities (SAUs) shall align themselves with NAPHRI for seeking research programmes with appropriate funding from various departments under designated ministries and other research funding systems. The existence of NAPHRI shall enable all funding agencies, desirous of pursuing plant health management and crop pollination studies to channelise funds and to effectively monitor the programmes through a single-window. Pragmatic and effective research in a coordinated fashion shall be enabled under this structure. The plant protection research system could be accredited by international standards under NAPHRI. A concept note on the structure of NAPHRI is given in *Annexure-III.*

ICAR, having the experience of National Agricultural Technology Project and now having designed the National Agricultural Innovative Project, could enable NAPHRI to be on a consortium mode for aiding public-private partnerships in addressing various issues of plant protection of the country. It could organize monitoring the assigned responsibilities in various research programmes in all SAUs, ICAR institutes, and in crop AICRPs.

Having enunciated the tasks of research in plant protection for the next five year plan, the Sub-group concurred with the idea to mobilize and reallocate resources in terms of manpower and infrastructure in addition to desirable funding to bolster the education and research in biotic stress management. Many of its dimensions could be on virtual mode through network and competitive grant process. Developing course curricula to off a PG diploma in apiculture, sericulture, lac culture etc. has to be taken up. Outreach education through various deemed universities as per the demands of user agencies would be appropriate.

3. Four PP Centres of Excellence

Four PP **Centres of Excellence,** in SAU system (*Annexure V*) in four parts of the country, may be developed, which shall be inter-institutionally networked under the National Centre of Integrated Pest Management along with Project Directorate for Biological Control. All PP research and development programmes in the country shall be networked through inter-ministerial networks. There should be a console at DAC-DARE (ICAR). This would ensure direction, accountability / responsibility; review/monitoring as well as collective wisdom. All professional societies shall be accountable for brainstorms on contextual PP issues as well as provide both solutions and advice R & D programmes for fellow scientists to take up through their institutions. Specific PP research programmes should be interlinked with national funding agencies such as DBT, DST, APPEDA, DoE and International agencies such as CGIAR and others. Good collaborations for research work shall be established with foreign universities/ research organizations in the areas under different sub-disciplines of Entomology, Plant Pathology, Nematology and vertebrate pest management as well as other relevant plant protection fields. The professional societies through its members shall identify such potential departments, faculty and institutions. The basic tenet of crop protection has to be put upon enhanced reliance on plants' capability to sustain invasion of various herbivores, but also through an enabled metabolic enhancement for compensation of crop loss. There is a strong need to revamp the direction of research in plant protection in order to acquire better understanding of the internal processes of each crop species alone and in combination with others of a cropping system and in sequence. Four centres of excellence in state agricultural universities on completive grant mode in Western India, Eastern India, North India and South India

TR:6 - To draw/suggest specific schemes/programmes/research area pertains to crop protection research and frontline transfer of technology including linkages with developmental departments.

Introduction of Integrated Pest Management (IPM) in Educational Programmes

Although this terms of reference does not directly provide the platform to discuss about the need for introduction of Integrate Pest Management (IPM) in Educational Programmes, looking into the country's need for huge manpower and expertise in this core area of crop husbandry, the following aspects are suggested.

Broad-basing Agricultural Education:

Indian Agriculture is in the throws of change. Agricultural education system has first to discern direction of the change and the environment leading to this change and then reorient and adapt itself to foster the desired change (Mehta, 1999). Course curricula need to be extensively revised so as to incorporate the requirement of contemporary agriculture in India in both the national and global setting. Greater emphasis need to be given to the internship at the graduate level so as to provide graduates with hands-on experience in agriculture. Exposure of students to various national programmes in the agriculture sector would equip them with knowledge and help in developing in perspective for the work being carried out in agriculture sector in public system at the central and the state level. Likewise, inclusion of a management module at both the graduate and Postgraduate level would improve the quality of the product.

Education at UG and PG levels:

In the undergraduate curriculum of the SAUs, microbial pesticides are taught as a part of biological pest control among various IPM components under the course "Principles of Pest Management". The students are only exposed to the new concept of microbial pesticides. There is not much time to learn more details about these insect pathogens. At the Masters level in most Universities, although there is one exclusive course on biological control, much needed hands-on training in the mass production, formulation, product development, etc. is wanting. The research scholars in the Ph.D. degree programmes with specialisation in biological control are far few. Since biopesticides R & D in the country is not as organised as chemical pesticide industry, there is need for fortifying SAUs in this area for appropriate extra-mural research.

An optional practical credit course called as "Commercial Agriculture" was introduced in early 1990s in Tamil Nadu Agricultural University in which commercial production of microbial pesticides and other bio-control agents is one of the many optionals for the students at the under graduate level. Though the number of students attracted to this course is rather limited, the graduates trained in this area are able to establish small commercial production centres for self-employment under the guidance of the teachers of the Tamil Nadu Agricultural University. Some of these production units are functioning fairly well. In as much as large number of farm graduates, zoology / microbiology graduates and diploma holders in agriculture remain unemployed or under employed, it would be worthwhile to orient them and train them intensively in the large -scale production and use of the possible microbial pesticides. This could be converted into a Post-graduate certificate course of appropriate duration in all the SAUs. The Government could plan to introduce agriculture subject in about 100 high schools and 100 higher secondary schools in the State. Such trained manpower can serve as middle level functionaries in promoting the use of microbial pesticides and IPM., as is proposed in Tamil Nadu.

Vocational Education:

Since future job opportunities would be in the private sector, agricultural education should have greater vocational input. Some beginning has been made in Punjab and Maharashtra to provide vocational training SAUs & vocational schools. Krishi Vigyan Kendras (KVKs) can also help in this area. Despite commercialisation of agriculture and increasing use of technology, agriculture sector will not be able to absorb the new addition to the labour force. The growth rate of labour force during Ninth Plan has been 2.5 per cent per annum. Improvements in rural infrastructure, increased incomes and diversified demand in rural areas would create new job opportunities in the service sector. There is need to develop skills of rural youth so that they can partake of the new opportunities in this sector. SAUs and ICAR with their KVKs and other rural outfits can greatly help in providing quality job-oriented vocational education to rural youth.

Outreach Educational Programmes:

Agricultural education today focuses almost entirely on courses leading to a graduate or post-graduate degree. In most of the States, it does not have any out-reach system in plan health management, except the Krishi Vigyan Kendras run by SAUs. It does not impart long duration training to farmers and farm youth in this area. Farmers, who wish to impart basic knowledge of modern agriculture to their children other than through acquisition of graduate or post graduate degree, fail to do so because SAUs do not cater to such requirement. SAUs should develop outreach system of agricultural education for farm-leaders through distance education (including through IGNOU and other deemed universities) and holding of short term and long term institutional trading courses. Such courses could also help in the development of system of community based para-extension specialist as much as in human health management. This would improve the interface between farmers and agri-specialists (Mehta, 1999).

Relating Education to Social needs:

To make agricultural education more relevant the SAUs are implementing the Rural Agricultural Work Experience (RAWE) programme, Village Stay Programme, Commercial Agricultural Course, Economic Surveys Programme, Earn While You Learn scheme, Crop Production courses, Development Communication, Rural Development and many other programmes. Plan health management tools such as biopesticides and IPM are invariably included in all these programmes. The students could also be involved in such vocational *in situ* courses at farm levels for dissemination of core knowledge in social forestry awareness campaigns, environmental awareness campaigns, etc. to farm families.

The curricula and syllabi of each degree programme are revised and completely updated to provide the graduates with aptitude, confidence, knowledge and skills to become entrepreneurs, to be well fitted into job on competitive basis with other degree graduates, to become owners or managers of commercial farms, and to offer counselling and advisory service in agriculture and related fields at hours of need in villages.

The best success-stories of dissemination of knowledge of plan health management in cotton, rice etc. during the last two plan periods have been through farmer-participatory, on-farm demonstrations which were later designated as Frontline demonstrations. Huge funding from Asian Development Bank, World Bank and other similar institutions under the aegis of Food and Agricultural Organisation of United Nations has enabled specific Indian experience in the past. Specific institutions of the state that are independent of generating the recommendations shall be given this responsibility under their guidance to replicate these experiences. *Krishi Vigyan Kendras* and Self-help village groups are the primary target groups for implementing this along programme with the intense participation of local progressive farmers. They, in-turn, form the secondary and tertiary knowledge transfer system with clear monitoring by the state extension machinery that is under revamp during the next plan period.

The best success-stories of dissemination of knowledge of plant protection in cotton, rice etc. during the last two plan periods have been through farmer-participatory, on-farm demonstrations which were later designated as Frontline demonstrations. Huge funding from Asian Development Bank, World Bank and other similar institutions under the aegis of Food and Agricultural Organisation of United Nations has enabled specific Indian experience. Specific institutions of the state that are independent of generating the recommendations shall be given this responsibility under their guidance. *Krishi Vigyan Kendras* and Self-help village groups are the primary target groups for this along with local progressive farmers. They, in-turn, form the secondary and tertiary knowledge transfer system with clear monitoring by the state extension machinery that is under revamp during the next plan period.

Agro-ecosystem analysis on pest population and natural enemy system as well as decision-taking ability by farmers shall be sharpened and fortified under the persistent guidance of various expert systems as well as kiosk-based knowledge sharing patterns that are to be in place in most of the intensively cultivated states.

Conclusions and Recommendations

The conclusions are:

1. Crop diversity, being the best agronomic tool to dilute the pest onslaught of herbivory and to enhance natural enemy diversity and dynamics, in a given geographic land mass, adequate focus on the research of protection of the crops involved in this scheme also need attention. Cropping intensity enhancement, being one of the tools for maximizing the efficiency of land use, crop diversity aspects along with rhizosphere engineering and

management are to be specialised approaches of plant protection research for the next five years. The overall concepts of crop health management have to be imbibed in order to focus on cost-effective crop production, as the only slogan for the XIth plan period.

2. The tenth plan period witnessed erosion of the tenacity and grip of some of these PP schemes, due to lack of national exposure and poor interaction with crop institutes and departments of SAUs and other stakeholders. The width of performance was narrowed in this process. It is recommended that there is a need to have directly recruited Coordinators in AINPs too. This would garner better confidence and professional acumen to lead the team towards the desired goals.
3. IPM in protected horticulture, development of suitable IPM for contract farming and large-scale farming need emphasis.
4. The enhanced global trade is perceived to result in threats of introduction of alien pests from other countries in the absence of appropriate pest-risk analysis as well as safety standards of consignments of commodities. The evolution of national data base on pesticide residue status in commodities is another prime area of focus for the next five year plan period.
5. Cropping intensity enhancement, being one of the tools for maximizing the efficiency of land use, crop diversity aspects along with rhizosphere engineering and management are to be specialised approach of plant protection research for the next five years. Field crops suffer major damage from the insects, plant diseases, mites and also nematodes immensely. Poor biodiversity in the soils has enabled the magnified spurt in crop loss due to various species of nematodes and root infecting pathogens. The effective principles of agriculture in qualified land mass having high organic carbon shall be the basic focus of research in plant protection to mitigate several soil-borne crop damage issues and for pest avoidance. The existing package of practices is not fully integrated between various plant protection sciences. This results in duplication, overlapping as well as unrealistic recommendation in the name of integrated pest management (IPM). The IPM concepts flourished on the hinges of low or no pesticide usage, primarily for insect pest management in crops. However, its limitations in the management of nematodes, vectors as well as various viral pathogens and disease complexes could be perceived. The last four years witnessed new pests which had only minor pest status so far. There is need for interdisciplinary research in plant protection to elucidate basic issues of herbivory as well as to develop suitable mitigations.
6. The Sub group conceptualised the threats of the next five years due to pestilence in agriculture. The expected enhancement of pestilence due to poor domestic quarantine enforcements is a cause of concern due to wide-scale spread of soil-borne pests along with planting materials from nurseries to main fields across states. The very tentative initiatives for addressing pest damage in crops have led to higher crop production costs. All the designated agencies have to be integrated in order to plan strategies as well as to implement those collectively instead of contingency planning. More than escalating costs, the lack of faith of farmers for ecosystem management due to short-sighted prescriptions over long standing and pragmatic measures resulted in crumbling protection of crops from key pests and diseases that limited productivity as well as enabled destruction of commodities after harvest too. This also led to the exploitation by local quack specialists, who acted as

advisors in hours of crisis and also serviced the necessary inputs as credit against the harvested produce.

7. Introduction of plant health management as a thematic emphasis on integrated pest management (IPM) in educational programmes of the country through broad-basing agricultural education; contextual fortification of extra-mural research; introduction of post-graduate certificate course directed towards vocational education for social needs to form para-agric team of the country as in para-medical team in order to practise plant health management; outreach educational programmes, (including through IGNOU and other deemed universities) etc. are thought by this Subgroup to bring about the much necessary HRD.
8. One of the major weaknesses in viral disease management is the poor understanding of vector relationships and their biology. Although there have been good strides in the case of aphids plant hoppers and whitefly in crops such as potato, cotton or rice, many potential vectors such as thrips, bugs and mites are not studied for their exact role and biological association in viral transmission. Strong network programme on this is essential to make viral disease management in Indian crop health scenario through vector control.
9. Karnal bunt of wheat, rice tungro, soil biology and rhizosphere engineering in regard to citrus decline, termites ins groundnut and sugarcane, white-grubs in hill agriculture and rain-fed areas, nematodes in various crops, elaborate studies on vectors such as thrips, mites, bugs and nematodes to develop management approaches of viral diseases in groundnut, sunflower and vegetables, root wilt of coconut, eriophyid mites in pigeonpea and coconut, arecanut yellows, mango malformation, Black Sigatoka (*Mycosphaerella fijiensisi*) Morelet [anamorph: *Paracercospora fijiensis* (Morelet) Deighton], Apple scab, interactive pestilence of viruses in crops, sugarcane red rot, white stem borer of coffee. A budget of Rs. 5-10 crore of funding for each area is essential.

The recommendations are:

SCHEMES/PROJECTS TO BE CONTINUED WITH SUITABLE AMENDMENTS

1. National Bureau of Agriculturally Important Micro-organisms

The Bureau is to be modernised in its skill and capabilities for handling the nation-wide collection of all classes of microbes. The next plan period shall witness development of exhaustive catalogues with digitised information on the taxonomic and genetic information of all the available items in the collections in all classes of organisms. The institute has two pronged mandate of cataloguing as well as identifying those that have applications in agriculture. The latter feeds the exhaustive Network project, AMAAS.

2. Network project on Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS)

This network project has been launched with five themes of research. These themes have to be enlarged into attainable applications in agriculture. These interdependent themes need concerted focus of research to develop suitable strains of importance in all the agro-climates. The fortified programme needs adequate budgetary support, during the next five year plan period, for research contingency under the expertise and tutelage of National Bureau of Agriculturally Important Micro-organisms (NBAIM).

3. Network Project on Biosystematics

This project has to be enlarged in its scope by incorporating all organisms that cause biotic stress in agro-ecosystem. The biodiversity of these organisms in agricultural environment need to be collected, catalogued and digitised.

4. All India Coordinated Project on Plant Parasitic Nematodes

This project is doing yeomen service to the farmers through identification of nematode problems, development of management strategies and conducting awareness campaigns in its centres. At present there are only 12 centres in the country, and it is recommended to increase to 18 centres in 18 states.

The serious reduction in the number of nematologists all over the country in SAUs is a cause of concern. It is imperative to enlarge this project so as to cover all the agro-climatic zones of the country for adequate representation. All ICAR crop institutes shall be voluntary centres of this AICRP. Separate Departments of Plant Nematology could not be established in many states, as there are not enough trained scientists in this field. Lack of adequate number Nematologists in many parts of the country in SAUs and ICAR Institutes is worrisome. It is imperative to enlarge this project so as to cover all the agro-climatic zones of the country for adequate representation. Manpower development in SAUs should be given priority.

5. All India Coordinated Project on Pesticide Residues

The AINP on Pesticide Residues has to be expanded into full-fledged AICRP with at least fifteen centres that represent all the fifteen agro-climatic zones. The pesticide residue issues have long-term concerns amongst consumers of domestic and international markets. The Indian obligations towards the generation of database for CCPR and JMPR of *codex alimentarius* as well as for the Ministry of Health for servicing Prevention of Food Adulteration Act need to be adequately enshrined in this programme and hence the upgradation is significant. All ICAR crop institutes, having commodity concerns with pesticide residues shall be voluntary centres of this AICRP.

SCHEMES TO BE DISCONTINUED OR MODIFIED

1. All India Network Project on Agricultural Acarology

This project has been in operation during the last four plan periods. It has served the purpose of its mandates in regard to providing awareness as well as developing solutions to major acarine problems in crops. The project has outlived its purpose over a period of time. The three major problems that are still causing concern are coconut eryiophyid mites, vegetable mites as well as the eryiophyid mite vector of pigeonpea sterility mosaic virus disease. The concerned crop research institutes of ICAR and SAUs in states, where the problems persist, have been deeply involved in these research areas. It is suggested that ICAR may launch a basic and strategic research project in few centres on this through competitive research grant.

2. All India Network Project on White grubs and Soil-borne organisms

This project has been in operation during the last four plan periods. It has served the purpose of its mandates in regard to providing awareness as well as developing solutions to major white grub problems in crops. The persistent problems in Uttaranchal state and eastern Uttar Pradesh in sugarcane due to white grubs as well as due to termites could be managed through research in concerned crop institutes as well as SAUs where the problems persist. It is suggested that ICAR launches a network strategic fund research project on white grubs, termites, cutworms, wireworms and weevils feeding on roots of many crops, as they have become serious following chemicalization of agriculture and climate change.

SCHEMES TO BE UPSCALED

1. All India Coordinated Project on Vertebrate Pest Management

Developing a new AICRP by combining AINP on Rodent Control and AINP on Agricultural Ornithology as AICRP on Vertebrate Pest Management is proposed. The dual research priorities in addressing these two key pestilence issues could be cohesively taken up by this combined programme. Further, this would facilitate the joint working of the two expert groups of the country having bio-diversity, ecology and management aspects to be commonly taken up along with utilisation of modern research tools for their population management. The aspects on predatory birds will also be covered.

2. All India Coordinated Project on Pollinators for Higher Crop Productivity

The existing AICRP on Honeybees Research and Training is recommended to be up-scaled into All India Coordinated Project on Pollinators for higher crop productivity. In order to undertake on the palinological and pollinator-behavioural studies in different agro-climatic regions of all potential pollinators including honeybees bumble bees, many flies, etc. Enabling processes for pollinator build up through intelligent agro-forestry and silvipasture tactics in addition to enhanced thrust on commercial apiculture is to be focused in cross pollinated crops.

Development of tools and techniques, methodologies as well as analytical approaches for assessing the impact of various recommendations, practices as well as *ex-ante* analysis of potential impacts of such recommendations shall be given major thrust. The impact of this project in sustained and cost-effective hybrid seed production of cross-pollinated various crops will be quite productive. Various ICAR institutions and SAUs shall be ideal for such networked programmes.

3. All India Coordinated Project on Integrated Pest Management

The next five year plan shall witness intensiveness of agriculture and hence it is imperative to develop and evaluate suitable models of Integrated Pest Management for various cropping systems in all the agro-climatic conditions in order to maintain the plant health of all crops at its best for effective metabolic enhancement to yield the best productivity. The All India Coordinated Project on Biological Control shall be suitably enlarged to be AICRP on Integrated Pest Management with the active involvement of both the Project Directorate for Biological Control and National Centre for Integrated Pest Management. This would bridge them through this common AICRP programme for Integrated Pest Management by upgrading AICRP on Biological Control. Natural and applied biological control will be integrated with other IPM tactics and tested as IPM modules in multi-locations and validated. This AICRP shall include biopesticide production labs in SAUs for upscaling manufacture processes, training & technology demonstration in every state. All the crop/horticultural institutes along with SAUs from all the agro-climatic regions shall be members of this Project. All ICAR institutes under Crop Science and Horticulture Divisions shall be voluntary centres of this AICRP.

4. Strengthening National Research Centre for Weed Science

Strengthening of National Research Centre (NRC) for Weed Science is recommended in order to address the various weed management issues as well as SPS aspects; this centre needs to diversify into expertise for weed seed identification. With globalisation of agriculture, there are increased chances of introduction of exotic weeds contaminants in grain/seed imports. This will automatically strengthen National Plant Protection Organisation (NPPO). Weed gene bank with sharpened molecular techniques for conservation of weed biodiversity, weeds as well as their use such as for medicinal purpose as also as sources for useful genes linked to abiotic and biotic stresses. A radio tracer laboratory and phytotron facility for studies on weed biology and ecology in addition to studies on herbicide dynamics in simulated agro-ecosystems is also required.

NEW INITIATIVES

1. National Animal and Plant Virology Research Institute (NAPVRI)

The **National Animal and Plant Virology Research Institute (NAPVRI)** is conceived to address the intensification of virology research in various crops to seek solutions to tackling many viral and phytoplasma infections. The concept note on this institute is available in Annexure II. The National Institute of Plant Virology (**Fig.1)** will address a few intriguing unresolved plant viral diseases for which etiology is not known such as Urdbean leaf crinkle disease, Parawilt disease of cotton, Arecanut yellows, Coconut root wilt etc. that evaded solutions in crop health for a long period of time. Major virus diseases in economically important crops such as Sunflower necrosis and Groundnut stem necrosis caused by *Tobacco streak virus*, Potato apical leaf curl caused by *Tomato leaf-curl virus*, *Groundnut bud necrosis virus* having a wide natural host range infecting tomato, potato, chilli, soybean, mungbean, urdbean, cucurbits etc. will be taken on priority and in depth study for virus-vector, host and environment need to be undertaken to develop management strategies by conventional and biotechnological approach. The institute will work on following diverse important aspects of the prioritized diseases for eventually finding management strategies and to act as a model for virologists working in other national laboratories to tackle stubbornly eluding solutions of many viral and phytoplasma diseases in field and horticultural crops. Animal virology research in animals including insects, mites etc. is to be given strong thrust.

2. National Plant Health Research Institutes (NAPHRI)

The Subgroup felt that there is a need for consolidation of research on plant health management. The National centre for Integrated Pest Management and the Project Directorate for Biological Control shall be merged to form a new institute, **National Plant Health Research Institutes (NAPHRI)**.

Ideally, integrated pest management has to seek solutions that have to be defined through all the available areas of suppression of pest population. Considering the enormous commonality between activities of these two institutes, it is recommended to ICAR to bridge them into a common AICRP programme for Integrated Pest Management by upgrading AICRP on Biological Control. All the crop/horticultural institutes along with SAUs from all the agro-climatic regions shall be members of this Project.

The Subgroup visualise this national institution to plan and execute research programmes of plant health management holistically. The concept note on this institute is available in *Annexure IV*. This umbrella organization shall address the above key national plant protection research programmes through implementation of basic and strategic research projects in its own ambit as well as network all applied inter-disciplinary research effectively. This is to provide effective leadership to all the prevailing plant protection programmes, as an apex organization for satisfying the national needs emanating out of SPS, CCPR/JMPR as well as PPQ issues of NPPO. Integration of resources is the call of the day for ideal optimizations. Research manpower, infrastructure utilization including laboratory tools and equipments, field facilities, mobility to farmers' fields etc. have to be integrated for ideal optimisations. Common facilities and technical manpower could be designed so as to reduce number of posts. While maintaining the autonomy and independence of various research systems in plant protection of DARE and available elsewhere, NAPHRI shall administer the Plant Protection research programmes in coordinated and network mode. ICAR, having the experience of National Agricultural Technology Project and now having designed the National Agricultural Innovative Project, could enable NAPHRI to be on a consortium mode for aiding public-private partnerships in addressing various issues of plant protection of the country.

Initiate strategic research through institutions and universities which can be invited on competitive mode for research to develop tools and techniques, methodologies as well as analytical approaches for assessing the impact of various recommendations, practices as well as *ex-ante* analysis of potential impacts of such recommendations shall be given major thrust. SPS related issues in the country to develop of suitable infrastructure.

3. Four PP Centres of Excellence in SAUs

Four PP **Centres of Excellence,** in SAU system (*Annexure V*) in four parts of the country may be developed, which shall be inter-institutionally networked under the National Centre of Integrated Pest Management along with Project Directorate for Biological Control. All PP research and development programmes in the country shall be networked through inter-ministerial networks. There should be a console at DAC-DARE (ICAR). This would ensure direction, accountability / responsibility; review/monitoring as well as collective wisdom. All professional societies shall be accountable for brainstorms on contextual PP issues as well as provide both solutions and advice R & D programmes for fellow scientists to take up through their institutions. Specific PP research programmes should be interlinked with national funding agencies such as DBT, DST, APPEDA, DoE and International agencies such as CGIAR and others. Good collaborations for research work shall be established with foreign universities/ research organizations in the areas under different sub-disciplines of Entomology, Plant Pathology, Nematology and vertebrate pest management as well as other relevant plant protection fields. The basic tenet of crop protection has to be put upon enhanced reliance on plants' capability to sustain invasion of various herbivores, but also through an enabled metabolic enhancement for compensation of crop loss. There is a strong need to revamp the direction of research in plant protection in order to acquire better understanding of the internal processes of each crop species alone and in combination with others of a cropping system and in sequence. Four centres of excellence in state agricultural universities on competitive grant mode in Western India, Eastern India, North India and in South India.

Strategic fund-based research in few critical areas such as pheromone research, indigenous synthetic process of botanical pesticides, development of microbial strains and their formulations against insects, microbial phyto-pathogens and nematodes.

4. Research thrusts during the next plan period:

The Plant protection research shall address the under-mentioned areas in the next five year plan period and some of them could attract competitive grant mode.

1. biodiversity and bio-systematics of all organisms of agro-ecosystems
2. Soil biology and rhizosphere engineering
3. crop health care modelling
4. components of host plants resistance, gone identification, multiple and durable resistance, transgenic induced systemic resistance biosystematics and biodiversity
5. tri-trophic relationships in cropping systems

6. insect genetics and breeding to improve efficiency of beneficial insects
7. development of better natural products and stable formulations
8. IPM for storage pests and pathogens; pre- and post-harvest management of myco-toxins; grain quality management and food safety
9. Synthesis of safer agro-chemicals

Special attention for research funding from strategic funds under NAIP, Karnal bunt of wheat, rice tungro, soil biology and rhizosphere engineering in regard to citrus decline, termites ins groundnut and sugarcane, white-grubs in hill agriculture and rain-fed areas, nematodes in various crops, elaborate studies on vectors such as thrips, mites, bugs and nematodes to develop management approaches of viral diseases in groundnut, sunflower and vegetables, root wilt of coconut, eriophyid mites in pigeonpea and coconut, arecanut yellows, mango malformation, Black Sigatoka (*Mycosphaerella fijiensisi*) Morelet [anamorph: *Paracercospora fijiensis* (Morelet) Deighton], Apple scab, interactive pestilence of viruses in crops, sugarcane red rot, white stem borer of coffee. A budget of Rs. 5-10 Crore of funding for each area is essential.

5. HRD in plant health management

Another core area is to revitalise the existing pattern of HRD (*Annexure* VI) in which there should be adequate thrust for plant health management as a thematic emphasis of integrated pest management (IPM) in educational programmes of the country through broad-basing the relevant syllabi to provide the graduates with aptitude, confidence, knowledge and skills to become entrepreneurs, to be well fitted into job on competitive basis; to become owners or managers of commercial farms; and to offer counselling and advisory service in agriculture and related fields at hours of need in villages. Fortifying curriculum in SAUs in this area for appropriate extra-mural research, post-graduate certificate course of appropriate duration in all the SAUs are proposed. Vocational education for social needs to develop trained manpower as middle level functionaries in villages to form para-agric team of the country as in para-medical team in order to practise plant health management, outreach educational programmes, (including through IGNOU and other deemed universities) etc. are certain other approaches to improve the interface between farmers and agri-specialists (Mehta, 1999).

FINANCIAL REQUIREMENTS

The following budget allocations are envisaged for the proposed plans of action in PHM Division of ICAR. An estimate of **Rs. 360 crores** is required as the budgetary provision for operating 3 institutes, 7 AICRPs, 2 Plan Network projects, as well as four Centres of Excellence during XIth five year plan period.

Budgetary provisions for XIth plan period for <u>Division of Plant Health Management</u>

(Rs in crores)

Schemes to be continued		Schemes to be up-scaled		New Schemes	
Scheme	Budget	Scheme	Budget	Scheme	Budget
AICRP on Plant Parasitic Nematodes	30	AICRP on Vertebrate Pest Management	40	National Plant Health Research Institute	35
AICRP on Pesticide residues	20	Network project on Biosystematics of insects, nematodes and plant pathogens	45	National Institute of Plant and Animal Virology	30
Network project on Application of micro-organisms in agriculture and allied sectors	30	AICRP on Pollinators for enhancement of crop productivity	50	Four centres of excellence	20
National Bureau of Agriculturally Important Micro organisms	25	**AICRP on Integrated Pest Management instead of AICRP on Biological Control**	35		
		Network project on mites	5*		
		Network project on White grubs, termites and soil borne arthropod pests	5*		
		Network project on Wilt diseases (fungus and bacteria)	5*		
		Network project on Mildew diseases	5*		
		Network project on Pheromone research (PPP)	10*		
		Network project on manufacturing processes of microbial pesticides (PPP)	10*		
		Network project on Pestilence diagnostics and its forewarning (PPP)	10*		
		Network project on Vectors of viruses in plant and animals	5*		
Total	105		170		85
Grand total					**360**
*** 8 Network projects from NAIP STRATEGIC FUNDS**					**55**

Annexure I

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

KRISHI BHAWAN, NEW DELHI- 110001

Dr. K.S. Khokhar
Asstt. Director General (PI & M)

F.NO.5(5)/2006-PIM Dated: 10-7-2006

O R D E R

Subject: Sub Groups constituted by XIth Five Year Plan (2007-2012) Working Group on Agricultural Research & Education.

In pursuance of the Order No. M - 12043/02/2006 - Agri. dated 9th May, 2006 of Planning Commission regarding constitution of Working Group on Agricultural Research & Education for XIth Five year Plan (2007-2012). The Working Groups in its first meeting held on 26-6-2006 has constituted Sub Group on **Plant Protection** as per the following composition and Terms and References:

I. Composition:

(i)	Dr. S.N. Puri, Vice Chancellor, CAU, Iroisemba, P.O. Box 23, Imphal-795004 Manipur, Tel: 0385-2410414 Email: snpuri@rediffmail.com, snpuri@rediffmail.com,	Chairman
(ii)	Dr. Anupam Verma, Ex. National Professor, ICAR, 253, Jaimaa Apartments, Plot No.16, Sector-5, Dwarka, New Delhi-110 075 Tel: 25072511 Email:anupamverma@vsnl.net	Member
(iii)	Dr. S. Jayaraj, Chairman, S. Jayaraj Research Foundation, No.39, First Floor, Main Road, A.G.S. Colony, Velachery, Chennai-600042 Tel: (O) 044-22533806 email: profsjayaraj@rediffmail.com	Member
(iv)	Dr. S.N. Nandal, Prof. & Head, Department of Nematology, CCSAHU, Hisar-125004, Haryana	Member
(v)	Dr. T.P. Rajendran, Asstt. Director General(PP), ICAR, Krishi Bhavan, New Delhi-110 001.	Member Secretary

II. Terms of Reference

(i) To make critical review of Xth Plan achievements in terms of Crop Protection research, in contrast to the objectives and targets set during Xth Plan.
(ii) To identify critical gaps in scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as enable the nation to enhance its agricultural competitiveness in the context of WTO & IPR regime.
(iii) To draw/suggest specific schemes/ programmes pertaining to crop protection research to address the problems of less privileged regions.

(iv) To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

(iv) To identify institutional mechanism for strengthening, monitoring and evaluation system in plant protection research, and to suggest efficient measures for effective coordination of agricultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public-private partnership.

(v) To draw/suggest specific schemes/programmes/research area pertains to crop protection research and frontline transfer of technology including linkages with developmental departments.

1. The Sub Group may also examine and address any other issues which are important but are not specifically spelt out in the ToRs or which were discussed and flagged in the First Meeting of Working Group held on 26.6.2006, the proceedings of which have already been circulated. The Sub Group may devise its own procedures for conducting its business/ meetings.
2. The expenditure of the official members on TA/DA in connection with the meetings of the Sub Group will be borne by their respective Ministry/Department as per the rules of entitlement applicable to them. . In case of non-officials, the TA/DA will be borne by the Planning Commission as admissible under SR 190(a).
3. The Sub Group will be serviced by the Department of Agricultural Research and Education, Ministry of Agriculture.
4. The Sub Group will submit its Interim Report by the end of August, 2006 and the final Report by the end of September, 2006 to the Chairman of the XI Plan Working Group.
5. Dr.(Mrs.)Vandana Dwivedi, Joint Adviser(Agriculture)Planning Commission, Room No. 230, Yojana Bhavan, New Delhi-110001, Tel No. 011-23096730, Email: dwivediv@nic.in and FAX No. 011-23327703 will be the nodal officer of this Sub Group and any further query/correspondence in this regard may be made with her.

(K.S.Khokhar)

Member Secretary

TO

1. The Chairman and all Members (including Member-Secretary) of Sub Group. 2.Chairman, Working Group on Agricultural Research & Education for the XIth Plan Five Year Plan

3.Dr.(Mrs.) Vandana Dwivedi, Joint Adviser(Agriculture)Planning Commission, Room No. 230, Yojana Bhavan, New Delhi-110001

Annexure II

XTH PLAN ACHIEVEMENTS OF PLANT PROTECTION SECTION

National Bureau of Agriculturally Important Microorganisms (NBAIM) **X Plan targets:** 1. Exploration and collection of agriculturally important micro organism (AIMs) from the soil, plants, freshwater etc.-covering different agro-climatic regions. Collection of AIMs from existing culture collection centers, institutions and universities. Bureau will function as a repository for all the agriculturally important micro organisms available in the country. Repatriation of cultures of Indian origin from different culture collections located in other countries including international centers. Identification, characterization and documentation of AIMs. Morphological, physiological, biochemical and molecular characterization based on prioritization with expansion IPR regimes. Development of molecular markers and diagnostic tools. Database of the entire collection of electronic format for easy access to information.	**Significant achievements:** Of the various isolates obtained during the surveys carried out by NBAIM, several strains belonging to *Bacillus subtilis*, *B. brevis, Fusarium oxysporum, Hypocrella discoidea, Metarhizium anisopliae, Pseudomonas sp. Trichoderma harzianum* the growth of soil borne pathogenic fungi *in vitro.* Of the various strains screened *P. fluorescens* isolate Pf4-92 improved the plant growth and reduced the incidence of Fusarium wilt on chickpea. An antifungal compound isolated from the bacterium was soluble in methanol and ethyl acetate and was analysed by HPLC and IR spectroscopy. Pathogenesis related proteins, chitinase and β 1, 3 - glucanases were induced in chickpea and were partially purified by gel filtration. The molecular mass of the purified chitinases were 31 and 62 and β1,3 – glucanases were 23, 27 and 39 kDa. Toxin from *Colletotrichum falcatum and C. capsici* was partially purified and was found to produce symptoms on sugarcane and red chilli respectively. The toxin was not found to be host specific. Toxin produced by *C.capsici* consisted of μ,β- unsaturated carbonyl, C=C-C=C-C=O, methylene, aliphatic C-H, C=O and C-H groups. The structure of the toxin from *C. falcatum* was also worked out and had a molecular weight of 203. Among the 34 isolates, 10 different genome clusters were defined at the 74% similarity coefficient. Clusters A, B and E were the major groups and contained 10, 4 and 6 isolates respectively. Interestingly all the isolates of this cluster could solubilize phosphorus. Conversely isolates from single location were distributed in different clusters. All the isolates in clusters C, H, I and J and one isolate each from clusters B and D failed to solubilize phosphorus. A total of 22 isolates of actinomycetes were screened for cellulase and xylanase activity. Six isolates with high unit of enzyme activity were identified to be utilized for biocomposting. Two species-specific primers were designed from the conserved sequence of ITS region of *Macrophomina phaseolina*. They were tested for their specificity with other soil borne microbes and were found to be specific only for *Macrophomina*. Long term and short term preservation of bacteria and fungi are maintained on slants. Fungi are maintained under mineral oil for short term preservation while bacteria are maintained as glycerol stock at –80° C. For long term preservation, 600 bacterial cultures have been lyophilized and rests are in the process of lyophilisation.

2. Conservation, maintenance and utilization of AIMs. Short-term and long-term conservation. Conservation of obligate parasites on host plants under controlled conditions. Build-up and exchange of exsiccate sets. Identification of AIMs for utilization as biofertilizer, biopesticides, food processing etc. Utilization of domestic tools. Utilization of molecular and immunological marker for diversity analysis. Information exchange. Preparation of monographs and synoptical keys for identification of AIMs. Surveillance of indigenous and exotic AIMs.	The following are the details of the culture collections centers from where NBAIM obtained Microbial cultures 1. CABI Bioscience, UK – 1450 Fungi 2. ATCC, USA- 20 fungi 3. HUT, Hiroshima Univ. Japan – 12 fungi 4. Fungal Genetic Stock Centre, USA- 21 fungi 5. Agricultural Research Service Culture collection, USA – 27 fungi 6. Bacillus Genetic Stock, USA -- 8 bacteria In addition, large numbers of cultures were obtained from the culture collection distributed throughout the country. From the various research institutes and universities a total of 395 bacterial and 1524 fungal cultures were obtained. About 1800 fungal cultures of Indian origin were to be repatriated from CABI, UK. 1450 cultures have been received so far. Software was developed at NBAIM for the digitization of microorganisms. It has been designated as 'MicroNBAIM'. The software is in Visual Basic with DOTNET with the features of accessing information on any microorganism
3. Surveillance of indigenous and exotic AIMs. 4.Microbial biodiversity and systematic. 5.Human resource development (HRD).	available at NBAIM by clicking on the particular group to which it belongs, that is, Bacteria, Fungi, Actinomycetes or Cyanobacteia with geographical location from where isolated, name of the donor (person or Institute), name of the depositor, cultural details of microorganism, the form in which it is preserved and many more with 200 fields with report generation component in PDF format. Collection of *Fusarium* Spp. From various agro-climates in pulses, cereals and cucurbits have been taken up and more than 100 isolates have been deposited from the Network project. These are under characterization. Projects of the institute on the survey for Indo-gangetic plains are in progress. A number of microbials have been brought to the Bureau during the current year for characterization.

Network Project on Application of microbes in agricultural and Allied Sectors (AMAAS) **X Plan targets:** Theme 1: Microbial Diversity and Identification Theme 2: Nutrient Management, PGPR and Biocontrol Theme 3:Agro-waste Management, Bioremediation and Microbes in Post Harvest Processing Theme 4: Microbial Management of Abiotic Stress Theme 5: Microbial Genomics	**Significant achievements:** The project was launched during 2004-05. The identified centres were sensitised about the targets of the various themes in the launch workshop. The infrastructure in terms of equipments has been put in place and the research work is in progress.
	Significant achievements: **Salient achievements:** The successes in the institute-funded projects attracted inter-institutional collaborative programmes wherein "online pest reporting system (www.ncipm.org.in/ipmnetwork)" has been initiated to collect data in an uniform patterns to suit other objectives. A thumb rule developed to predict *Helicoverpa armigera* in Deccan region has been field validated using historical data for this region and is being used successfully for forewarning the pest outbreaks in Karnataka. Forecasting models were also developed for potato aphids (*Myzus persicae*) at Pantnagar (Uttaranchal), Deesa (Gujarat) and Kalyani (W.B), to predict aphid population two weeks in advance. Geographical pest distribution maps of rice and cotton have been

	developed using Geographic Information Systems (GIS) for identifying the hot spots of key pests.
	The community approach and participation of farmers as decision makers in IPM successfully demonstrated at Ashta in cotton and in Basmati Rice at Shikohpur (UP) during the IX Plan were further replicated over larger areas with fine tuning as per area specific needs during the X Plan. The successes in the institute-funded projects attracted external funding from TMC, NATP and AP-Cess. These projects helped to forge a more sizable network consisting of SAUs, ICAR Institutes, AICRPs, NGOs, Central Instts. (BARC), and private seed and pesticide industry. The activities have grown further to cover vegetables, protected cultivation, sugarcane and fruit crops and helped in promotion of technologies in an area of > 4000 ha through Mission mode projects (TMC and NATP) covering > 150 villages. • **Basmati Rice:** IPM modules were validated in farmers participatory mode for *Pusa Basmati* 1, *Taraori Basmati,* and *Dehraduni Basmati*, which are the export oriented varieties covering 80% of the total area under Basmati Rice in India. This crop consumes on an average 5 kg/ha of pesticides which was reduced < 0.2 kg/ha with higher economic returns. Adoption of IPM in *Pusa Basmati* 1 alone would result in an additional gain of Rs. 704 crores per annum. Impact assessment of IPM in *Pusa Basmati* 1 and *Taraori Basmati* showed the sustainability of the approach. • **Organic rice:** Validation of IPM strategies in the organically grown exportable basmati rice initiated in Haryana indicated better performance of scientifically proven IPM components compared to conventional practices used by farmers. • **Rice-Wheat Cropping System:** IPM validation in rice and wheat in rice-Wheat cropping system under NATP during 2000-04 at some locations of Indo-gangetic plains revealed higher economic returns and cost benefit ratios in both the crops. • **Cotton:** "Ashta model" of community approach was successfully replicated at 15 villages across 3 zones over 652 ha. resulting in 60% reduction of pesticide use and 24% increase in seed cotton yield over non-IPM. IPM technology developed for conventional cotton was adapted to Bt cotton which showed improvements in yield. Bt technology proved to be an important component of IPM though its evaluation across the 3 zones showed varied performance leaving room for

	conventional cotton. Biotic stresses hitherto unknown/minor were identified in response to Bt cultivation. • **Oilseeds:** IPM technologies for mustard, groundnut, castor and safflower were validated at 9 centres in the country. In all the cropping systems, IPM practices increased population of natural enemies, decreased pest incidence and produced higher yields. • **Pulses:** IPM strategies in chickpea and pigeonpea at various locations under diverse cropping systems were validated. Use of pheromones, microbial and botanicals were promoted as alternatives to chemical pesticides. • **Vegetables:** IPM worked well for okra and brinjal which resulting in reduction of pesticides sprays to 4-6 from 9-12 in farmers' practices. In protected cultivation, use of microbials as IPM components has been promoted for vegetables and ornamentals. The following databases and decision making softwares have been developed to meet the requirements on various aspects of national plant protection needs. Pest Management Information System – a generic software for Basmati rice, Cotton, Mustard, Chickpea, and Groundnut. Pesticide Advisor – Version 2005.1.0. to assist judicious use of pesticides under IPM ambit.
	15 online databases at NCIPM website (www.ncipm.org.in/databases.htm) made available to cater the information needs (consumption of pesticides, banned, restricted, registered, pest resistance) on critical inputs. (a) Explorations of Indigenous Technical Knowledge (ITKs) in pest management in cotton based cropping system documented. (b) Interactive "Kiosk" (English and Hindi) developed to provide technical and general information. Educational video films developed to promote cotton IPM. Print media developed for educating farmers and extension workers about pest and beneficials of different crops, utilization of biodiversity and local resources in pest management. Integrated Pest management tools and techniques in various crops were researched upon. The significant results are given below:

	Validated IPM protocols in *Pusa Basmati 1* Baghpat (Uttar Pradesh), *Taraori Basmati* Panipat (Haryana) and in *Dehraduni Basmati*, Dehradun (Uttranchal) gave higher yield levels viz. 55.68; 27.09 and 21.16 q/ha in IPM as against 45.77; 22.32 and 18.12 q/ha in FP in *Pusa Basmati 1* with higher population of natural enemies. Impact assessment of IPM in Rice Pusa Basmati -1 in Baghpat (U.P.) showed the sustainability of IPM technology and adoption of all its components by 90% of the farmers. Basmati rice grain, soil and water samples collected from IPM and non-IPM trials of rice field, from Kaithal and Dehradun region showed that basmati rice was free from any of the pesticides. Residues of pesticides i.e. lindane, atrazine, chlorpyriphos and pendimethalin in soil and water samples of rice from Kaithal region were observed to be below detectable level (BDL). Reduction of number of pesticides sprays to 4-6 from 9-12 in farmers' practices (FP). A higher yield of 110.71q/ha and 105.79 q/ha in IPM and 76.19 q/ha and 74.60 q/ha in non-IPM fields in Raispur & Harsawan was obtained resulting into a higher C: B ratio of 1:1.71 and 1:1.26 in IPM and 1:0.87 and 1:0.68 in non-IPM fields, respectively. Similarly, in brinjal crop, spraying was reduced to 2-3 in IPM fields in comparison to 5-7 in non-IPM fields and with fruit yields of 394 and 424.4 q/ha in IPM and 302.6 and 311.2 q/ha in non-IPM fields. IPM technologies for mustard and groundnut crops were validated in Navgaon (Alwar) and Sriganganagar and results revealed that seed (10 g/kg) and soil application (4 kg/ha) of *T. harzianum* significantly reduced (51-60%) collar rot incidence and rendered 17 to 24 per cent higher yields as compared to Farmer Practice where improved technology components were not provided. IPM approach in Haryana for cotton has shown higher seed yield (15.90 q/ha) and cost benefit ratio (1:3.17) in IPM as compared to FP (14.55 q/ha and 1:2.60). There was significant decrease in number of sprays (2.0) and quantity of commercial grade insecticides (3.13 kg/ha) in IPM as compared to FP (5.83 and 6.54 kg/ha), respectively. Even after withdrawal of the input support, the cotton farmers in Nanded district of Maharashtra continued to adopt at least 4 out of 10 IPM components in cotton. More than two-third of the farmers continue to adopt 5-7 IPM components. Egg Collection Device, "Aerial Insect Trap", "UV (Ultra violet) Chamber for large scale *Corcyra* eggs sterilization", "Foolproof

	cage for rearing *Corcyra cephalonica*", "Mating and oviposition cage for *Helicoverpa* during winter season" have been adopted. IPM approach in Haryana for cotton has shown higher seed yield (15.90 q/ha) and cost benefit ratio (1:3.17) in IPM as compared to FP (14.55 q/ha and 1:2.60). There was significant decrease in number of sprays (2.0) and quantity of commercial grade insecticides (3.13 kg/ha) in IPM as compared to FP (5.83 and 6.54 kg/ha), respectively. Even after withdrawal of the input support, the cotton farmers in Nanded district of Maharashtra continued to adopt at least 4 out of 10 IPM components in cotton. More than two-third of the farmers continue to adopt 5-7 IPM components.
	Egg Collection Device, "Aerial Insect Trap", "UV (Ultra violet) Chamber for large scale *Corcyra* eggs sterilization", "Foolproof cage for rearing *Corcyra cephalonica*", "Mating and oviposition cage for *Helicoverpa* during winter season" have been adopted. Distribution maps and the associated hot spots of insect pests and diseases of cotton were published. Developed information modules comprising of user friendly softwares, video films, 14 posters & 9 photo blowups of crop pests & natural enemies in Hindi and English and loaded in kiosks. 19 Training programmes were organized and 320 subject matter specialists were exposed to IPM activities. The successes in the institute-funded projects attracted inter-institutional collaborative programmes wherein "online pest reporting system (www.ncipm.org.in/ipmnetwork)" has been initiated to collect data in an uniform patterns to suit other objectives. A thumb rule developed to predict *Helicoverpa armigera* in Deccan region has been field validated using historical data for this region and is being used successfully for forewarning the pest outbreaks in Karnataka. Forecasting models were also developed for potato aphids (*Myzus persicae*) at Pantnagar (Uttaranchal), Deesa (Gujarat) and Kalyani (W.B), to predict aphid population two weeks in advance. Geographical pest distribution maps of rice and cotton have been developed using Geographic Information Systems (GIS) for

	identifying the hot spots of key pests. Softwares have been developed to meet the requirements on various aspects of national plant protection needs. Pest Management Information System – a generic software for Basmati rice, Cotton, Mustard, Chickpea, and Groundnut. Pesticide Advisor – Version 2005.1.0. to assist judicious use of pesticides under IPM ambit. 15 online databases at NCIPM website (www.ncipm.org.in/databases.htm) made available to cater the information needs (consumption of pesticides, banned, restricted, registered, pest resistance) on critical inputs. Explorations of Indigenous Technical Knowledge (ITKs) in pest management in cotton based cropping system documented. Interactive "Kiosk" (English and Hindi) developed to provide technical and general information. Educational video films developed to promote cotton IPM. Print media developed for educating farmers and extension workers about pest and beneficials of different crops, utilization of biodiversity and local resources in pest management.
	A total of 19 training programmes (week to month long) were organized and 320 subject matter specialists trained on the following topics: National training on IPM in important field crops Mass production technology of biocontrol agents Online monitoring of pests International training programme on IPM **Improved techniques:** UV Chamber for large scale *Corcyra* eggs sterilization Foolproof cage for rearing *C. cephalonica* Mating and oviposition cage for *Helicoverpa* during winter

Project Directorate for Biological Control (PDBC) **X Plan targets:** Quantification of natural enemy biodiversity through development of a biosystematic database on insects, pathogens and nematodes Enhancing the sustainability in crop production through increased uptake of biological control strategies either by conservation or augmentation Facilitating commercial scale production of key species of bioagents for large scale utilization Development of rearing techniques on synthetic diets for cost-effective commercial production of bioagents Development of superior strains of bioagents for different crop ecosystems Identification of biocontrol friendly crop genotypes	**Significant achievements:** Studies on biosystematics on Indian coccinellidae progressed to the extent of preparation of identification guide of 125 spp. of coccinellidae which has been uplinked to a web site coccinellidae. The weed biocontrol agent *Cecidochares connexa* imported from Indonesia and released in Bangalore has established well resulting in significant reduction in the growth of *Chromolaena odorata*. *Puccinia spegazzinii* the rust pathogen of *Mikania* has been released to Assam and Kerala for the biological control of *Mikania*. The Sugarcane woolly aphid has been effectively suppressed in the states of Maharashtra, Karnataka and Tamil Nadu using the predators, particularly *Dipha aphidivora* and *Micromus.* Improved strains of *Trichogramma* with multiple pesticide and temperature tolerance and high hosting searching ability were developed and their field efficacy demonstrated in Gujarat, Tamil Nadu and Karnataka. *Dipha aphidivora* (Pyralidae), *Dideopsis aegrota* (Syrphidae), *Cheilomenes sexmaculata, Anisolemnia dilatata, Synonycha grandis* (Coccinellidae) were recorded as predators of sugarcane woolly aphid (SWA). *Cryptolaemus montrouzieri* was successfully reared on *S. cerealella* eggs for five generations. A method was standardized for mass rearing of *Sitotroga cerealella.* Successfully developed semi-synthetic diets for chrysopids, *Orius tantillus*, *Cryptolaemus montrouzieri* and *Cheilomenes sexmaculata,* which supported their development. Artificial diets successfully developed for the coconut leaf-eating caterpillar, *Opisina arenosella* and *Plutella xylostella.* Developed a novel technique of modified atmosphere packing and storage of *Corcyra cephalonica* eggs, which enhanced the shelf-life of *C. cephalonica* eggs by 3–4-fold. Protocols were standardized for PCR and RAPD-PCR studies on *Trichogramma* spp. For the first time in India, the ITS-1 and ITS-2 regions were used for molecular identification of seven species/strains of *Trichogramma* through PCR and RAPD-PCR. PCR amplicons were sequenced and accession numbers were obtained from NCBI GenBank.

Formulation of kairomones and synomones for enhancing the effectiveness of parasitoids and predators.	A simple magnetic stirrer technique for faster mass production of *Hirsutella thompsonii* has been developed. A wettable powder formulation of *H. thompsonii* sprayed twice at 50 g/l, reduced *Tetranychus urticae* population by up to 62.7% on okra in farmers' field in Coimbatore (Tamil Nadu). Isolate *Bt* 4 showed (log 5.83 spores/ml) highest toxicity to *Plutella xylostella*. Congo Red was a better UV protectant for Bt. *Bacillus megaterium* (MTCC 6533). A checklist of the Coccinellidae fauna of the Indian subcontinent has been prepared. A website on the Coccinellidae of the Indian region featuring image galleries of common species and their natural enemies has been constructed and hosted. An identification guide to 125 species of coccinellids commonly found in the agro-ecosystems of the Indian subcontinent has been prepared. A host-parasitoid list and a checklist of the fauna of the Indian region have been prepared for Tachinidae of the Indian region. An interactive identification key to the families of insect bioagents and a pictorial guide to insect bioagents on CD Rom have been prepared.
	The gall fly, *Cecidochares connexa,* introduced from Indonesia for trials against the Siam weed, *Chromolaena odorata,* did not attack 78 species of plants in host-specificity tests. Limited field releases of the stem gall fly at the UAS, Bangalore, resulted in significant decrease in several plant growth parameters. *Trichogramma* sp. nr. *mwanzai* from Kenya for evaluation against *Helicoverpa armigera*) and *Eriborus trochanteratus* (adapted to *Opisina arenosella* from Sri Lanka) were introduced. *Puccinia spegazzinii*, the rust pathogen of *Mikania micrantha* has been established in the containment-cum-quarantine facility (CQF) at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi Four anthocorid predators, *Cardiastethus exiguus, Blaptostethus pallescens, Orius tantillus* and *O. maxidentex* were successfully mass produced in the laboratory. *Orius tantillus* was reared on *Corcyra cephalonica, Blaptostethus pallescens* was found to prey on *H. armigera* eggs/larvae on chickpea *C. exiguus* was effective @ 50 predators per palm against *Opisina arenosella*. Storage and shipment techniques for *Telenomus remus* were standardized.

	Large cages measuring 1.7x1.7x2.5′ were utilized effectively for multiplying ichneumonid parasitoids, *Campoletis chlorideae* and *Eriborus argreteopilosus*. A temperature of 26-28°C and 70-80% relative humidity were optimum for production. Creation of quarantine facilities of international standard for facilitating the import/exchange of beneficial organisms and to make available several new natural enemies for use Creation of quality control mechanism for biocontrol agents Identification of virulent/host specific pathogens/antagonists against insects, plant diseases, phytonematodes and weeds using biotechnological tools Developing Information System on Biocontrol using latest tools in information technology Isolates of *Pochonia chlamydosporia, Paecilomyces lilacinus*; *Trichoderma, Arthrobotrys oligospora* and *Pseudomonas fluorescens* were isolated and were antagonistic to cyst, reniform & root-knot nematodes. Molecular identity of PDBC isolates of *P. chlamydosporia* was established and gene sequences registered in the Genbank, NCBI, Maryland, USA. Media and protocols for solid, liquid and di-phasic mass production standardized for *Arthrobotrys oligospora* for the first time in India. Integration of antagonistic fungi, soil solarization and organics effectively controlled root-knot and reniform nematode infection in vegetables, gherkin, grapevine and polyhouse crops, and root-knot nematode-Fusarium wilt disease complex in tomato and pepper. Talc formulations of *P. lilacinus & P. chlamydosporia* reduced golden cyst nematode in potato & pigeon pea cyst nematode in pigeon pea in AICRP trials. Yeast granules were found to be suitable for mass production of *Nomuraea rileyi* on rice grains, which are much cheaper than the yeast extract. Maximum conidial production of *N.rileyi* on Rice+ 5% Yeast granules was observed at 25^{o}C and 90% RH ($3.7X10^{9}$ cfu/g). Mass production technology for *Beauveria bassiana* was standardized using ten-liter fermentor and corn meal broth. Soy jaggery yeast broth was found more suitable for liquid fermentation technology for Metarhizium *anisopliae*. Promising strains of *N. rileyi* against *H. armigera and S. litura*, *B. bassiana* and *M. anisopliae* strains *P. xylostella* and *A. gossypii* and *V. leca*nii isolates against *A. craccivora* were identified based on bioassays.

	A cheap and rapid mass production protocol was developed for *Steinernema tami* PDBC EN 2.1, *S. carpocapsae* PDBC EN 6.11, *Heterorhabditis indica* PDBC EN 13.3 and *H. bacteriophora*. Artificial media for higher yields of *S. carpocapsae* and *H. indica* were developed. LC50 and LD50 for *H. indica* and *H. bacteriophora* , *S. abbasi* and *S. carpocapsae* against *P.xylostella*, *S. litura*, and *H. armigera* larvae worked out. *H. indica* was found more virulent than *S. carpocapsae* against *P. xylostella*. Sodium sulphate (0.25-1%) was effective as UV protectant for *S. carpocapsae* and *H. bacteriophora* when sprayed on cotton leaves. Gum-based gel formulation was suitable for storage and transport of *S. carpocapsae* IJs for 30 days at 30°C. Talc-based formulation of *S. carpocapsae* was found suitable and stable for surface transport. Persistence of *S. carpocapsae, S. abbasi, H. indica* and *H. bacteriophora* under shaded and open conditions in soil ranged from 60 to 90 days. Starch, Triton X 100, glycerol, castor oil and liquid paraffin as antidesiccants at 0.5- 1.5% were safe to *S. carpocapsae* (PDBC EN 11) and *H. indica* (PDBC EN 13.3) and aided in survival of nematodes sprayed. Improved strains of *Trichogramma chilonis* (with high temperature tolerance, multiple insecticide resistance and high host-searching ability) and *Trichogrammatoidea bactrae* (with high host-searching ability for use against *P. xylostella*) have been developed. Field releases of multi-insecticide tolerant strain (MITS) of *T. chilonis* at GAU, Gujarat; CICR Regional Station, Coimbatore; UAS, Dharwad and TNAU, Coimbatore against cotton bollworms in cotton resulted in low percent boll damage, higher per cent egg parasitism and higher yield in treated cotton compared to the fields that received non- insecticide tolerant trichogrammatid populations. Field releases of temperature-tolerant *T. chilonis* at Regional Station (CICR), Coimbatore, recorded higher parasitism and lesser damage of fruiting bodies in cotton. Similarly, the release of temperature-tolerant *T. chilonis* at RRS, Karnal, reduced the incidence of stalk borer, *Chilo auricilius* in sugarcane. High temperature tolerant strains of *T. chilonis* and *T. japonicum* were developed. Similarly, low temperature-adapted strains of *T. chilonis* (18-24^{o}C) and *Chrysoperla carnea* (18° - 24°C) were developed. Jaggery-soy medium gave good biomass of *Trichoderma harzianum*. Addition of glycerol (3 and 6%), colloidal chitin (0.2%) in production medium or 2% chitin in formulation enhanced shelf life of *Trichoderma harzianum* formulation. Heat shock at the end of fermentation at 35^{o}C for 45 min enhanced the shelf life of *T.*

	harzianum up to 8 months. *T. harzianum* isolate GTH-7 and *T. viride* isolates Tv23, Tv5, Tv8, Tv30, Tv32, Tv23 and Tv35 showed high endochitinase activity. *T. harzianum* isolates Th-14, Th-1, Th-6 and Th-8 and *T. viride* isolates Tv3, Tv8, Tv10, Tv23, Tv25, Tv28, Tv30 and Tv32 showed high exochitinase activity. TV17, TV23, TV25, TV30, TV31, TV34 and TV 35 were found to be highly efficient in the bioassay against chick pea wilt pathogen *Fusarium ciceri*. NPVs of *Trichoplusia ni, Spodoptera exigua, Crocidolomia binotalis, Opisina arenosella, Chilo infuscatellus, Chrysoperla carnea* and *Cadra cautella* have been isolated and tested. Popularizing biological control as an important component of pest management for adoption by farmers **Strengthening the capacity and expertise of scientific personnel by exposing them to advancements taking place in other countries** Strengthening the existing training facilities for HRD in biological control for Asian region. Developed a novel technique of modified atmosphere packing and storage of *Corcyra cephalonica* eggs, which enhanced the shelf-life of *C. cephalonica* eggs by 3-4 fold. A novel method of storage and shipment for *Telenomus remus* has been developed. Strains of *Trichoderma* spp. with high chitinase activities have been identified. Techniques of efficient mass production of several fungal biocontrol agents were standardized. Molecular characterization of several biocontrol agents has been done and gene sequence registered in the Gen Bank of USA. A CD version of the software, \`Helico-info' and expert system BIORICE for biocontrol of rice-pests were developed. Kairomones treated *Campoletis chlorideae* batches improved parasitism (40.2%) compared to control (25.0%). *Fusarium pallidoroseum,* a potential biocontrol agent for parthenium, was formulated as powder, oil emulsion, alginate pellets and pestagranules. *Alternaria alternata,* a pathogen of water hyacinth was mass-produced by fermentation method and formulated in powder, oil emulsion, alginate pellets and pestagranules. Under open-air conditions, significant disease severity with two sprays was obtained. A CD version of the software, "Helico-info" and Expert system 'BIORICE' for bio-control of rice-pests were developed.

All India Coordinated Research Project on BIOCONTROL **X Plan targets:** To exploit indigenous biodiversity of natural enemies in biocontrol Import potential agents in the absence of effective indigenous natural enemies Conservation of biocontrol agents and enhancing their effectiveness by establishment of crop habitat diversity Augment biocontrol as part of IPM for ecofriendly perst management Promotion of public-private sector joint R & D efforts to enhance the commercial scale production and uptake of quality biocontrol agent	**Significant achievements:** Natural occurrence and feeding of coccinellid predators such as *Coccinella* spp., *Cheilomenes* sp., neuropterans, *Mallada* spp. were noticed on sugar woolly aphid (SWA) in four severely affected districts of Maharashtra. The release of *Dipha* in shade nets recorded 93.6- 97.2 % control of SWA. A simple laboratory technique was developed for rearing *D. aphidivora.* Eight releases of *T. chilonis* (@50,000/ha) at 10 days interval proved effective against *Chilo infuscatellus* and *Chilo auriculius* on sugarcane. Large scale demonstration of biocontrol of early shoot borer of sugarcane using *T. chilonis* was conducted at Pravaranagar, Maharashtra. BIPM module using *Trichoderma, Chrysoperla carnea* and neem based insecticide sprays effectively controlled sucking pests, bollworm and *Spodoptera litura* in *Bt* and non-*Bt* cotton. *Nomurea rileyi* @ 10^{13} spores/ha suppressed *H. armigera.* BIPM with *Trichoderma* and *B. bassiana* minimized pest and disease damage and increased yield in soybean. Integrated use of *T. chilonis* and *T. japonicum* @ 1,00,000/ha reduced *C. medinalis* and stem borer of rice. *Verticillium lecanii* and *Ischiodon scutellaris* @ 1000 adults/ha (50,000 larvae/ha) sprays controlled *Lipaphis erysimi* in mustard. Two new formulations of *Hirsutella thompsonii* along with Mycohit against coconut mite in multi-location trials significantly reduced the mite population. *Bacillus thuringiensis* was effective against pomegranate fruit borer, *Deudorix* spp. *Encarsia* spp. including *E. guadeluopae* effectively parasitized spiralling white fly on guava in Maharashtra and Kerala. This was also demonstrated in the farmer's orchards in Karnataka. Enhancement of shelf-life of *Trichoderma* and *Pseudomonas* formulations. Bt @ 2 kg/ha was very effective against brinjal shoot and fruit borer and increased fruit yield. *V. lecanii* @ 10^{10} conidia/L was found effective against thrips on chilli in Maharashtra. *Neochetina eichhorniae* and *N. bruchi* established successfully in Assam, A.P. Gujarat, Kerala, Maharashtra, T.N. and Punjab.

	Mass multiplication of *Dipha aphdivora*, a predator on sugarcane woolly aphid has been standardized. Inoculative releases of this predator in Maharashtra, Karnataka and Tamil Nadu have successfully suppressed the aphids. Demonstration programmes on the management of woolly aphid given to sugar factories in Tamil Nadu.
	Release of *Trichogramma japonicum* alone was sufficient for the management of both stem borer and leaf folder of rice. BIPM practices suppressing the sucking pest complex and increasing the yield of Bt cotton developed. Improved strains of egg parasitoids (heat tolerant strains and multiple insecticide tolerant strains of *Trichogramma*) found promising for the management of cotton boll worms identified. Biological control based management package developed for the management of pod borer complex in pigeon pea. A biocontrol module consisting of *Trichogrammatoidea bactrae* and *Bacillus thuringiensis* was developed for the management diamondback moth on cabbage. *Encarsia guadeloupae* identified as an effective parasitoid against spiraling white fly on guava. *E. perniciosi* and *Aphypis proclia* were identified as potential bioagents for the management of San Jose scale. Technology of using trap crops and NPV against *S. litura* on tobacco is perfected. Large scale demonstrations were conducted on the use of *Zygogramma bicolorata* against parthenium, EPN against white grubs in golf course, and *Cryptolaemus montrouzieri* against grape vine mealy bug. BIPM technology for the management of tomato fruit, boll worm of cotton, and stem borer and leaf folder of rice well demonstrated in farmers' fields.

All India Coordinated Research Project on Honeybees Research & Training **X Plan targets:** Utilization of honeybees for pollination of different crops in field and poly-houses To conduct research on honeybee breeding for disease resistance and high yielding strains To conduct multi-locational trials in different agro-climatic conditions on management of honeybees for higher production of hive products To conduct location specific research on honeybee disease, enemies and their management To organize and impart trainings on various aspects of beekeeping with special reference to mass queen rearing and royal jelly production	**Significant achievements:** In sweet orange *Apis mellifera* honeybees play major role in good fruit set as well as less fruit drop. Initial fruit set was lowest (57.69%) in self pollination treatment and highest in. *A. mellifera* (76.88%) pollination treatment followed by open pollination (66.55%). The per cent increase in fruit set over self pollination was 19.19 per cent in *A.mellifera*, 9.85 per cent in open pollination treatments. The fruit drop percentage was lowest in *Apis mellifera* treatment (16.32%) compared to self pollination (20.31%) and open pollination treatment (21.81%). *Apis mellifera* bee pollination in snap melon resulted in highest yield (17.0 Q/ha) as compared to without bee pollination i.e. self pollination (11.46 Q/ha). The fruit weight was also high in bee pollination (250 grams) than in self pollination (193.5 grams) and open pollination (183.5 grams). Litchi orchards where *A. mellifera* honeybee colonies were placed produced more number and heavier fruits. The maximum number of fruit set and fruit weight were obtained from the orchard where 25 colonies per ha. were placed. Hence for proper pollination of litchi 25 colonies per ha are recommended. Cage sizes (6x3, 6x6 and 12x3 m) did not significantly affect the yield of *Brassica napus.* However, the cages with 4 frame bee strength colonies resulted in higher self yield and more darting than with 2 frame bee colonies. Heavier and bigger strawberries were produced by placing 4 *A.mellifera* colonies under caged condition in variety Chandler (19.8g), Belrubi (19.1g) and Etna (19.1g). Studies also revealed that there is need to evaluate some bee attractant to enhance bee activity.
	Gala selection has been recommended as a polarizer of standard variety Vance Delicious. It was found that average fruit set was 66.23 and 65.38 per cent in bee pollinated and hand pollinated flowers with Gala pollen. However, fruit set in open pollinated Vance Delicious with standard pollinizer was 64 – 66 percent. Four *Apis cerana* colonies of 15,000 workers strength have been recommended for obtaining optimum yield i.e. 48.88 t/ha in Assam lemon. For pollination of cucumber and muskmelon in polyhouse (80x20x10 ft.) introduction of 3 frame strength nucleus honey bee

	colonies (*Apis mellifera*) of young bees at the time of flower initiation in the crop has been recommended. A technique to train the foragers of *A. cerana, A.mellifera, A. florae, A. dorsata and Mellipona sp.* was developed to feed on desired location. Based on the technique developed a method was devised to utilize the bee foragers in hybrid seed production of *Brassica napus*. Nectar sugar secretion pattern of 30 plant species belonging to 17 families during different seasons was studied. Effect of temperature and relative humidity on nectar – sugar secretion was also determined. Out of 30 plant species, nectar sugar secretion in 19 plant species peaked at 11.00 h. Technique for Mass Queen Rearing has been standardized and refinements in technique are made. In this regard it has been finalized that queen cell builder colonies for mass queen bee rearing are better over queen less ones. For mass rearing of *Apis mellifera* queen bees, use 60 larval grafts during spring and 40 grafts during autumn in PVC queen cell cups in 20 bee frame strength queen right cell builder colonies. For making improvement in Mass Queen rearing techniques 3 methods viz. Karl-Jenter, Modified Doolittle method using plastic queen cell cups and Doolittle Method using beeswax queen cell cups were compared and concluded that Doolittle Method using plastic cell cups was best as the queen acceptance (cell raising) by this method was maximum (58.33%) followed by Doolittle method using beeswax (35%) and Karl Jenter (26.57%). Technique for Royal jelly production has been standardized. For royal jelly production 20 bee frame strength queen less cell builder colonies duly fed on pollen supplement during royal jelly production period should be used to increase royal jelly production. For maximizing royal jelly production per colony, 150 grafts in PVC cell cups should be used. Due to dearth of pollen in different times/months in different agro-climatic zones, bee colonies perish. A pollen substitute based on Brewer's yeast (42 parts) + parched gram (4 parts) + SMP (4 parts) kneaded in 50% sugar solution to form a patty, is effective in worker brood rearing, enhancing and extending period of drone rearing and royal jelly production. Evaluated performance of *Apis mellifera* a new introduction in Kerala and standardized its management practices under Kerala

	conditions. Bee packages of 1.5 – 2.0 kg bees are effective in establishing colonies at new site. Their transportation is cheaper. These are lighter and occupy less space, more units can be transported per unit vehicle. They also mitigate the chances of the spread of the diseases. Hence are recommended for transportation of colonies at new site.
	Staingless bee *Trigona iridipennis* smith which is domesticated can be recommended for Meliponiculture in homesteads of Kerala and bamboo hive with 1500 c.c. capacity is recommended for its rearing. Ethnol extracted propolis at 10% controlled 52.5 and 63.2% of *Alternaria* and *Fusarium* fungus and at 5% ethanol extracts level, reduction was 32.3% in Alternaria and 39.60% in *Fusarium oxysporum*. The reduction per cent of fungus by propolis in aqueous extract and PDA was nil. Enzyme-Linked Immuno Sorbent Assay (ELISA) kit was prepared to detect the Thai Sac Brood Virus of *A.cerana* and sacrood of *A mellifera*. The product tested through DAC-ELISA found to be very effective in detecting the viruses at very high dilution. European foul brood in *Apis mellifera* can cause considerable loss to the colonies. Oxy-tetracycline @ 200 mg/colonies has been found very effective and recommended for the control of the disease. Formic acid is recommended for the control of *Tropilaelaps clareae* in *Apis mellifera*. But some farmers use higher doses which may cause losses. To settle this controversy it is recommended that dose of formic acid higher than 5 ml per day is detrimental for the development of the colonies and hence higher doses should not be used. *Bt.* formulation *Var. kurstaki* @ 0.5 gm per litre of water per hive has been recommended for the control of *Galleria mellonella* which is a serious enemy of honeybee particularly in weak colonies and stored combs. Coconut leaves were found better as a physical barrier to prevent direct access of bees to predatory wasps compared to queen excluder sheet, palm mat and nylon net. Selected Thai Sac Brood virus tolerant colonies, multiplied and distributed to beekeeper of Kerala through HORTICORP (NGO).

	Out of insecticides (endosulfan, chlorpyriphos, deltamethrin, thiomethoxam, profenofos, imidachlor and lambdacyhalothrin) were tested for safety to *A. mellifera*. Only endosulfan and lamdacyhalothrin are considered as relatively safe. Application of pesticides in crown of the coconut palm reduces the visitation of honeybees which in tern reduces the rate of pollination. As far as possible avoid use of toxic insecticides viz.carbaryl, dicofol, malathion, quinalphos, endosulfan and dimethoate. However, use of neemazal (1%) and neem oil/garlic emulsion (2%) is recommended. Bee packages of 1.5 – 2.0 kg bees are effective in establishing colonies at new site. Their transportation is cheaper. These are lighter and occupy less space, more units can be transported per unit vehicle. They also mitigate the chances of the spread of the diseases. Hence are recommended for transportation of colonies at new site. Staingless bee *Trigona iridipennis* smith which is domesticated can be recommended for Meliponiculture in homesteads of Kerala and bamboo hive with 1500 c.c. capacity is recommended for its rearing.
	Ethnol extracted propolis at 10% controlled 52.5 and 63.2% of *Alternaria* and *Fusarium* fungus and at 5% ethanol extracts level, reduction was 32.3% in Alternaria and 39.60% in *Fusarium oxysporum*. The reduction per cent of fungus by propolis in aqueous extract and PDA was nil. Enzyme-Linked Immuno Sorbent Assay (ELISA) kit was prepared to detect the Thai Sac Brood Virus of *A.cerana* and sacrood of *A mellifera*. The product tested through DAC-ELISA found to be very effective in detecting the viruses at very high dilution. European foul brood in *Apis mellifera* can cause considerable loss to the colonies. Oxy-tetracycline @ 200 mg/colonies has been found very effective and recommended for the control of the disease. Formic acid is recommended for the control of *Tropilaelaps clareae* in *Apis mellifera*. But some farmers use higher doses which may cause losses. To settle this controversy it is recommended that dose of formic acid higher than 5 ml per day is detrimental for the development of the colonies and hence higher doses should not be used.

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All India Coordinated Research Project on Plant Parasitic Nematodes and their management **X Plan targets:** Identification of hot spots and agro-ecologically conducive areas for key nematode pests. Documentation of the state-wise distribution maps of agriculturally important nematode fauna of India.	**Significant achievements:** **Identification of hot spots of economically important nematode pests:** *Heterodera avenae,* the causal organism of Molya disease of wheat, barley and oat, which is a major nematode problem in Rajasthan and Haryana, has also been reported in high numbers (80-270 eggs and larvae/200 g soil) from U.P. during the nematode surveys. Betul and Raisen villages in Vidisha and Padri in Sagar district in M.P. and Udaipur, Bhilwara, Rajasamand and Kota districts in Rajasthan were identified as hot spots for wheat, seed gall nematode (*Anguina tritici*). Rice root-knot nematode, *Meloidogyne graminicola* was identified as major nematode pests in rice growing areas of Karnataka, Orissa, Assam, West Bengal and Kerala. Its hot spots were identified in Mandya, Mysore, Shimoga, Chickmaglur districts of Karnataka; in Khurda, Puri and Cuttack districts of Orissa; in Dhubri,

Identifying sources for nematode resistance in different agricultural and horticultural crops and their testing under nematode infested conditions. Dynamics of community structure of nematodes for their management in need based cropping systems (vegetables, pulses and horticultural crops) in different agro-climatic ecosystems. Impact of nutrient supply system on major nematodes in cereals, pulses and vegetables based cropping systems in different agro-climatic systems. Development and demonstration through on-farm testing of cost-effective, eco-friendly integrated nematode management technologies against key nematode pests. To carry out front line demonstration (FLD's) at farmers' fields to demonstrate and validate the most effective low cost, eco-friendly nematode management technologies generated in the project. To carry out researches on use of diazotrophic rhizospheric bacteria for their antagonistic role against plant parasitic nematodes.	Goalpara, Barpeta districts of Assam and from paddy fields of Nadia, 24-Parganas and Burdwan districts of West Bengal. Seed stocks of paddy analysed from villages located in Thasra, Nadiad and Matar blocks of Kheda district of Gujarat and a few blocks of M.P. were found to be infested with foliar nematode, *Aphelenchoides besseyi*. Bud and leaf nematode, *Aphelenchoides* spp. was observed as a serious problem causing necrosis in the emerging floral buds of tuberose in the state of West Bengal and Orissa and such planting material becomes the source of infection at grower's fields. Hot spots for pigeonpea cyst nematode, *Heterodera cajani* infesting various pulse crops were observed in Vadodara district of Gujarat; Coimbatore and Erode districts of Tamil Nadu; Hamirpur district of U.P.; Latur and Parbhani districts of Maharashtra. Lesion nematode, *Pratylenchus thornei* was identified as major nematode pests being bottleneck in cultivation of chickpea in Bundi, Chittorgarh and Bhilwara districts of Rajasthan; Jabalpur district of Madhya Pradesh and Kanpur, Etawah & Mainpuri districts of U.P. Reniform nematode, *Rotylenchulus reniformis* was observed for the first time causing yellow symptoms in betelvine crop in Kerala State. Root-knot nematode, *Meloidogyne incognita* has been observed causing substantial yield losses in pomegranate growing areas of Maharashtra and cotton growing areas of Haryana. Citrus nematode *Tylenchulus semipenetrans* in north eastern hill region (NEH) and also in North India; root-knot nematode, *Meloidogyne indica* in Gujarat were observed causing appreciable yield losses in citrus. **Nematode Management Technologies developed & demonstrated at farmers' fields**: Management of rice root knot nematode, *Meloidogyne graminicola* was demonstrated by seed soaking with carbosulfan 25 EC @ 0.1% a.i. for 12 hours seed soaking and was found very effective in reducing nematode population in on-farm trials at Malipara (District Khurda, Orissa) and Harnghat (District Nadia), West Bengal. Nursery bed treatment with phosphonothioate @ 1 kg a.i./ha, 7 days prior to transplanting + main field application with the same dose 45 days after transplantation was effective in reducing the rice root knot nematode, *M. graminicola* & in improving the yield.

Pest risk analysis for major nematode pests in Indian Agriculture to address phytosanitary needs of International trade in agricultural commodities. Designing nematode management technologies for organic farming systems. Human resource development: Organisation of short-term training programme in nematology in order to update the knowledge of scientists working in the project. Organisation of national campaign and countrywide public awareness drive against key nematode problems of the country.	Use of carbofuran @ 0.3 g a.i./m² was most effective followed by neem cake @ 100 g/m²/*Trichoderma* viride @ 20 g/m²/NSKP (10% W/W)/ *Pseudomonas flourescens* @ 20 g/m² for the management of rice root knot nematode infecting rice in organic farming system. White tip disease of rice caused by *Aphelenchoides besseyi* in the states of M.P. and Orissa was managed by seed soaking with carbosulfan (25 EC) @ 0.1% a.i. for six hours followed by foliar spray with carbosulfan 25 EC @ 0.2% 40 days after transplanting. The treatment reduced the white tip nematode population and increased the grain yield by 8.62-27.8% respectively compare to untreated check. In all the treatments, nematode populations in the seeds were reduced by 50-88% in comparison to untreated check. Based upon cost benefit ratio, seed soaking treatment with carbosulfan 25 EC @ 0.1% a.i. for 4 hours irrespective of nematode species in pulses was effective and demonstrated at farmers' fields. Application of carbosulfan 25 SD @ 3% a.i. w/w as seed dressing coupled with summer ploughing led to 29.9% increase in yield of kharif pulses compared to 17.9% increase in yield when the carbosulfan treated seeds were sown in non-ploughed, root-knot nematode infested field.
	Demonstration of integrated nematode management technologies against root-knot nematode, *Meloidogyne* spp. infesting tomato, brinjal and chillies conducted at farmers' fields were successfully laid out by raising seedlings in nursery beds treated with carbofuran @ 0.3 g a.i./m² of tomato, brinjal & chillies followed by root dip treatment with carbosulfan @ 500 ppm at the time of transplanting in the main field. This combined treatment gave 6-34% increase in yield over untreated check with a cost benefit ratio of 1:4.1 in tomato; 1:22.7 in brinjal and 1:6.7 in chilli respectively. Management of root-knot nematode in vegetable based cropping system by adopting crop rotations/cropping sequences prevalent in the area has revealed that cropping system of okra - cucumber-mustard in Assam and okra-rice-fallow in Orissa & West Bengal were effective in reducing root-knot nematode populations. In western zone, population of root-knot nematode declined following cultivation of non host crops such as garlic and onion etc. in Rabi season and clusterbean during summers. Among various bio-agents tested, seed treatment with *Pseudomonas flourescens* @ 20 g/kg + *Trichoderma viride* each @ 5 g/kg seed was found most effective for the management of reniform neamtode, *Rotylenchulus reniformis* on cowpea.

	Seed dressing with carbosulfan 25 SD @ 3% a.i. w/w + soil application of carbofuran (3G) @ 1 kg a.i./ha proved effective in management of reniform and root knot nematode infects cotton. Application of carbofuran (3G) @ 1 kg. a.i./ha + castor cake @ 1000 kg/ha for the management of *Meloidogyne arenaria* gave groundnut yield to the tune of 1381 and 1134 kg/ha at two locations compared to 963 & 721 kg/ha in untreated control respectively at Junagadh in Saurashtra region of Gujarat. Management of root-knot nematode, *Meloidogyne javanica* on groundnut was successfully demonstrated at farmers' fields in U.P. by application of neem cake @ 1000 kg/ha + neem oil @ 5 litre/ha + carbofuran @ 1 kg/ha. This treatment increased the groundnut yield by 40.3% and reduced *M. javanica* Patho.2 population by 35% over untreated control. Nematode disease complex in banana caused by burrowing nematode, *Radopholus similis*, root-knot nematode, *Meloidogyne* spp., Lesion nematode, *Paratylenchus* spp., & spiral nematode, *Helicotylenchus* spp. was effectively managed by paring of suckers + hot water treatment at 55^0 C for 20 minutes + application of carbofuran @ 16.6 g/pit and neem cake @ 1 kg/pit. This technology has been demonstrated at farmers' fields at Kerala, Karnataka, Tamil Nadu and Gujarat. Hot spots of root-knot nematode (*Meloidogyne graminicola*) in rice growing areas from Mandya districts of Karnataka and from Mandi and Kangra districts of Himachal Pradesh were identified. Burrowing nematode on banana at Hasan, Shimoga and Chikmaglur districts of Karnataka was identified as potential nematode pest wherein good number of management demonstration trials was laid out. Hot spots were identified for pigeonpea cyst nematode (*Heterodera cajani*) infecting urdbean and chickpea in Karnataka and on pigeonpea in Buldhana district of Maharashtra and also for root-knot nematode (M. incognita) infecting sunflower, cotton, citrus from Shimoga, Chikmaglur and Hasan districts of Karnataka. Root-knot nematode (M. incognita) was found to be pre-dominant causing appreciable yield losses in pomegranate at farmers' fields in Nasik district of Maharashtra. Application of Cartap hydrochloride @ 1 kg a.i./ha in solarized nursery beds followed by same treatment in the main field 40 days after transplanting was effective against root-knot nematode (M. graminicola) thereby reducing the root-knot nematode population up to 70% over untreated control in Tamil Nadu, Kerala and Orissa. Management technologies developed against root-knot nematode (*M. incognita*) infecting vegetables and pulses by treating the seeds

	of cucumber, bottlegourd, okra, chickpea, pigeonpea with carbosulfan (25 DS) @ 3% a.i. w/w was demonstrated at farmers' field in the States of Orissa, Maharashtra and Kerala. This treatment gave 20% higher yield of cucumber over untreated control at farmers' field in the Orissa.
	The demonstration trials conducted against root-knot nematode disease complex in groundnut in Saurashtra region of Gujarat indicated that soil application of neem cake @ 1000 kg/ha + neem oil 5 litre/ha + carbofuran @ 1 kg a.i./ha resulted in reduction of root-knot nematode infection and enhancing the yield up to 43% with cost benefit ratio of 1:4.5 Seed treatment with *Pseudomonas flourescens* @ 20 g/kg seed + *Trichoderma viride* @ 4 g/kg seed in pulses was effective against pigeon pea cyst nematode (*H. cajani*) and reniform nematode (*Rotylenchulus reniformis*) thereby reducing the nematode population significantly and enhancing the yield by 17-22% depending upon initial nematode population in the States of Tamil Nadu and Rajasthan. A Summer School on Identification and role of beneficial and harmful nematode in crop health was organized for the participants, mostly from AICRP (Nematodes) centres in collaboration with Division of Nematology, IARI, New Delhi from September 7-27, 2006. Nematode Awareness programmes viz. Field days, exhibition on nematode symptoms along with question-answer sessions were organized in the States of Tamil Nadu, Gujarat and Orissa.
All India Network Project on Pesticide Residues **X Plan targets:** To coordinate and monitor the research activity of multilocational centers i.e. SAU's and ICAR based institutes in different agroclimatic zones of the country; Based on research findings obtained from various	**Significant achievements:** Multilocational Supervised Field Trials: Supervised field trials are primarily conducted to generate pesticide residue data required for setting up their maximum residues limit (MRL), finding safe pre harvest interval for pesticide spray and registration of pesticides. To obtain necessary data for these purposes, crops are grown under different agroclimatic conditions and treated with pesticides using good agricultural practices. Supervised trials were conducted under AINP on Pesticide Residues during Xth plan on following crops-pesticide combinations: The persistence/dissipation of Spiromesifen was studied on a chilli, cotton, apple, tea and brinjal. Supervised field trial of spiromesifen was carried out at three centers YSPUH&F, Solan; PAU, Ludhiana and ANGRAU, Hyderabad. With each crop the

multilocational supervised field trials, to recommend farmers pesticide usage; To provide the leadership for human resource management; To provide the financial assistance according to the need of research programmes	trial was conducted at four locations and two dosage i.e. recommended and double the recommended dose of application (96 and 192 g a.i. ha^{-1}). The half-life of Spiromesifen was found to be 5.0-8.5 days in the tea leaves. The residues of Spiromesifen on brinjal fruits and soil were found non-detectable on the 15^{th} day of application at all the locations at both the dosages. The half life on chilli was found 2-2.5 days. In the chilli field soil no residues were detectable at harvest. Residues of Spiromesifen in cotton lint, seed and soil at the time of first picking were below detectable at all three locations. Supervised trial of Mancozeb75 % WP on cumin was carried out at four centers viz. Anand, Kalyani, Jaipur and Hyderabad at two dosages i.e. 1125 g a.i. /ha and 2250 g a.i./ha The mancozeb residues at harvest in cumin seeds were below its MRL of 3.0 CS_2 μg g^{-1} at Anand and Jaipur and below detectable limit at the other two locations. The residues were not detected in soil samples at harvest at any of the four locations. Supervised trial of Tricontanol on potato was carried out at four centers viz. Anand, Kalyani, Solan and Ludhiana at two dosages i.e. 0.25 g a.i. /ha and 0.5 g a.i. /ha. Residues of tricontanol in potato tubers as well as soil at the time of harvest were Below Detectable limits (BDL) at all the four locations. Spinosad (45 % SC) persistence on red gram was carried out at Rahuri, Anand, Kalyani and Hyderabad centers at two dosage i.e. 73.0 and 146.0 g a.i. /ha. Spinosad residues in red gram as well as soil at harvest were below detectable limit at all the locations. The persistence of a number of pesticides was studied on apple crop by Solan center at four different locations of Himachal Pradesh, India viz. Solan, Mashobra, Matiana and Thanedhar. Spiromesifen was sprayed at two dosage i.e. 120 g a.i. /ha and 240 g a.i. /ha. The half-life of spiromesifen was found 5.47-6.24 days at the recommended dose. Bifenthrin (Brigade)® persistence was studied at 60.0 g a.i. /ha and 120.0 g a.i. /ha dosage. Bifenthrin residues in apple fruits were below detectable
	limit at harvest i.e. 30 days after spray. Fenazaquin (Magister)® was sprayed in triplicate plot in two dosages i.e. 40 g a.i. /ha and 80 g a.i. /ha. Initial deposits of fenazaquin on apple fruits were 0.432-0.564 and 0.998-1.064 mg/kg due to application of 40 g a.i./ha and 80 g a.i./ha, which dissipate to below detectable limit in 30 days. Diniconazole (Sumi-8®, 25 WP) was applied at 500 and 1000 g a.i./ha dosages. Initial deposits of diniconazole on apple fruits were 0.55-1.34 mg/kg, which dissipate to below detectable limit in 30 days. The persistence and residues of imidacloprid was determined

	at two dosages 890 and 1780 g a.i. /ha. The residues of imidacloprid (Confidor 200 SL) become non-detectable on 30th days of sampling. Supervised trial of Fenpropathrin (Meothrin 30 EC) was carried out at 450 g a.i. /ha and 900 g a.i. /ha. Fenpropathrin residues in apple fruits and soil were non detectable at 30th day after spray. Supervised trial of Imidacloprid on cotton was carried out at college farm of Hyderabad center. The pesticide was applied twice first 60 days after sowing and then 75 DAS at two application rate i.e. 35 g ha^{-1} and 70 g ha^{-1}. None of the sample (soil, lint and seed) showed presence of imidacloprid residues in all treatments. Mixed formulation of acephate 50 % and imidacloprid 1.8 % SP (Lancer Gold)® on Cotton was evaluated at experimental field of PAU, Ludhiana. Residues of acephate dissipated to below detectable limit of 0.02 mg kg^{-1} after 15 days of its application and that of imidacloprid below detectable limit of 0.02 mg kg^{-1} after 7 days of application. Supervised trial of Imidacloprid (Confidor, 350 SC and 70 WG) on paddy was conducted at Hyderabad, Vellayani and Ludhiana at 75 and 150 ml ha^{-1} dosage. None of the sample (rice grain, husk, straw and soil) showed presence of imidacloprid residues in any treatments. Mixed formulation of chlorpyriphos 50% and cypermethrin 5% (Nurelle-D 55% EC) on chilli was evaluated at four centers Rahuri, Jaipur, Kalyani and Ludhiana at 1000 and 2000 ml ha^{-1} of the formulation. The residues of chlorpyriphos on chilli after 15 days of spray were in the range BDL- 0.08 μg g^{-1} at 500 g a.i. ha^{-1} application rate. The cypermethrin residues were below detectable limit after 15 days of spray. Supervised trial of Spiromesifen was carried out at three centers Solan, Ludhiana and Hyderabad at two dosage i.e. 96 g a.i. /ha and 192 g a.i. /ha. Tebuconazole (2 % DS) (Raxil)® on ground nut was evaluated at experimental fields of Agricultural Research Station, Durgapur, Jaipur at two dosages i.e. 0.025 and 0.05 g a.i. /kg seed. None of the sample of groundnut and soil showed presence of tebuconazole residues in any treatments. Persistence of Bifenthrin as termiticide in Building Soil was studied jointly by P.C. Cell, Delhi and CBRI, Roorkee. Field trial was laid at Indian Institute of Petroleum, Dehradoon. Residues of bifenthrin were detected up to 60 cm layer at 0.075 and 0.1 percent rate of application. Surface residues persist up to 37 months at lower dosage of application and even after 53 months at higher dosage of application (0.075 and 0.1%). Collaborative Studies: AINP on Pesticide Residues has collaboration with other ICAR institutes. Vellayani centre in

	collaboration with AINP Acarology, analysed coconut samples for monocrotophos residues. Following peduncle injection of monocrotophos @ 0.2ml+2ml water in coconut, the mean residues in tender coconut water dissipated from 0.786 ppm on 3rd week to 0.002 ppm on 20th week after treatment. Under NCIPM collaboration, Rahuri centre analysed cotton and sugar samples, in both IPM and non IPM samples residues were found below detection limit. Paddy, soil and water samples were analysed by Delhi centre, residues were found below detection limit in all the samples. Pesticide residues in soil samples collected from IPM and non IPM trials of cotton fields from Fatehbad were estimated by Hisar centre. Residues of endosulfan, chlorpyriphos and SP were detected and were found higher in IPM trial field soil samples.
	Processing Factor for Pesticide Residues in Spices: The level of pesticide residues on the agricultural commodities and their processed food commodity varies due to the effect of processing. The level of pesticides in processed food might increase or decrease due to cumulative effect of various processes of processing such as dehydration, sun drying, cooking, fermentation etc. To study the effect of processing on residue level of pesticides in the harvested and processed (sun dried) red chilli powder, laboratory experiments were conducted with dicofol (18.5 EC), ethion (50 EC) and cypermethrin (25 EC) at 0.05%, 0.05% and 0.015%, respectively by Hyderabad, Ludhiana, Jaipur, Hisar, Kanpur, Bangalore, Delhi and Anand. Different centers calculated different processing factor. Vellayani center estimated dehydration factor for λ-cyhalothrin and chlorpyriphos in/on cardamom and pepper also. ***Multilocational Supervised Field Trials:*** Flubendiamide on cabbage, tomato, rice and pigeon pea, Flubendiamide+ thiacloprid on tomato, Imidacloprid on Grapes and okra, Multilocational trial of flusilazole and thiacloprid on apple, Propargite on brinjal and okra, Propineb on tea, Quizalofop-ethyl on cotton, ground-nut, Thiacloprid on tea Experiments of Local Importance:- Following persistence and dissipation studies will be carried out. Diflubenamide on mustard, chickpea and pigeon pea, Chlorpyrifos and phorate in banana, Chlorpyrifos in pepper, Chlorpyrifos, phorate, carbofuran and

	acephate in cardamom, Fipronil in paddy, Profenophos and triazophos in tomato, Dimethoate in safflower, Imidacloprid and acetamaprid in soil and water, Insecticide mixtures on tomato, Thiodicarb in cotton, Endosulfan and imidacloprid on cabbage, Chlorpyrifos and quinalphos on mustard crop Endosulfan and fenvalerate in chickpea, Spinosad on cabbage and tomato Method Validation Standardization and estimation of aflatoxin in groundnut on HPTLC/HPLC Validation of Multiresidue methods for grape and pomegranate for the mixture of fungicides and insecticides Method validation of insecticide and herbicide residues using GC-MS Multi residue method validation for pesticides in vegetables using GC-MS Multiresidue method validation of CRMs using GC and GC-MS. ***SP E method Validation*** ***C Collaborative Studies*** Collaborative study with CPRI, Simla for pesticide residue analysis in Potato Collaborative study with AINP on Ornithology for analysis of bird tissue samples for the pesticide residues Collaborative study with NCIPM for Pesticide residue analysis in IPM vs Non-IPM trials on cotton, paddy and cabbage
	Accreditation of Laboratory Initiation of the process of NABL accreditation of laboratory, preparation of Quality Manual and accreditation of laboratories ***Quality Assurance Programme*** ***Processing Factor*** ***Effect of dehydration and processing factor on pesticide residues in chilli, cardamom and pepper.*** Wesite of the Project The website of the All India Network Project on Pesticide Residues

has been launched with domain name www.ainppr.com.

Accreditation of Laboratories: In order that the data generated by AINP on Pesticide Residues is accepted internationally, the laboratories should have accreditation from authorized agency National Accreditation Board For Testing And Calibration Laboratories (NABL). The scientists of ten out of twelve coordinating centres has participated in the "Training Programme on laboratory Quality System, Management and Internal Audit as per ISO/ IEC 17025" organized by (NABL) during 2005-06. The preparation of quality manual for accreditation of laboratories is under progress at various centers.

Publication of Pesticide Residues Analysis- A Complete Guide: The simple and effective methods of analysis of pesticide residues in various matrix have been developed and validated by all the coordinating centers. The validated methods have been documented in the form of Manual of Pesticide Residues Analysis and have been submitted to the Directorate of Information and Publication of Agriculture (DIPA), ICAR, KAB-I, Pusa, New Delhi for its publication.

Resource Generation:

A target of Rs.100 lakhs has been fixed by the council for the resource generation for the project under the X Five year plan. Upto June, 2006 a sum of Rs 143.08 lakhs has already been generated in Xth plan. The resource generated has been utilized for the development of infrastructure at various laboratories of the project.

Human Resource Development: Seven research scientists from coordinated centers participated in Group Training on Pesticide Residues Analysis at PC Cell on January 27- 31, 2004. Seventeen participants from Central Forensic Science Laboratory attended training on Pesticide Residue Analysis in Biological Matrix on 7-11 February 2005. Group training on GC-MS was also organized on July 12-13, 2004.

Distribution Of Certified Reference Material (CRM): Certified Reference Material of about 40 pesticides was distributed to all centers of the AINP (Pesticide Residues), other collaborative partners and participating labs of project Monitoring of Pesticide Residues at National Level every year.

All India Network Project on Rodent Control **X Plan targets:** Survey and surveillance of pest rodents Study pest species composition in strategic areas *vis a vis* cropping systems, changes in land use pattern and bamboo flowering pockets of NEH region. Breeding biology and population, Ecology of predominant rodents. Crop loss assessments.	**Significant achievements:** Four species viz., *Niviventer niviventer, N. fluvescens, Rattus sikkimensis* and *R.nitidus* were identified as problem species showing upsurge in their population synchronizing with bamboo flowering in NEH region. Two squirrel species, *Calloscirrus* and *Dremnomys lokriah* were reported to be major problem species in fruit crops in Assam. Monitoring of rodent problem in NEH revealed population upsurge in parts of Manipur and Assam in 2003-04 and in Arunachal Pradesh in 2004-05 due to mass flowering of bamboos. The prediction factor based on studies of 1990's in this regard has been validated and found to be fairly accurate. The gerbils inflicted 6.8-18% damage to seedlings and 3.5-20% pod damage to moong moth and sesame crops in Rajasthan, whereas in A.P. and Punjab, the tiller damage in rice fields surrounded by maize, sugarcane and wheat fields adjoining sugarcane experienced higher rodent damage than that of solo cropping system. Among vegetables, potato, brinjal and cucurbits suffered 2.1-7.2 and 4.2-6.9% rodent damage. The losses due to hoarding by bandicoots were 1.2-5.2 kg/burrow. Rice and ragi crops experienced 3-6 and 5-7% damage in Karnataka. Neem leaf powder (5%) showed antifeedant action on rodents, hence recommended as protectant in storage, whereas neem oil repelled the rats to the tune of 18-48%. Neem formulation BBR recorded a repellency index upto 87% at 3% conc. in baits against rodents. Jojoba seed cake powder (10-20%) recorded a repellency index of up to 90% in *Tatera indica*. The aversion through learning persisted for a week. Among other botanicals kaner seeds, neem cake, castor seeds and jatropha seeds too showed anti rodent properties in preliminary trials. The new Rodenticide molecules evaluated against rodents pest included difethialone, coumatetralyl, cholecalciferol and alpha-chlorohydrin. A new relatively safer and ready to use formulation of bromadiolone (0.005%) containing denatonium benzoate was found effective in containing the rodent menace. Attempts were made to develop a new formulation of bromadiolone by adding Plaster of paris in bromadiolone bait which yielded 80% mortality of R. rattus within 5-10 days. Difethialone (0.0025%) in fresh baits proved effective against bait shy rodents. Vitamin K1 supplementation @ twice the dosage intake of Difethialone for two weeks was sufficient to reverse the anticoagulation process in rodents. • Monitoring of changes in rodent species composition and studies on bioecology of species registering predominance due

	to changes in land use. Infestation of Tatera indica and Nesokia indica in fruit orchards were reported from Nagaur district in western Rajasthan. • Sporadic flowering of six bamboo species viz., Bambusa tulda, B.balcoa, B.pallida, Melocanna bambusoides and *Dendrocalamus* Hamilton was reported from Hozai subdivision of Nagaon distt Assam. • Rodent abundance in Central Brahmaputra Valley Zone In Assam revealed predominance of B. bengalensis (58.82%) followed by Rattus *sikkimansis* (29.41%0, Mus booduga (11.76%) in rice fields. B. bengalensis has shown its spread in urban locales in arid zone. • Coating of glue paste containing 5% neem leaf powder on wheat filled card boxes resulted in 100% protection from house rat infestation up to 29 the day of treatment. • Field trials at farmers' fields during kharif and rabi seasons for scheduling the poison baiting operations under Social Engineering Activity. • Evaluation of pellet formulation of Aluminium phosphide (0.6g) @ 2 pellets/ burrow yielded a control success of 60-67% in Rajasthan and Karnataka. • Two-three farmers' trainings and campaigns on rodent control were organized by each center.
	• Two technical bulletins and Rodent Newsletter are to be published. • Principal Investigators' Meeting of AINP on Rodent Control to be organized. • Meeting of Scientific Advisory Committee on Rodenticides, constituted by CIB & RC is to be organized. Consulting and Advisory Services to clients mainly pesticide industries and railways.
All India Network Project on Agricultural Acarology **X Plan targets:**	**Significant achievements:** Role of the eriophyid mite, *Aceria cajani* as vector of sterility mosaic virus in pigeonpea has been confirmed. Transmission studies have shown that one to five mite vectors per leaflet are sufficient to

Develop the bio-ecology of newer mites pests of crops such as rice, cotton as consequence of the changing agricultural scenario in the country. Evaluation of potential biocontrol agents including the behavioral studies with regard to inter and inter-plant dispersal, temperature, humidity and pesticide tolerance in predators, development of pesticide tolerant strains of predators, tritrophic level interactions, mass culturing of promising/potential predators, etc. Understanding the resurgence of mites with special reference to the impact of broad-spectrum pesticides, fertilizers, plant growth regulators and other agricultural chemicals Nature of causal agents associated with pigeonpea sterility mosaic disease and ascertain he role of *Aceria cajani* in transmitting causal agent from suspected weed hosts like *Atylosia* sp. Identification of pigeonpea lines resistant to mite vector/disease and their utilization in breeding programmes. Nature of spread and distribution of coconut mite in the country and evolve effective IPM using biological methods Interaction between mite	transmit the PPSM virus. ICPL 27, ICPL 87, ICPL 7035 and Hyd 3C have been identified fairly tolerant to disease as well as the vector mite. The vector was observed surviving on a weed, *Atylosia scarabaeoides.* Host plant resistance studies on mites infesting tomato indicated that resistance in genotypes like LA 1740, LA 1777, LA 2580 and LA 2963 can be attributed to glandular trichomes and biochemicals in the leaves *viz*. 2- tridecanone, 2 - undecanone, phenols and acylsugars. Biological control of *Tetranychus urticae* infesting rose, carnation, marigold *etc.* using *N. longispinosus* in a polyhouse at Bangalore has been successfully demonstrated. About one-lakh predators released significantly brought down the spider mite population on rose in 2-3 weeks period as the decline in the mite damage was very evident. An eco-friendly strategy for the management of the coconut eriophyid mite involving nutrient management, organic manuring, and botanical pesticides has been developed and popularized among the coconut growers through the state departments of horticulture and agriculture in Karnataka, Tamil Nadu and Kerala. Newer molecules such as fenpyroximate, diafenthiuron, milbemectin, flufenzin, clofentezine and fenazaquin were able to control mite infestation (80 to 90% reduction) in chilli, brinjal, tomato and okra crops in 15 days period and better fruit yields were obtained.

feeding and physiological processes n plants like photosynthesis, water retention, stomatal conductance and the resulting biochemical changes in the infested plants.	
Estimation of loss due to mite damage in agricultural crops like rice, cotton, coconut, vegetables, etc. and in commercial floriculture industries and work out economics of mite control Evaluation of newer molecules including botanicals against mite pests of crops	
All India Network Project White grubs and Soil arthropods **X Plan targets:** Refinement of existing white grub management technology through eco-friendly new compounds and entomo-pathogenic bioagents: fungi, bacteria, nematodes. Monitoring and identification of pests like cutworm, wireworm and termites in different agro-climatic situations and quantification of losses in different corps.	**Significant achievements:** Management of whitegrub (*Holotrichia consanguinea*) through beetle control by spraying insecticides (chlorpyriphos 20 EC, o.05% a.i. or quinalphos 25 EC, 0.05% a.i. or carbaryl, 0.2% a.i.) on host trees followed by application of pheromone chemical (methoxy benzene @ 15 ml/3 pieces of sponge (each 5 cm x 5 cm) per tree for 3 consecutive days has been found very effective. With a view to economize the pheromone application, the technology was further improved. With the result, the dose of pheromone chemical has been reduced to 1.5 ml/3 pieces of sponge (each 5 cm x 5 cm) per tree for 3 consecutive days instead of 15 ml/tree pheromone for effective management of whitegrub. Thus, this technology has become more economical and less hazardous. Application of chlorpyriphos 20 EC @ 400 g ai/ha alone or in combination with Nicast (organic manure) 500 kg/ha at the time of second earthing in the month of June was found very effective for protecting the potato crop from whitegrub (*Holotrichia coriacae*) at Palampur (H.P.). Field performance of *M. anisopliae* against whitegrub when placed at different soil depths

Studies on ecology, behaviour, biology, physiology and population dynamics of cutworm, wireworm, termites etc. Eco-friendly and integrated management strategy for cutworm, wireworm, termite etc. Study of soil microorganisms in relation to management of cutworm, wireworm, termite etc. Role of natural enemies and decomposers in soil health management in different cropping systems	Mean of two years data reveal that out of 4 soil depths (10, 15, 20 cm and normal sowing depth), *M. anisopliae* formulation placed at 10 and 15 cm @ 1x10^{14} conidia/ha, provided reduced plant mortality (56.5 – 61.2% protection) along with 40-44 per cent higher mean pod yield in groundnut as compared to the plots sown without bioagent formulation. Also enhanced crop protection and pod yield were obtained through these treatments (10 & 15 cm depths) as compared to the bioagent applied at normal sowing depth. Management of whitegrub by chemicals: i. Seed treatment: For the protection of monsoon sown groundnut crop against whitegrub, efficacy of some new chemical formulations along with recommended insecticides was tested as seed dresser. The newer insecticides as seed dresser, thiamethoxam 70 WS, imidacloprid 70 WS both at 80 g ai/ha and fipronil 5 FS at 100 g ai/ha were found effective against whitegrub and provided maximum protection to groundnut crop at Durgapura. All the treatments gave 72 to 78 per cent protection against whitegrubs. ii. Standing crop treatment: In standing crop of groundnut, some new chemicals were tested along with recommended insecticides for comparison. Two formulations of thiamethoxam 70 WS and 25 WS and fiprnil 5 FC, all three insecticides at 150 g ai/ha were provided more than 70 per cent protection to the groundnut at Durgapura-Jaipur and performed better than existing recommendations. For cutworm control soil application of imidacloprid 200 SL (48 g ai/ha) and chlorpyriphos 20 EC @ 400 g ai/ha at first earthing up in potato crop was found effective. Two sprays of chlorpyriphos @ 0.04% a.i. within three weeks after germination provided good protection to potato crop. Field performance of *Metarhizium anisopliae* against whitegrub when placed at different soil depths: Mean of two years data reveal that out of 4 soil depths (10, 15, 20 cm and normal sowing depth), *M. anisopliae* formulation placed at 10 and 15 cm @ 1x10^{14} conidia/ha, provided reduced plant mortality (56.5 - 61.2% protection) along with 40-44 per cent higher mean pod yield in groundnut as compared to the plots sown without bioagent formulation. Also enhanced crop protection and pod yield were obtained through these treatments (10 & 15 cm depths) as compared to the bioagent applied at normal sowing depth. Pathogenicity of *M. anisopliae* isolate Ma-4 on new insect hosts: On *Leucopholis lepidophora*: Third instar larvae of *L.lepidophora*

received from UAS, Bangalore centre were dip inoculated with *M.anisopliae* ($1x10^7$ conidia/ml) suspension in the laboratory. Mortality commenced after 14 days of inoculation at 27°C which increased over time. About 70% mortality was noted after 25 days of inoculation which increased to 90 per cent after 30 days. However, in case of *Holotrichia consanguinea* complete mortality occurred within 9 days under similar set of conditions.

On cutworms: *Agrotis ipsilon* attacking maize crop was found to be susceptible to *Metarhizium anisopliae* isolate Ma-4 and *B. bassiana* isolate Bb-3 in a pot experiment at Palampur, 86.6 and 73.3 per cent mortality, respectively occurred after 10 days of inoculation.
The baits containing pulse (1 kg as per base material + Jaggery 100 g + yeast 1 g + chlorpyriphos 20 EC (1 ml) proved highly effective against cutworm in potato crop at Palampur (Himachal Predesh) and Ranichari (Uttaranchal).

Imidacloprid 200 SL (80 g ai/ha) gave effective control of wireworm, *Drasterius* sp. damaging potato crop at Ranichauri.

Qualitative and quantitative distribution of soil microarthropods was done in various ecosystems. Maximum number of soil microarthropods was present in the forest ecosystem followed by agro-ecosystem and fallow land. Collembolans and soil mites were found to be major group of soil microarthropods. Further, it was also observed that the population of soil microarthropods was comparatively higher in upper layer of soil (0-10 cm depth) as compared to lower layer of soil (10-20 cm depth). Itinerary of soil micro and meso arthropods of different regions have been prepared.

The pesticide application for management of crop pests also have harmful effect on the non-targeted soil arthropods like collembola, soil mites, etc. Many mites are good predator/parasites of harmful insect pests and regulate the pest population. Collembolans are helpful in decomposition of biowaste. Thus, the use of pesticides decreased the population of pest regulators and soil helpers. Population of collembolans, mites and nematodes were restored after 1-3 months in quinalphos, chlorpyriphos and imidacloprid treated plots.

Among the four cutworm species, *Agrotis ipsilon* was found to be key species of cutworm in Uttaranchal, while *A. segetum* was major species in the Himachal Pradesh. They caused heavy damage in maize, potato and off-season vegetable crops, etc. Half life (DT_{50})

	for decomposition of Khejari, *Prosopis cinerarium* leaves was done at Durgapura. Transfer of Technology: Beetle management through pheromone technique was demonstrated in 290 ha in 4 villages of Dausa district near Jaipur. About 80 per cent beetles were attracted to the pheromone loaded host trees and were killed by the action of pesticide sprayed on the trees. This greatly reduced the pesticidal load on the environment. In IPM area, the average groundnut productivity was raised to more than 15 q/ha as compared to 12 q/ha before the initiation of the project.
	Whitegrub management technology for *Holotrichia consanguinea* was demonstrated successfully by pheromone technique through on farm trials and large scale demonstrations in more than 1000 hectares during plan period. This pheromone technique for whitegrub management has reduced the pesticide consumption by more than 60 per cent, resulting reduced the cost of protection labour and pesticide load on the environment. The pest population and crop damage in demonstration villages was reduced by more than 80 per cent and increased productivity of groundnut crop by more than 4 q/ha. Development of effective and economical management technology for several whitegrub species such as *Holotrichia consanguinea, H. coriacae, Leucopholis lepidophora, Lepidiota stigma, Leucopholis burmeisteri, L. concophora, Anomala rufiventris, H. longipennis, H. serrata and H. reynaudi* which caused severe damage to several crops including groundnut, potato, palm, soybean, maize, pea, arecanut, pulses, vegetables, apple, peach, pear, plum, millets, upland rice and vegetables. A number of new chemicals along with recommended pesticides (chlorpyriphos and quinalphos) and among them imidacloprid 200 SL, imidacloprid 70 WS, thiamethoxam 70 WS, fipronil 5 FS as seed dressers and thiamethoxam 70 and 25 WS as standing crop treatment were found promising at comparatively low doses, reducing the pesticide load on the ecoystem. Pheromone from whitegrub female adults of *Holotrichla consanguinea* was isolated and identified during the last plan period. During the present plan period refinement in the pheromone technique of whitegrub (*H. consanguinea*) management was done. On campus and off campus training programmes were organized

	for farmers and extension functionaries to educate them about pheromone technique of whitegrub management. Large-scale demonstrations/on farm trials were conducted in several v pillages covering more than 900 ha. The pheromone technique of whitegrub management has reduced the pesticidal consumption by more than 60 per cent which ultimately reduced the cost of protection, labour and pesticidal load on the environment. The pest population and the crop damage in campaign area/demonstration villages was reduced by more than 80 per cent and increased the productivity of groundnut crop by more than 4 q/ha. Under taxonomic studies work on identification of whitegrub species is continued at Bangalore centre. During the plan in 2002, 6 species; in 2003, 22 species; in 2004, 23 species and in 2005, 20 species were identified and added the database. Database on whitegrub for the entire country updated with 12435 specimens recorded from 1682 locations; about thirty crops/cropping systems and representing 268 species. The database provided information on present taxon status, distribution and host range of the whitegrubs. In Rajasthan, Himachal Pradesh, Karnataka Uttarnchal and Assam states many species of whitegrubs i.e. *Holotrichia consanguinia, H. coriacae, Leucopholis lepidophora, Lepidiota stigma, Leucopholis burmeslsteri, L. Coneophora, Anomala rufiventris, H. longipennis, H. serrata and H. reynaudi* are causing server damage during 2002-2006 to crops including groundnut, potato, palm, soyabean, maize, pea, arecanut, pulses, vegetables, apple, peach, pear, plum millets, upland rice and off season vegetables. To overcome the menace due to this polyphagous scarabid number of new chemicals were tried along with the recommended pesticides (Chlorphyriphos and quinalphos) and among them imidacloprid 200 SL, imidacloprid 70 WS, thiamethoxam k70 WS, Fipronil 5 FS as seed dressers and imidacioprid 200 SL, fipronil 5 FS and thiamethoxam 70 & 25 WS as standing crop treatment were found promising.
	Two entomophagous fungi, *Metarhizium anisopllae* and *Beauveria bassiana* and entomophilic nematodes were tested to control the whitegrubs in different agroecosystems. Several local trains of entomophathogenic nematodes have been isolated from different ecosystems with the objective of evolving their potential in whitegrub management.

	The population of soil micro-arthropods was comparatively higher in upper layer of soil (0-10 cm depth) as compared to lower layer of soil (10-20 cm depth). Further, it was note that maximum number was present in the forest ecosystem followed by agro ecosystem and fallow land. In trials to record the effect of pesticides on non-target organisms. It was noted that use of pesticides decreased, the population of collembola, soil mites and other soil micro arthropods. It was also observed that the population of collembola, soil mites and nematodes are restored after 1-3 months in quinalphos, chlorpyriphos and imidacloprid treated plots
Network Project on Insect Biosystematics **X Plan targets:** Insect biodiversity to be collected from all states of India Seven agriculturally important insect groups to be studied for biosystematics Inventories of insects in rice, cereals, pulses, oilseeds, fruits and vegetables to be prepared Basic information for CDROM to be developed 52 RAs/SRFs to be trained in biosystematics	**Significant achievements:** Sixteen orders (56 families) of insects surveyed (1400 field trips) from 20 states and 50249 specimens collected. Taxonomic studies focused on 16 selected families on agriculturally importance. Diagrams on taxonomic characters prepared. 2250 visuals of insects and mites occurring in agricultural crops documented along with salient information Basic information on 17500 species (2 lakh specimens) in NPC documented and digitized. 26 RAs/SRFs trained in basic aspects of taxonomy of insects and mites. The rest is in progress.

Annexure III

Proposal for National Institute of Plant Virology

Background

Virus and virus-like diseases continue to inflict heavy losses in crops both in qualitative and quantitative terms, particularly in the tropics and sub-tropics which provide ideal conditions for the perpetuation of viruses and their vectors. Enormity of the losses can be easily judged from the fact that recently *Tobacco streak virus* alone has resulted in a loss of Rs. 76 Crores in sunflower and Rs. 300 Crores in groundnut. *Mungbean yellow mosaic virus* alone is reported to cause an annual loss of over US $ 300 million in legume crops. The losses are even more alarming in rice, cassava and horticultural crops like banana, citrus, coconut, papaya, etc. Besides, emergence of newer viral disease problems is posing serious threat to crop production in the country. For example, necrosis disease nearly wiped out the cultivation of sunflower and is threatening groundnut cultivation and leaf curl has become a major threat to cotton production in North West cotton fields of India.

The development of resistant cultivars by conventional breeding did contribute in controlling viral diseases to some extent but the lack of durability of resistance genes or the absence of resistance sources have signalled the importance of more effective and comprehensive approach to tackle the deadly viruses. Besides, the lack of proper certification methodology for viruses that are carried by the vegetative propagules/ true seeds of a number of horticultural and vegetable crops have further compounded the losses caused by viral diseases and are a limiting factor for boosting our export potential of such crop commodities. Though recently we could unfold the etiology of sterility mosaic disease of pigeon pea, an economically very important disease of the sub-continent, there are certain other economically important viral diseases such as **urdbean leaf crinkle disease** of mungbean and urdbean, ***chirkey* and forked disease** of cardamom, etc. that remain to be of unknown etiology. The threat to our agriculture from the exotic destructive viruses also cannot be neglected in this era of liberalized import under WTO regime. The role of seed borne viruses have been undermined since long despite the fact that it is becoming one of the major phytosanitary issue in trade negotiations. It has been demonstrated that even low rate of virus transmission through seed can lead to epiphytotics in the field through vector spread of the viruses to the healthy plants. Also, to tackle the increasing trend of bioterrorism there is an urgent need for preparedness to deal with the situation before it is too late.

Current Status – A SWOT

The science of modern plant virology started developing about two decades back in India when the Advanced Centre for Plant Virology was established in 1988 under the UNDP programme at IARI, New Delhi. Since then a number of reasonably well equipped virology laboratories were developed in certain ICAR and State Agricultural Universities and in a few CSIR Institutes also. The recent efforts seem to be on human resource development, diagnostics and transgenic under the National Agricultural Technology Project of World Bank and more recently under the ICAR-Network projects. The following analysis highlight the status of crucial areas in plant virology in which much is yet to be achieved with a focused attention for eventually managing the viral diseases.

- Though recent advances in the field of molecular virology have lead to better understanding of the viral genomics and are being utilized in certain cases to develop transgenic against viral diseases but as on today we have not developed products to be released for the benefit of farmers for large scale cultivation.

- No concerted efforts have been made to understand the genetics of resistance to major diseases, to identify the resistance genes for durability of resistance to multiple viruses in important crops like rice, maize and grain legumes, by pyramiding both conventional and molecular genes for resistance.

- Efforts were made to develop diagnostic protocols for plant viruses in different national laboratories but have not reached the level of diagnostic kits which are commercially available and could be used by the certification agencies or seed testing laboratories.

- Efforts have been rarely made to work on epidemiological parameters of viruses and studies concentrating on population structure of viruses/ vector are yet to be initiated.

- Developing realistic standards for certification of horticultural and vegetable crops has unfortunately not gained priority despite its immense importance in trade. It is alarming to note the lack of certification standards even for destructive seed-borne viruses.

- With the change in cropping system there is a resurgence of new viral disease problems such as **necrosis in sunflower, groundnut, leaf curl in potato,** etc., which are warning signals that cannot be neglected to sustain the crop production and food security.

- Studies are required to predict emergence of potential viruses and their management. This is also important in the context of pest risk analysis that needs to be done for every crop in trade.

- Also, the growing threat due to viruses that can be used as a **bio-weapon** has not been tackled so far by any of the Institutes. The recent interceptions of deadly plant viruses such as ***Cherry leaf roll virus*, *Tomato ring spot virus*** etc. in exotic material of import, and the recent examples of SARS and Avian flu disease in humans/ animals is an indicator of new dimensions of virology that need to be looked into by the plant virologists.

Thrust Areas of National Institute of Plant Virology

A. Studying important viral diseases as models

<u>Prioritizing the virus/ crop</u>

The National Institute of Plant Virology (**Fig.1)** will address a few intriguing unresolved plant viral diseases for which etiology is not known such as **urdbean leaf crinkle disease, para wilt disease of cotton, arecanut yellows, coconut root wilt** etc. that evaded solutions in crop health for a long period of time.

Major virus diseases in economically important crops such as **Sunflower necrosis** and **Groundnut stem necrosis** caused by *Tobacco streak virus*, **Potato apical leaf curl** caused by ***Tomato leaf-curl virus***, ***Groundnut bud necrosis virus*** having a wide natural host range infecting tomato, potato, chilli, soybean, mungbean, urdbean, cucurbits etc. will be taken on priority and in depth study for virus-vector, host and environment need to be undertaken to develop management strategies by conventional and biotechnological approach.

<u>Prioritizing Areas of Work</u>

The institute will work on following diverse important aspects of the prioritized diseases for eventually finding management strategies and to act as a model for virologists working in other national laboratories.

- To develop novel diagnostic approaches for detecting multiple infections simultaneously by developing crop/ virus-based chips and nanotechnology for detection of exotic and indigenous viruses that are of grave concern.

- To exactly delineate the virus species involved in the etiology of the disease so that the corresponding resistance genes can be tagged, lineage understood and used in breeding programmes with marker assisted selection.

- To strive for imparting multiple resistance and to enhance the durability of resistance by pyramiding genes from novel sources and through search for novel molecules from sources other than plants for managing viral diseases.

- To study the role of vectors and their hosts in order to manage them prior to crop seasons.

- To study structural and functional genomics which will lead to gene mining for search of novel genes and promoters etc., which would facilitate molecular farming and would be very useful in developing management strategies by developing transgenics resistant to viruses and their vectors, if any.

B. Facilitator for National Laboratories

The Institute with all its modern facilities and expertise will serve as a centre where in virologists of various national laboratories can come for a short period and prepare their requirements of diagnostic kits i.e. for developing broad spectrum diagnostics viz., group specific monoclonals/ polyclonals, dip stick formats, group specific primers/ PCR protocols, multiplex PCR etc.

Also Virologists can use the facilities and expertise to undertake studies on genomic characterization and molecular variability of their respective viruses, develop certification protocols for seeds and planting material and for producing virus-free in vitro culture develop molecular markers for selecting virus resistance sources from the available genetic resources etc.

This would facilitate research by those laboratories which are not well equipped and will boost research in case of many regional and chronic viral diseases such as ***Mungbean yellow mosaic virus*, *Cotton leaf curl virus*, *Papaya ring spot virus*,** etc. Also, it may give impetus to work on a number of destructive viruses and even **viroids of fruit and ornamental crops** and the nearly unexplored viruses inflicting plantation/ forestry crops.

C. Obligatory Functions

- Preparation of Standard Operating Procedures for those plant viruses that can be used as a bio-weapon and to serve as focal point for dealing with bioterrorism
- Development of repository of virus cultures, indicator hosts, antisera, primer sequence for diagnostics
- Preparation of distribution maps for viral diseases in India including mapping of virus-free areas through networking with regional Institutes.
- Development of database on plant viral diseases in India
- Centre for human resource development in plant virology
- Net-working with leading virology centres in India and abroad with online interactive biophysics, identification diagnosis service.

Human Resource or Staff Requirements

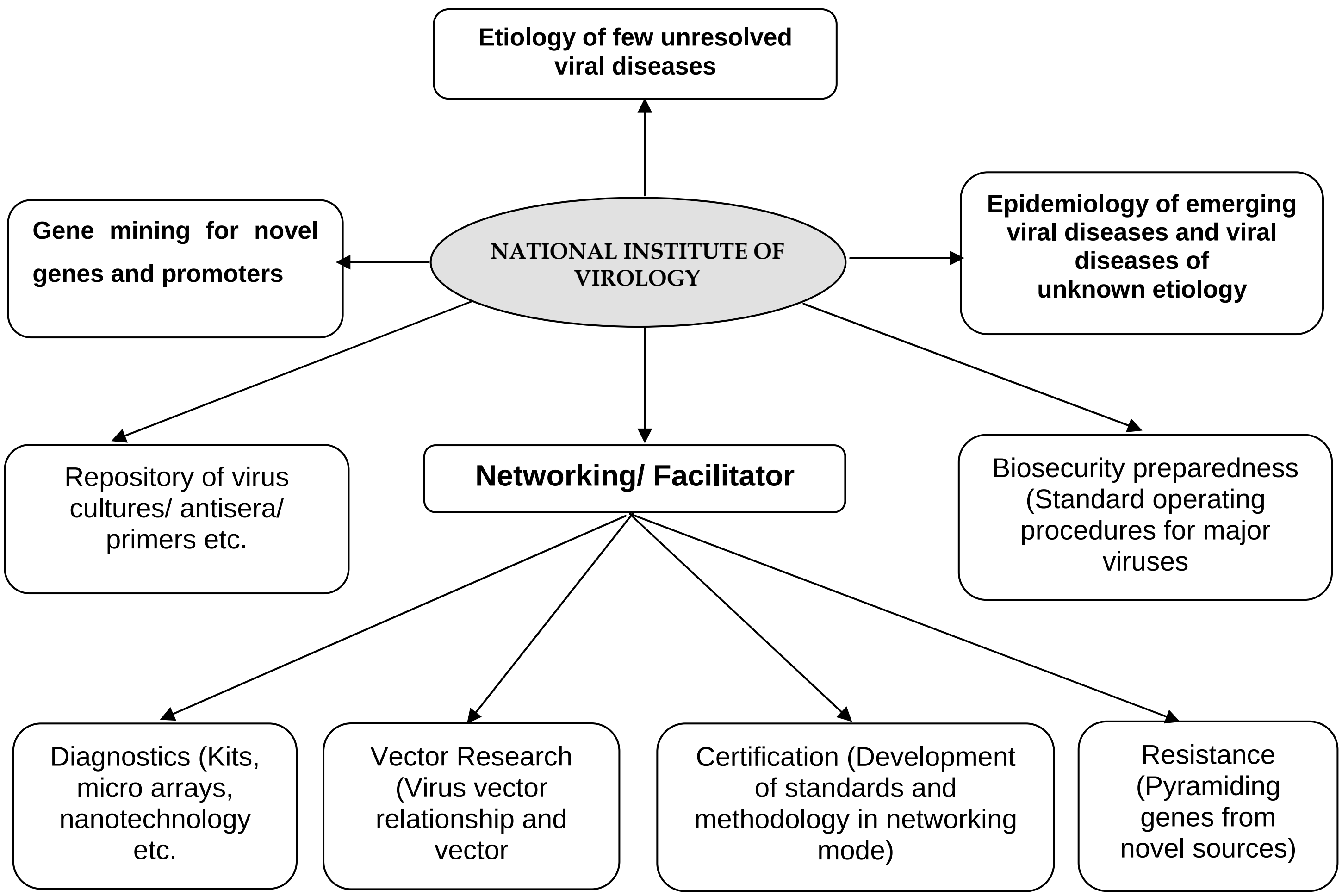
- Experts in molecular and conventional virology, biotechnology, entomology for studies on insect vectors, nematology for studies on seed-transmitted viruses, genetics, horticulture, tissue culture
- Post-doctoral associates from all over the world
- Provision for getting time-bound national/ international expertise by outsourcing

Anticipated Output

- Focussed attention for managing unresolved viral diseases of national concern
- To develop a world class institute with all modern facilities and expertise par excellence on which various national laboratories would bank upon to accomplish their sophisticated research programmes.
- Ideal platform to address virus related biosecurity issues

Budget Proposed: Rs. 35 Crores approx.

Fig.1 Organisational structure of National institute of Virology



Annexure IV

Concept Note on
National Plant Health Research Institute (NAPHRI)

Preamble

National Plant Health Research Institute **(NAPHRI)** has been conceived as a research system for undertaking exclusively strategic research in all those fields of Crop health management that have been otherwise, either scattered or dissipated in their energetics of operation in the country for the last four decades or more (**Fig.2)**. The immense need for establishing such an umbrella institute is to provide strategic support in scientific analysis and research on a number of gaps that is perceived to be difficult for the existing crop-based, plant protection research institutes to address in addition to many private and government organizations of the country.

There has been deterioration in focus as well as efforts on the areas of research in plant health management in an integrated manner by clearly understanding the biology of herbivory as well as that of crop compensations in a tri-trophic system of the food chain. Several food chains, constituting interactively, form food webs that are poorly deciphered in agro-ecology of various cropping systems. A number of minor pests have risen to menacing levels and affect plant health. The solemn intention of harvesting cost-effective commodities and food shall be achieved only if the overall crop health is expressed at its best to both thwart the damage from biotic stresses and to compensate effectively for the damage that is accrued by crop plants over the cropping period.

The NAPHRI has the design of an apex research organization for the above purpose and would address the strategic realms of plant protection. There has been call and clamour for unifying and integrating plant protection processes in the past. Discipline-oriented approaches to look for mitigations only resulted in compartmentalized outcome for each crop species within the addressed questions of limiting crop production in respect of a given plant protection discipline such as entomology, plant pathology or Nematology. The extent of holism that was essential for the farmer to practise a unified protocol of crop protection under a background good agricultural practice was missing.

Mandate:

1. The NAPHRI shall provide autonomous research support for undertaking strategic support system for the country's growing needs of indigenization of its crop health care.
2. The institute shall nurture multi-disciplinary research, cross-cutting formal boundaries of disciplines and fields of research to evolve strategic research results.
3. The NAPHRI shall be the mother institute that keeps in its folds all the present plant protection system of the country.

Objectives:

The NAPHRI shall provide basic infrastructure and facilities to undertake core strategic research of a multidisciplinary nature and act as a mother i0nstitute for crop health research in the country.

The institute should pioneer and lead the nation in interdisciplinary research to provide holistic and cost-effective solutions for crop health care.

Organisational structure:

The Institute shall be headed by Director, who is equivalent in position to the Deputy Director General in ICAR. There shall be the following eight divisions, viz., Crop health care modelling (with three groups, Forecasting, IPM and Simulation and stochastic models), Host plant resistance, Commodity health management, Agro-ecosystem research, Natural produce research, Agro-chemical research (synthesis of pesticides, active ingredients of natural products, pheromones and other behaviour modifying chemicals and Formulation technology of these), (biosystematics, behavioural relations,. Soil biology, pollinators and honey bees as groups), Phyto-sanitation and Appliance engineering

Infrastructure required

Building and farm: A research farm area of 20 ha with facilities for both irrigated and rainfed- farming shall be there. The Building of 3000 sq.metre in three floors shall house the eight divisions. Common facility for supply of water, electricity and gas in addition to fuel shall be available in addition to workshop facility.

Manpower: The Director shall be of the position of DDG of ICAR with independent leadership quality for the promotion and supervision of multi-disciplinary research. The eight Divisions shall have the purposive Group Directors of the status of Directors of NRCs of ICAR with specialization of the research priority of the concerned Divisions. Some of them have specialised groups that shall be headed by the Sectional Heads of the rank of Project Co-ordinators of AICRPs of ICAR. The Scientists of the rank of Principal Scientist: Senior Scientist: Scientist in the ratio of 1:3:6 shall be provided. The laboratory and field assistance shall be through contractual positions of Research Associates and Senior Research fellows, in accordance with ICAR guidelines.

Strategic Research:

The NAPHRI shall induct only problem-solving approach for its strategic research programmes. These would be exclusively interdisciplinary and shall attract best talents and workmanship with cutting-edge technologies and tools available through skilful and committed scientific manpower.
Budget: A budget allocation of Rs 15 Crores is required for NAPHRI, for laboratory building, field infrastructure etc. If the EFC is combined with the three Institutes of Plant Protection Section in addition to the various AICRPs and AINPs, proportionate Plan fund enhancement could be made on rationalized basis.

National Plant Health Research Institute (NAPHRI)

(for strategic research in the pattern of BARC)

Director (equivalent to DDG of ICAR)

Divisions (8) under Group Directors

- **Crop health care modelling**
  - Forec asting
  - IPM
  - Simulati on & stochasti c models
- **Host Plant Resistance research** (Components of resistance, Formulation of selection index Multiple resistance, Durable resistance, Inheritance of resistance, Molecular approaches of breeding, transgenic etc. Pseudo-resistance,
- **Commodity health Management** (insects, pathogens, Mycotoxins in storage)
- **Agro-ecosystem Research**
  - **Biosystematics** of (insects/ pathogens/nematodes, repository and exchange)
  - **Behavioural relations** (alimonies, kairomones and pheromones) **Tri-trophic relations** of insects, pathogens, nematodes, vertebrate pests etc.
  - **Soil Biology**
  - **Pollinators & honey bees**
- **Natural Products Research** (botanicals, natural enemies such as insects, Microbials against Insects, Nematodes, Weeds, and antagonists etc.)
- **Agro-chemicals research**
  - Synthesis of pesticide molecules
  - Synthesis of active ingredient of natural products
  - Synthesis of pheromone s & other potent behaviour modifiers
  - Formulation technology (agro-chemical microbial pheromones natural products etc.)
- **Phytosanitation**
- **Appliances engineering**

Annexure V

Concept Note on

CENTRES OF EXCELLENCE IN PLANT PROTECTION RESEARCH

The need for the establishment of four **Centres of Excellence on Plant Protection** research was felt by this Sub-group in order to address the following areas of regional importance.

a. studying the biodiversity in various agro-ecosystems of the prevailing concerned cropping systems
b. developing biological resource maps in the concerned agro-ecosystems
c. developing appropriate modules of integrated pest management for all biotic stresses of the concerned cropping systems
d. evaluating their performance in farmer-participatory mode
e. liaison with National Centre for IPM in testing and evaluation of all IPM modules
f. act as regional repositories of all natural enemies
g. provide expertise in IPM to all the KVKs and other organisations to enhance capacity building in IPM
h. enhance farmers' perception of non-chemical pest management
i. develop exacting interventions to reduce and suppress herbivory

These centres shall be working in tandem with the plant protection departments of various research institutions of the region in order to develop pragmatic and reliable pest suppression techniques. These centres shall be inter-institutionally networked under the National Centre of Integrated Pest Management along with Project Directorate for Biological Control. All PP research and development programmes in the country shall be networked through inter-ministerial networks. There should be a master control at DAC-DARE (ICAR). This would ensure direction, accountability / responsibility; review/monitoring as well as collective wisdom.

The funding for these centres shall be from the new AICRP on Integrated Pest Management. Suitable number of posts as admissible may be provided for this purpose.

Annexure VI

Introduction of Integrate Pest Management (IPM) in Educational Programmes

IPM in Educational Programmes

Broad-basing Agricultural Education:

Indian Agriculture is in the throws of change. Agricultural education system has first to discern direction of the change and the environment leading to this change and then reorient and adapt itself to foster the desired change (Mehta, 1999). Course curricula need to be extensively revised so as to be in tune with the fast changing requirement of contemporary agriculture in India in both the national and global setting. Greater emphasis need to be given to the internship at the graduate level so as to provide graduates with hands-on experience in agriculture. Exposure of students to various national programmes in the agriculture sector would equip them with knowledge and help in developing in perspective for the work being carried out in agriculture sector in public system at the central and the state level. Likewise inclusion of a management module at both the graduate and postgraduate level would improve the quality of the product.

Education at UG and PG levels

In the undergraduate curriculum in the SAUs microbial pesticides are taught as a part of biological pest control among various IPM components under the course “Principles of Pest Management”. The students are only exposed to the new concept of microbial pesticides. There is not much time to learn more details about these insect pathogens. At the Masters level in most Universities, there is an exclusive course on biological control in which the students learn the principles and practices of employing entomophages (parasitoids and predators), insect pathogens, insect weed killers, etc. The students get better exposure on microbial pesticides in this course, though they are not able to get the much needed hands-on training in the mass production, formulation, product development, etc.

The research scholars in the Ph.D. degree programmes with specialisation in biological control are able to do much more intensive basic and applied research in various aspects of microbial pesticides both under course work and thesis research work. However, the number of students specialising in microbial pesticides under masters and doctoral levels is far few. Most of the pesticide companies sponsor research studentships only in bio-efficacy and toxicology of chemical pesticides in the country.

A new optional practical credit course called as “Commercial Agriculture” was introduced in early 1990s in Tamil Nadu Agricultural University in which commercial production of microbial pesticides and other bio-control agents is one of the many optionals for the students at the under graduate level. Though the number of students attracted to this course is rather limited, the graduates trained in this area are able to establish small commercial production centres for self-employment under the guidance of the teachers of the Tamil Nadu Agricultural University. Some of these production units are functioning fairly well. In as much as large number of farm graduates, zoology / microbiology graduates and diploma holders in agriculture remain unemployed or under employed, it would be worthwhile to orient them and train them intensively in the large -scale production and use of the possible microbial pesticides.

The Government of Tamil Nadu has planned to introduce agriculture subject in about 100 high schools and 100 higher secondary schools in the State. Such trained manpower can serve as middle level functionaries in promoting the use of microbial pesticides and IPM.

Vocational Education

Since future job opportunities would be in the private sector, agricultural education should have greater vocational input. Some beginning has been made in Punjab and Maharashtra to provide vocational training SAUs & vocational schools. Krishi Vigyan Kendras (KVKs) can also help in this area. Despite commercialisation of agriculture and increasing use of technology, agriculture sector will not be able to absorb the new addition to the labour force. The growth rate of labour force during Ninth Plan has been 2.5 per cent per annum. Improvements in rural infrastructure, increased incomes and diversified demand in rural areas would create new job opportunities in the service sector. There is need to develop skills of rural youth so that they can partake of the new opportunities in this sector. SAUs and ICAR with their KVKs and other rural outfits can greatly help in providing quality job-oriented vocational education to rural youth.

Outreach Educational Programmes

Agricultural education today focuses almost entirely on courses leading to a graduate or post-graduate degree. In most of the States, it does not have any out-reach system except the Krishi Vigyan Kendras run by SAUs. It does not impart long duration training to farmers and farm youth. Farmers, who wish to impart basic knowledge of modern agriculture to their children other than through acquisition of graduate or post graduate degree, fail to do so because SAUs do not cater to such a requirement. SAUs should develop outreach system of agricultural education for fun leaders through distance education and holding of short term and long term institutional trading courses. Such courses could also help in the development of system of community based para-extension specialists. This would improve the interface between farmers and agri-specialists (Mehta, 1999).

Relating Education to Social needs

To make agricultural education more relevant the SAUs are implementing the Rural Agricultural Work Experience (RAWE) programme, Village Stay Programme, Commercial Agricultural Course, Economic Surveys Programme, Earn While You Learn scheme, Crop Production courses, Development Communication, Rural Development and many other programmes. Biopesticides and IPM are invariably included in all these programmes. The students are also involved in extension programmes like the method and result demonstration in farmers' fields, social forestry awareness campaigns, environmental awareness campaigns, etc.

The curricula and syllabi of each degree programme are revised and completely updated with the following specific objectives:

i) to provide the graduates with aptitude, confidence, knowledge and skills to become entrepreneurs,

ii) to be well fitted into job on competitive basis with other degree graduates,

iii) to become owners or managers of commercial farms, and

iv) to offer counselling and advisory service in agriculture and related fields.

3. HORTICULTURE & PROTECTED CULTIVATION

Doubling of production of vegetables, fruits, spices and plantation crops to meet nutritional and livelihood requirement of envisaged human population of 1200 million by 2012 is a stupendous task. Domestic demand for flowers, flower based products, and fragrances and flavours are on rise. Growth rate in Horticulture needs to be 6%, if the National GDP has to be above 8%. Among inputs to Horticulture, water and energy are critical and costly. Water Saving Horticulture through use of low water requiring crops and varieties demands priority. The X Fiver Plan witnessed intensification of crop production for apparent reasons shared the threats and risks of crop loss due to several biotic and abiotic stresses. Hence, a massive funded network project on water saving fruits, vegetables, ornamentals, spices and medicinal plants need to be initiated. Petroleum based energy is costly and non-renewable. Planning Commission of India has identified 12 crops for this purpose. In addition, possibility of bio-diesel from oils of coconut, oil palm and palmyrah are also to be explored. Indian Horticulture faces challenges from biotic and abiotic stresses. Major diseases and pests call for economic and eco-friendly solutions. More than 75% of pre-school children suffer from iron deficiency anemia. About 57% have sub-clinical vitamin deficiency. The escalation in cost of production due to increase in the input costs resulted in non-profitability under the volatile market prices for agricultural produce. More than 50% of women and children suffering from malnutrition and micronutrient deficiency in the world are in India. Leaf vegetables, tuber like kekrol and many under-utilized crops like agati, chekkurmanis, water leaf, amla, water chestnut, kokkam, noni, koranda, bael, ber, tamarind, passion fruit, chow-chow etc. need promotion.

India is known for plantation crops, spices, medicinal plants, mushrooms and ayurvedic, unani and siddha medicinal practices. Except for rubber, other sectors are facing challenges of an open market, consequent to WTO agreements. India is known worldwide for its 1000-year odd Horticulture history. There are traditional wisdoms and indigenous knowledge. But they lack test of science to be accepted by the west who are the importers of our goods and products for which verification has to be done. Human resource development in Horticulture is vital for nation's growth and development. Documenting India's wealth in Horticulture and DNA Bar coding is a priority item to be taken up to protect our vast and valuable plant biodiversity.

Protected cultivation in India is in its infancy even after 25 years of efforts in R & D and promotion. While the advantages are appreciated, a large-scale use of these technologies has not been made so far. This requires special attention in Eleventh Five Year Plan.

The growth of Horticulture in sustaining the high growth in agricultural productivity has been highly appreciated. Investment in various Plan Periods to enhance sustainable infrastructure for research and training in various production and protection of horticultural crops is justifiable The Sub-Group on Horticulture and Protected Cultivation constituted as a part of the Working Group on Agriculture Research and Education of the Planning Commission with the following Terms of Reference (Annexure-1).

(i) To make critical review of X Plan achievements in terms of horticultural research, in contrast to the objectives and targets set during X Plan.

(ii) To identify critical gaps in scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as enable the ration to enhance its agricultural competitiveness in the context of WTO and IPR regime.

(iii) To draw/suggest specific schemes/programmes pertaining to horticultural research to address the problems of less privileged regions.

(iv) To critically review the status of post harvest management research, value addition and identify the priorities in terms of human resource development and institutional mechanism for attaining the desired results in this vital sector.

(v) To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

(vi) To identify institutional mechanism for strengthening, monitoring and evaluation system in horticultural research, and to suggest efficient measures for effective coordination of horticultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public private partnership.

(vii) To draw/suggest specific schemes/ programmes/ research area pertains horticultural research.

The Sub-Group met on 17th July, 2006 and 15th September, 2006 to deliberate and finalize the report (Annexure-II and III). The Sub-Group pursued the material provided by various concerned organizations and discussed thoroughly in the two meetings. The final report thus emerged and is presented here.

REPORT

The Sub Group considered the significant achievements made in Horticultural research under various schemes of the ICAR during X Fiver Plan period. The committee looked into various the extensive information generated by through high quality research in various Institutes and AICRPs/AINRPs in the Horticulture Division.

Tenth Five Year Plan Achievements in terms of Horticultural research:

Horticultural research under the ICAR system is being carried out under six programmes, fruit crops, vegetable crops, potato and tuber crops, floriculture and medicinal and aromatic plants, plantation crops and spices. These programmes are being undertaken by 10 Institutes and 12 NRCs and 13 AICRPs/AINRPs. Horticultural institutes under ICAR are targeted to:

- Production of quality and disease free seed and planting materials for supply to State Departments of Agriculture/Horticulture for further multiplication and distribution as certified materials to farmers/growers.

- Improving productivity of horticultural crops by growing high-yielding and disease resistant varieties and Hi-Tech farming including high-density/close-spacing plantation, canopy management, protected cultivation, integrated nutrient and water management (INWM) and Integrated Pest Management (IPM).

- Using gene-pyramiding technologies for developing resistant varieties against biotic stresses in horticultural crops.

- Exploiting potentials of under-utilized fruits and vegetables.

- Research on post harvest management and value addition is accorded a high priority to minimize post harvest losses of horticultural produces and products.

- Horticulture is given its due place in agriculture diversification to increase production and productivity linked with quality.

- Emphasis is given on arid and dryland/rainfed horticulture to increase production through arid/dryland technologies.

- Heterosis for yield and quality will be exploited in horticultural crops with emphasis on vegetable crops.

- Development of transgenics in horticultural crops with respect to resistance against biotic and abiotic stresses, quality improvement and shelf-life enhancement.

- Developing diagnostic kits for identification of viruses in horticultural crops for their effective management.

- Expertise available in information technology would be exploited to develop commercially viable computer programming on geographical information system (GIS), remote sensing, crop modeling, expert system and precision farming to find out weather parameters, forecasting occurrence of diseases and insect/pests, genetic diversity, etc in various horticultural crops.

- More has to be achieved in breeding of varieties for different processing purposes. Varieties of potato suitable for making French fry, chips, dehydrated product and for baking should be developed.

- Promotion of protected cultivation for growing off-season vegetables, flower seedlings and planting materials of perennial crops.

- Practicing organic farming in horticultural crops.

Major achievements made during Tenth Five Year Plan period:

FRUIT CROPS

- Under germplasm collection, 356 accessions comprising 28 mango, 273 banana, 11 grape, 15 guava, 2 papaya, 1 sapota, 5 macademia, 20 bael and 1 aonla accessions were added to field gene bank. Twenty eight different fruit varieties were better in yield and quality. In ADB-TFT Project, 125 accessions of mango, 68 of citrus and 30 of litchi were added to field gene-bank.

- In banana, a new species of *Ensete* from Kodaikanal hill of Tamil Nadu and a new sub species of *Musa acuminata* from Anaimalai hill of Western Ghats were collected. Further 138 accessions were collected from Andaman and Nicobar Islands and North Eastern States. Sixty-one exotic collections were also added.

- In mango, two hybrids analyzed for fruit characteristics, exhibited good fruit quality with more than 70 % pulp recovery. Molecular characterization of 45 mango, 24 papaya, 52 banana accessions was completed using RAPD markers as per IPGRI descriptors. Mapping of citrus genetic diversity was done with help of GIS. Under ADB-TFT Project, 194 mango accessions were documented and characterized.

- Drip irrigation method was standardized in mango, Nagpur mandarin and pomegranate. Drip irrigation coupled with mulching was optimum for increasing fruit production and water use efficiency in pomegranate and grape.

- IPM including bio-agents was tried out in mango, banana, citrus and grapes against important insect pests.

- Storage life was extended up to 30 days at 8°C by packing mango fruits individually in micro-perforated polyethylene or polypropylene films.

- Twenty mango and 2 papaya hybrids were evaluated for fruit characteristics. Three banana hybrids were evaluated for plant and fruit characteristics.

- In pomegranate, 860 hybrids from 26 crosses were evaluated for drought resistance. Cell membrane stability test was carried out in 10 pomegranate hybrids.

- Two promising hybrids in grape were identified. Two hybrids of rough lemon are promising for nursery characteristics and resistance to *Phytophthora.*

- Germplasm Information System was developed at IIHR, Bangalore for computerization of central accession register containing records of germplasm of different horticultural crops over last four decades. Separate database design structures were developed to store and retrieve information about fruit crops, vegetable crops, medicinal and aromatic plants and ornamental crops.

- Rootstocks `Vellaikolumban' and 'Rumani' recorded maximum productivity/unit canopy volume and unit land area. Technique was demonstrated in guava that it was possible to grow up to 5000 plants/ ha at a spacing of 1.0 m x 2.0 m coupled with regular topping and heading.

- Studies carried out by using different fertigation levels under high density planting in Robusta, Rasthali and Saba cultivars of banana showed that paired row system (5200 plants /ha) gave better plant growth compared to other densities in all fertigation levels.

- In grape, Thompson Seedless and Flame Seedless scions showed maximum compatibility with Dogridge B and 99 R stocks respectively. Among different rootstocks, Thompson Seedless grafted on Dogridge B recorded maximum yield of 2.79 kg/vine.

- Post-harvest treatment with Prochloraz (0.1%) and hot water treatment at 52ºC for 10 minutes were the most effective for management of disease in mango.

- Botanical extract *Solanum torvum* spray at 50% concentration on banana fruits after harvest not only controlled anthracnose disease but also increased shelf life of banana to more than 26 days over control. Dot blot technique was developed for detection of BBTV.

- Citrus plants treated with Ledermycin 600 ppm + $ZnSO_4$ + $FeSO_4$, shows the highest reduction in greening disease.

- Preharvest treatment of grapes with chitosan alone or in combination with *Trichoderma* improved shelf life of grapes. XAD-16 resins was the best for removing bitterness in citrus juice.

VEGETABLE CROPS

- Central Varietal Release Committee notified Fifty-two (52) varieties in different vegetable crops.

- Promising ToLCV resistant tomato hybrids were evaluated for confirming resistance. Multiple resistant superior hybrid (TLBRH 1) was identified. Promising 81 lines were identified along with one joint less mutant and β-carotene rich tomato line. 300 IIVR collections and 163 exotic collections were evaluated and characterized. 124 crosses were developed for further evaluation.

- DNA based technique for screening of tomato germplasm is used. Construction of dimeric constructs in plant transformation vector is in progress. PCR primers are used for detection in plants. Beta DNA association has been observed, and cloning of this gene in plant transformation vector is in progress.

- In tomato, two field resistant lines to leaf curl, H 88-78-1 and H 88-78-2 are identified. A total of 81 advance lines were planted in two locations namely IIVR, Varanasi and Sarghatia farm and evaluation of same is underway. A total of 142 RILs was planted and evaluation is underway. All the wild species except L. *chilense* and L.*pennelli* were successfully maintained using manual selfing and sibmating. A total of 53 L. *hirsutum* introgressed lines were introduced. Maintenance and multiplication are underway. A total of 300 hybrids are developed. 60 F1 hybrids in brinjal were planted for evaluation. 112 RILs were planted in three replications, data analysis is under progress. Single plant selection was made in segregating generation (F2-F5). Bulk seeds are being produced in advanced lines and identified hybrids. Putative transgenic plants in tomato cv. H-86 and in brinjal cv. IVBL -9 were developed using Cry 1Ab and Cry 1 Ac gene constructs. Confirmation of putative haploids through cytological investigations was done. Protocols for transformation of cauliflower lines through Cry 1Ab gene construct were standardized. Haploids and double haploids in tomato, brinjal and cucumber through anther culture were produced.

- A regeneration protocol for developing five commercially grown transgenic brinjal (resistant to shoot and fruit borer) was in place using epicotyl and hypocotyl explants. A new species of begomovirus (Tomato leaf curl Gujarat virus) causing leaf curl disease of tomato in Varanasi (ToLCGV-(Var) was discovered which appears to be a recombinant one. It shares many fragments of its genome with several Asian begomoviruses, confirming that recombination is an essential molecular component for geminivirus evolution. Sex pheromone based IPM technique was developed for management of brinjal shoot and fruit borer.

- Seeds of 3 hybrids (2 cms based) and three improved populations were multiplied. Crossing programme using cms lines was undertaken. Nucleus seed of identified okra varieties namely VRO-6, VRO-5, and IIVR-10 were produced. Varieties/advanced lines were evaluated for summer season. Germplasm of cauliflower, radish and carrot were evaluated. Nucleus seed of identified varieties of radish namely IIVR-1, IIVR-2 were produced. Promising varieties/ hybrids of cauliflower, cabbage, radish and carrot were evaluated. 200 lines of different groups of Indian cauliflower, 70 lines of radish and 50 lines of carrots were evaluated. 25 hybrids of cabbage are under evaluation stage. 40 F1, F2, F3, F4 and one population of 6 generation mean analysis were grown and data recorded in pumpkin. The beta carotene analysis of pumpkin in six generation population was analyzed plant wise.

- In ash gourd, 60 new F1 were developed. Segregating population was handled and seed of selected variety was multiplied. 128 germplasm selfed and maintained, 62 F1s and 41, 23, 14, 9 plant populations were evaluated. VRH-1 (F1) was selected. Seeds of DVBG-1 and DVBG-2 and DVBTG-1 and DVBTG-2 got increased. IIVRPG-1, IIVRPG-2 and parthenocarpic lines got multiplied. 37 and 113 germplasm of ridge and sponge gourd selfed and seeds collected, 10 and 22 cross combinations developed. Germplasm of *Vicia faba* (4), *Chenopodium* (1), *Basella alba* (2), *Basella rubra* (1), Moringa (2) lines were collected.

- Important antioxidant phytochemicals viz., ascorbate, carotenoids, lycopene, lutein and phenols in promising 59 tomato lines and hybrids were estimated with help of HPLC. Standardized HPLC estimation procedures for glucosinolate and quantified sinigrin content in Brassica vegetables. Maximum content was recorded in Broccoli followed by Brussel's sprouts. Estimated antioxidant phytochemicals in 12 OP varieties and hybrids in tomato. Estimated capsaicin and oleoresin content in 81 F1' s in chilli and ascorbate and carotenoid content in 40 pumpkin lines

- Very high anthracnose severity in chilli was recorded during October and varied between 58-70% in different treatments. Under pathogenic and molecular characterization of *A. solani*, isolates Va-3, Va-5, Dh were the most virulent. Screening by PCR is in progress for maximum polymorphism. A total of 575 kg *Trichoderma* was prepared and 434 kg was distributed among 612 farmers. A total 7 IPM training and farmers meetings were conducted in Mirzapur, Chandauli and Varanasi districts.

- Fruit fly population dynamics were studied. Screening of cultivars and botanicals were conducted. Population dynamics of jassid and influence of organics were studied. 60 kg of okra breeder seed and IIVR seeds of different vegetables were produced. 15 *Dolichos* bean and 22 okra genotypes were characterized on the basis of total soluble protein profile.

- Drying onion seeds to 6 % moisture content, packaged in laminated pouches along with silica gel increased storability to 18 months under Varanasi conditions.

- Technology for producing quality tomatoes under green house was standardized with marketable fruit yield of 171t/ha in the medium of soil : compost : saw dust (2:1:1) and fertigation with commercial fertilizer, indicating possibility of reducing production cost due to fertilizers. Average fruit weight was 80 g/fruit and on an average 74 fruits were harvested from each plant.

- Evaluation of *Cynadon dactylon* for management of disease complex of tomato (validation of ITK) by spraying extract fortnightly, resulted in reduced incidence of wilt, leaf curl, early blight, and increase in harvest of healthy fruits in *Cynadon* treated plots as compared to untreated control.

- Technology for production of quality capsicum was standardized. The highest marketable yield of 113.8 t/ha was harvested under growing medium of Soil: Compost: Saw dust (2:1:1) and fertigation with water-soluble fertilizers. Average fruit weight was 149g/fruit and on average 18 fruits was harvested from each plant. French bean line IIHR 220 x Arka Komal 12-B with pod yield of 18-21 t/ha and resistance to rust was released and named 'Arka Anoop'.

- In potato, six hybrids viz. JW-160, MS/92-2105, SM/87-185 and HT/92-621 were recommended for release. Hybrid HT/92-621 is heat tolerant, resistant to leaf hopper and mites. It possesses high dry matter and is the most suitable for French fries. Hybrid JW 160 possesses wide adaptability and excellent keeping quality and can be stored under ambient temperatures. Integrated use of vermicompost and inorganic fertilizers gave 290 and 362 q/ha in Kufri Chipsona-1 and Kufri Anand, respectively besides improving tuber dry matter, specific gravity and chip colour in Kufri Chipsona-l. A total of 161.621 t nucleus seed and 2523.544 t breeders' seed was produced in plains and hills.

- A total of 2.2305t potato breeders' seed was supplied from plains and hills respectively to state departments and other seed producing agencies.

PLANTATION CROPS

- Genetic base of coconut was further strengthened by adding large number of collections from various sources.

- Integrated approaches for management of major diseases like root (wilt) disease, stem bleeding and insect pests like eriophyid mite, rhinoceros beetle, red palm weevil in coconut and yellow leaf disease in areca nut were developed.

- Fertigation technique to save water and nutrients in coconut was developed.

- Soft wood grafting was standardized in cocoa.

- Coconut based cropping systems suitable for different regions were developed.

- In cashew, high-density planting and canopy management were standardized.

- Technologies for management of cashew stem and root borer were developed.

- Value added products like coconut chips and snowball tender nuts were developed.

- Vermicomposting technique using coconut and farm wastes was standardized.

- Remote sensing and GIS techniques were successfully employed for identification of root (wilt) diseased palm.

TUBER CROPS

- A total of 5578 accessions of tuber crops are conserved *ex situ* at CTCRI. About 30% are maintained in *vitro*.
- High yielding varieties of cassava, sweet potato and taro were developed.
- A high carotene sweet potato hybrid, Sree Kanaka is developed which gives a yield of 10-15 t/ha in 75-85 days after planting.
- Two triploid hybrids of cassava having high and stable starch yield (29-32%) and high tuber yield (>36 t/ha) were developed for Tamil Nadu.
- Two superior hybrid selections in Amorphophallus with higher tuber yield (38-42 t/ha) were identified for release.
- Virus elimination through meristem culture was standardized.
- Integrated disease management against taro blight was developed.

MUSHROOM

- About 935 mushroom specimens were collected and taxonomically described and characterized using RAPD technique.
- A high yielding strain of *A. bisporus* with better quality and tolerance to fly was developed. Four high yielding strains of *A. bitorquis* with tolerance to false truffle were identified.
- Developed indoor compost production technology and rapid composting using thermophillic fungi.
- Cultivation techniques of famous edible and medicinal mushroom, Shiitake (*Peninsula*), Reishi (*Ganoderma lucidum*), Flammulina and Agrocybe were standardized.

SPICES

- 110 accessions of black pepper and 49 of cardamom were characterized based on IPGRI descriptors. Collection 1041 was registered as field tolerant to foot rot disease.
- High yielding varieties of black pepper, cardamom, ginger, turmeric and cinnamon were released for commercial cultivation.
- Black pepper lines OPKm, HP-728, HP-1411 and HP-780 are promising.

- Accession HM-444, 372 and 376 of fenugreek recorded the highest yield. HM 444 are resistant to downy and powdery mildew diseases.

- A technique ‘Serpentine layering ‘ was developed to produce healthy planting materials of black pepper.

- IPM/IDM technologies with emphasis on biocontrol agents were developed for all major diseases and pests.

- Diagnostic kits for detecting viral infection in planting materials is under way.

- Rhizome solarization is highly promising for management of bacterial wilt in ginger.

- Organic farming in spice crops is attempted.

FLORICULTURE

Rose

- HT rose ‘Pusa Gaurav’ and floribunda rose “Arunima” performed well at majority of centers.

- For loose flower production, varieties “Neelambri”, and Arunima” were promising while “Banjarani” was the best for garden display.

Gladiolus

- Arka Kesar, Swarnima and Shagun performed better at many places.

Carnations

- The cvs Impala, Superstar, Veleta and Fantasia provided with 4 hrs extended light resulted in maximum flowering stem length and early flowering.

Chrysanthemum

- Newly developed varieties viz Arka Ravi, Punjab Gold, Mother Teresa, CO.2, Indira, Yellow Gold, Ratlam selection, Sonali Tara, Sunil, Baggi etc were promising at different locations.

Orchid

- Coconut husk was the best suitable media for Dendrobium cv Sonia.

Tuberose

- Prajwal and Vaibhav performed outstandingly.

Gerberas

- Gerbera cvs grown under low cost polyhouse performed better than those grown under shade net and open field conditions.

MEDICINAL AND AROMATIC PLANTS

- Germplasms of various medicinal and aromatic plants were enriched.
- Digitization of germplasm is in progress.
- Good Agronomic Practices for these crops are being standardized.
- Ashwagandha MWS 133 gave maximum root yield (1091 kg/ha) and MWS-212 seed yield (1905 kg/ha). Alkaloid content was maximum in MWS-100 (0.56 %)
- In isabgol, the maximum yield (1232 kg/ha) was recorded in G-1-2 genotype at Faizabad.
- High yielding genotypes of safed musli, opium poppy, kalmegh, satavari, lemongrass, palmarosa, chandraasur, mentha etc were identified.

Critical Gaps to be addressed during Eleventh Five Year Plan:

Realising significance of nutritional and livelihood security, horticulture received emphasis since VIII plan. During X plan, emphasis was on increase in production, broadening genetic base, crop improvement, dry land (arid) horticulture, sustainability, clonal production of planting materials, post harvest handling and up-gradation of research infrastructure. Recently diversification and value addition leading to livelihood security received attention. . National Horticultural Mission came in place, which seeks doubling of production by 2010 and to achieve 8% growth rate. Research agenda needs emphasis on following areas/aspects.

Technology driven programme for horticulture development needs focus:

1. Improvement in production, productivity and quality of produce.

2. Reduction in post harvest losses.

3. Value addition through post harvest management (PHM) and processing.

4. Export promotional activities with high quality produce targeting Niche market.

5. Encouraging horticulture crops based nutritional security and improvement in income generation to farm households.

6. Competitive production through efficient natural resource use and management.

7. Survey of indigenous biodiversity for resistance to various biotic and abiotic stresses.

All these require support during Eleventh Five Year Plan period.

- Introduction of consortium approach for survey and development of database of natural resources for planning fruitfully utilizing GIS technology and remote sensing for survey work and geographical indexing.
- Institutional strengthening for crop specific problems through specific schemes.

- Strengthening of Institutes (upgradation in frontier research areas- biotechnology, molecular breeding) to solve issues. Of national importance.
- Establishment of new Institutes like Central Institute for Post Harvest Technology, Product Development, Handling and cold chain, Central Institute of Horticulture for NE Hill Region and Institute of Coastal Horticulture.
- Commercialization of under exploited fruit crops like wood apple, beal, khirni, lasoda, tamarind, jamun, date palm, ber, aonla, jack, and mangostein, Kokam etc.
- Holistic Arid horticulture
- Upscaling clonal fruit plant production by exploiting known protocols.
- Improved inputs use efficiency (nutrients, pesticides, water) through integrated use.
- High density orcharding and canopy management through mechanization
- Development of diagnostic tools against viral diseases in all major horticultural crops.
- Solving national problems like

Mango-	Malformation, spongy tissue, hopper
Banana-	Viruses
Grapes-	Mildews, anthracnose
Papaya-	Viruses
Apple-	Scab
Ber-	Fruitfly
Tropical fruits-	Fruit fly
Vegetables-	Hybrids in onion; fruit and shoot borer in brinjal and okra; fruit fly in cucurbits; viruses in tomato, okra, chilli etc; bacterial wilt in tomato, chilli, brinjal etc.
Tuber Crops-	Cassava mosaic virus
Coconut –	Root (wilt) disease
Arecanut –	Yellow leaf disease
Black pepper –	Phytophthora foot rot, viral diseases
Floriculture-	Development of export oriented varieties of flowers

PROTECTED CULTIVATION

Scope for expansion of area under protected cultivation in the country is immense. A target of 500,000 ha area may be brought under protected cultivation over a period of five years. Greenhouses, low tunnels, cloches and plastic mulching form an integral part of peri-urban horticulture where land is limited and demand for certain perishable horticultural produce is very high round the year. The technology will be an extremely useful intervention in those regions where normal growing season is limited to 4-6 months. Horticultural produces in these areas of UP hills, Himachal Pradesh, Jammu and Kashmir, Northeastern hills and even in desert areas of Rajasthan and Gujarat could be expanded for a larger part of year. Another aspect of greenhouse technology is that it has a greater scientific input.

Following aspects require immediate attention:

- Development of reasonable cost-effective greenhouse structures and environmental control strategies for region and crop specific situations utilizing locally available materials as far as possible.
- Development of appropriate machinery for protected cultivation practices.
- Development of suitable varieties for protected cultivation.
- Development of protected cultivation practices for different horticultural crops.
- Characterization of quality parameters of produces from protected cultivation in relation to consumer requirements and development of appropriate post harvest management practices.

Biotechnology

India is the single largest producer, consumer and exporter of both mango and cashew nut and available genetic stock is also quite rich. Both mango and cashew being highly cross-pollinated, conventional breeding results are uncertain and time consuming. India should be the leader in using molecular biology tools against biotic stresses in both these crops. Biotic stresses in various farming zones are already identified by ICAR institutions and SAUs, but the control remained mainly through agronomic manipulations. Research networking involving Centres of Excellence, selected ICAR Institutions/SAUs is very much needed to retain India's predominance in both these crops.

In vegetables, a good number of commercial hybrids are now available and are in large-scale use. As already identified as a thrust programme for XI Plan, research on introduction of genetic factors for apomixes for production of hybrid seeds (in vegetable crops like tomato, brinjal, cabbage where hybrids dominate) which can be saved by farmers and reused, need attention. Also, cloning and characterization of new genes and promoters for tolerance to biotic stress should receive special emphasis.

Phytophthora diseases are common to many important horticultural crops (citrus, apple, black pepper, yams, rhizomatous crops etc.) and pathogen being soil borne, their control particularly in the high rainfall areas is very difficult. Research thrusts in isolating effective biocontrol agents for different locations and their mass multiplication for use in different crops are needed. Blanket recommendations for commercial products (namely *Trichoderma* spp.) by a few agencies would not solve the problem.

New Schemes for Horticulture during Eleventh FiveYear Plan

Creation of research infrastructure for technology generation for major horticulture crops (fruits, vegetables, plantation crops, spices etc.) has largely been achieved earlier through establishment of ICAR Institutions/NRCs and strengthening SAUs mainly through research projects (AICRP, NARP, NATP, Network Project, A.P. Cess Fund etc.). All the ongoing schemes would continue during Xi Five Year Plan. A few critical gaps in terms of Institution building, however, remained un-addressed are as follows.

Floriculture

Floriculture both for domestic market and export market received focused attention in recent past and export of cut flowers picked up quite fast. Excepting NRC (Orchids) located in Sikkim, there is no specialized Institutional base for generating technologies in flowers and ornamentals. In addition to traditional flowers of local use, flowering crops like roses, carnation, gerbera, anthurium, tropical orchids etc have great scope for enhancing export earnings. Dry flowers and perfumery industry using flowers are both potential sectors. It is therefore, essential to create a new NRC for Floriculture, preferably in Pune in Eleventh Five Year Plan under ICAR.

Budget estimates: Rs. 8 crores.

Post Harvest Management in Horticulture

Perishable commodities like fruits, vegetables and flowers incurred huge post harvest losses due to poor handling, storage and processing. Since Post Harvest Management (PHM) of perishable commodities is different from cereals and other crops, separate treatments are essential for reducing post harvest losses. Earlier there existed AICRP (PHT) dealing with horticultural crops, which discontinued during Eleventh Five Year Plan. It is strongly felt that a separate Institute for dealing with Post Harvest Management (PHM) and value addition of horticultural crops is established this new Institute should also act as Nodal agency for market intelligence and developing standards and exportable products for horticultural crops of the country.

Budget estimates: Rs. 10 Crores.

Horticulture Research Institute for NER

North Eastern Region (NER) covering 8 States (Assam, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Tripura, Sikkim and Mizoram) offers unique opportunity for development of Horticulture industry. Rich germplasm, suitable agroclimate, and farming practices are unique features of NER. Horticulture technology generation remained nonsignificant and technology transfer is almost absent. Existing horticulture research supports in ICAR Research Complex for NEH Region and Assam Agricultural University (AAU) are too meager to address the problems of horticulture crops. Recently a separate institute named Central Institute of Horticulture was established in Nagaland under the Department of Agriculture and Cooperation, Ministry of Agriculture for promotion of developmental activities. This Institution would not be able to make a dent in developmental activities, if there is no technology backstopping. Therefore, a strong need to establish a Central Research institute for Horticulture for the NEH focusing hill horticulture covering crops like citrus, banana, pineapple, cashew, apple, kiwi, off season vegetables, ginger, turmeric, large cardamom, flowers like anthurium, lily and selected medicinal and aromatic plants is felt.

Budget estimates: Rs. 15 Crores.

Research Centre for Temperate Vegetables

At present research on temperate vegetables is not taken care of. Hence it is suggested to carry out research on temperate vegetables, a sub station under Indian Institute of Vegetables Research (IIVR), Varanasi (U.P.) may be started in the temperate region of the country. Alternatively, the IARI Regional Station at Katrain, Himachal Pradesh may be transferred to IIVR, Varanasi to strengthen the research on temperate vegetables.

Budget estimates: Rs. 5 Crores.

Medicinal and Aromatic Plants

Medicinal and Aromatic Plants are gaining importance as alternate medicines for domestic and export markets. National Medicinal Plant Board has already identified 32 crops of great economic importance. The NRC for M&AP located at Anand, Gujarat with a limited manpower and infrastructural support is unable to cater needs of the country. ICAR has the mandate for development of cultivation practices including crop improvement of M&AP. The existing NRC on M&AP is, therefore, to be upgraded as National Institute with one or two regional centers in potential agro-climatic regions, to realize full potentialities of these crops.

Budget estimates: Rs. 7 Crores.

Tribal Horticulture

Horticultural crops including fruits, vegetable, root & tubers, medicinal and aromatic plants provide food security and livelihood support in tribal areas. In shifting cultivation (Jhum) areas of NEH, Orissa, and A.P. an alternate land use for horticulture many emerge up. In tribal areas, input use (particularly agricultural chemicals) is minimum and production is organic. Hi-tech horticulture does not fit well in tribal belts and there is need to develop separate package of practices for tribal areas, focusing organic farming with minimum chemical inputs, rainwater management, pest management technology etc.

At Ranchi (Jharkhand) there was Centre of Indian Institute of Horticultural Research (IIHR), Bangalore with good physical infrastructure. This center needs to be de-linked from ICAR Research Complex and upgraded to an Institute with special emphasis on Tribal Horticulture to generate relevant technologies for tribal farmers of Jharkhand, M.P., A.P. and Orissa.

Budget estimates: Rs. 8 Crores.

Gender issues

In tribal areas, tribal women participate in a big way in agriculture/horticulture production system. Generation of women friendly technology and training on post harvest management (including primary processing, low cost storage etc.) Of horticultural crops will go a long way in women empowerment and in integrating farmwomen with horticultural production system. Training on group marketing through self help groups (SHG) will resolve problems of marketing of perishable high value horticultural crops. Past experience (viz. Andhra Pradesh) shows that SHG movement is successful mainly where women farmers are involved.

Financial Requirements

The following budget allocations are envisaged for the proposed new schemes in the XI Five Year Plan.

Si. No.	Name of the Institute proposed In the XI Five Year plan	Budget estimates (Rs. In lakhs)
1	**NRC for Floriculture**	**800**
2	**Post Harvest management Institute for Horticultural crops**	**1000**
3	**Central Institute of Horticulture for NEH Region**	**1500**
4	**NRC for Temperate vegetables**	**500**
5	**Upgradition of NRC for Medicinal & Aromatic Plants to a National Institute and two more centers under AINRP on Medicinal & Aromatic Plants**	**700**
6	**Institute for Tribal Horticulture**	**800**
	Total	**5300**

Summary Recommendations

Horticultural research under the ICAR system is being carried out under six programmes, fruit crops, vegetable crops, potato and tuber crops, floriculture and medicinal and aromatic plants, plantation crops and spices. These programmes are being undertaken by 10 Institutes and 12 NRCs and 13 AICRPs/AINRPs. All these on going Schemes would continue during the XI Five Year also.

Horticultural institutes under ICAR are targeted to:

- Production of quality and disease free seed and planting materials for supply to State Departments of Agriculture/Horticulture for further multiplication and distribution as certified materials to farmers/growers.

- Improving productivity of horticultural crops by growing high-yielding and disease resistant varieties and Hi-Tech farming including high-density/close-spacing plantation, canopy management, protected cultivation, integrated nutrient and water management (INWM) and Integrated Pest Management (IPM).

- Using gene-pyramiding technologies for developing resistant varieties against biotic stresses in horticultural crops.

- Exploiting potentials of under-utilized fruits and vegetables.

- Research on post harvest management and value addition is accorded a high priority to minimize post harvest losses of horticultural produces and products.

- Horticulture is given its due place in agriculture diversification to increase production and productivity linked with quality.

- Emphasis is given on arid and dryland/rainfed horticulture to increase production through arid/dryland technologies.

- Heterosis for yield and quality will be exploited in horticultural crops with emphasis on vegetable crops.

- Development of transgenics in horticultural crops with respect to resistance against biotic and abiotic stresses, quality improvement and shelf-life enhancement.

- Developing diagnostic kits for identification of viruses in horticultural crops for their effective management.

- Expertise available in information technology would be exploited to develop commercially viable computer programming on geographical information system (GIS), remote sensing, crop modeling, expert system and precision farming to find out weather parameters, forecasting occurrence of diseases and insect/pests, genetic diversity, etc in various horticultural crops.

- More has to be achieved in breeding of varieties for different processing purposes. Varieties of potato suitable for making French fry, chips, dehydrated product and for baking should be developed.

- Promotion of protected cultivation for growing off-season vegetables, flower seedlings and planting materials of perennial crops.

- Practicing organic farming in horticultural crops.

Research agenda needs emphasis on following areas/aspects in XI Five Year Plan:

1. Improvement in production, productivity and quality of produce.

2. Reduction in post harvest losses.

3. Value addition through post harvest management (PHM) and processing.

4. Export promotional activities with high quality produce targeting Niche market.

5. Encouraging horticulture crops based nutritional security and improvement in income generation to farm households.

6. Competitive production through efficient natural resource use and management.

7. Survey of indigenous biodiversity for resistance to various biotic and abiotic stresses.

All these require support during Eleventh Five Year Plan period.

- Introduction of consortium approach for survey and development of database of natural resources for planning fruitfully utilizing GIS technology and remote sensing for survey work and geographical indexing.
- Institutional strengthening for crop specific problems through specific schemes.
- Strengthening of Institutes (upgradation in frontier research areas- biotechnology, molecular breeding) to solve issues. Of national importance.
- Establishment of new Institutes like Central Institute for Post Harvest Technology, Product Development, Handling and cold chain, Central Institute of Horticulture for NE Hill Region and Institute of Coastal Horticulture.
- Commercialization of under exploited fruit crops like wood apple, beal, khirni, lasoda, tamarind, jamun, date palm, ber, aonla, jack, and mangostein, Kokam etc.
- Holistic Arid horticulture
- Upscaling clonal fruit plant production by exploiting known protocols.
- Improved inputs use efficiency (nutrients, pesticides, water) through integrated use.
- High density orcharding and canopy management through mechanization
- Development of diagnostic tools against viral diseases in all major horticultural crops.
- Solving national problems like

Mango-	Malformation, spongy tissue, hopper
Banana-	Viruses
Grapes-	Mildews, anthracnose
Papaya-	Viruses
Apple-	Scab

Ber-	Fruitfly
Tropical fruits-	Fruit fly
Vegetables-	Hybrids in onion; fruit and shoot borer in brinjal and okra; fruit fly in cucurbits; viruses in tomato, okra, chilli etc; bacterial wilt in tomato, chilli, brinjal etc.
Tuber Crops-	Cassava mosaic virus
Coconut –	Root (wilt) disease
Arecanut –	Yellow leaf disease
Black pepper –	Phytophthora foot rot, viral diseases
Floriculture-	Development of export oriented varieties of flowers

Protected cultivation:

- Development of reasonable cost-effective greenhouse structures and environmental control strategies for region and crop specific situations utilizing locally available materials as far as possible.
- Development of appropriate machinery for protected cultivation practices.
- Development of suitable varieties for protected cultivation.
- Development of protected cultivation practices for different horticultural crops.
- Characterization of quality parameters of produces from protected cultivation in relation to consumer requirements and development of appropriate post harvest management practices.

Biotechnology

- introduction of genetic factors for apomixes for production of hybrid seeds (in vegetable crops like tomato, brinjal, cabbage where hybrids dominate) which can be saved by farmers and reused.

- Cloning and characterization of new genes and promoters for tolerance to biotic stress should receive special emphasis.

- *Phytophthora* diseases are common to many important horticultural crops (citrus, apple, black pepper, yams, rhizomatous crops etc.) and pathogen being soil borne, their control particularly in the high rainfall areas is very difficult. Research thrusts in isolating effective biocontrol agents for different locations and their mass multiplication for use in different crops are needed.

New Schemes for Horticulture during Eleventh Five Year Plan

Creation of research infrastructure for technology generation for major horticulture crops (fruits, vegetables, plantation crops, spices etc.) has largely been achieved earlier through establishment of ICAR Institutions/NRCs and strengthening SAUs mainly through research projects (AICRP, NARP, NATP, Network Project, A.P. Cess Fund etc.). A few critical gaps in terms of Institution building, however, remained un-addressed.

Floriculture

Floriculture both for domestic market and export market received focused attention in recent past and export of cut flowers picked up quite fast. Excepting NRC (Orchids) located in Sikkim, there is no specialized Institutional base for generating technologies in flowers and ornamentals. In addition to traditional flowers of local use, flowering crops like roses, carnation, gerbera, anthurium, tropical orchids etc have great scope for enhancing export earnings. Dry flowers and perfumery industry using flowers are both potential sectors. **It is therefore, essential to create a new NRC for Floriculture, preferably in Pune in Eleventh Five Year Plan under ICAR.**

Estimated budget: Rs. 8 Crores.

Post Harvest Management in Horticulture

Perishable commodities like fruits, vegetables and flowers incurred huge post harvest losses due to poor handling, storage and processing. Since Post Harvest Management (PHM) of perishable commodities is different from cereals and other crops, separate treatments are essential for reducing post harvest losses. Earlier there existed AICRP (PHT) dealing with horticultural crops, which discontinued during Eleventh Five Year Plan. It is strongly felt that a separate **Institute for Post Harvest Management (PHM) and Value addition of horticultural crops** is established this new Institute should also act as Nodal agency for market intelligence and developing standards and exportable products for horticultural crops of the country.

Estimated budget: Rs. 10 Crores.

Horticulture Research Institute for NER

North Eastern Region (NER) covering 8 States (Assam, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Tripura, Sikkim and Mizoram) offers unique opportunity for development of Horticulture industry. Rich germplasm, suitable agroclimate, and farming practices are unique features of NER. Horticulture technology generation remained nonsignificant and technology transfer is almost absent. Existing horticulture research supports in ICAR Research Complex for NEH Region and Assam Agricultural University (AAU) are too meager to address the problems of horticulture crops. Recently a separate institute named Central Institute of Horticulture was established in Nagaland under the Department of Agriculture and Cooperation, Ministry of Agriculture for promotion of developmental activities. This Institution would not be able to make a dent in developmental activities, if there is no technology backstopping. Therefore, a strong need to establish a **Central Research institute for Horticulture for the NEH** focusing hill horticulture covering crops like citrus, banana, pineapple, cashew, apple, kiwi, off season vegetables, ginger, turmeric, large cardamom, flowers like anthurium, lily and selected medicinal and aromatic plants is felt.

Estimated budget: Rs. 15 Crores

Research Centre for Temperate Vegetables

At present research on temperate vegetables is not taken care of. Hence it is suggested to carry out research on temperate vegetables, a sub station under Indian Institute of Vegetables Research (IIVR), Varanasi (U.P.) may be started in the temperate region of the country. Alternatively, the IARI Regional Station at Katrain, Himachal Pradesh may be transferred to IIVR, Varanasi to strengthen the research on temperate vegetables.

Estimated budget: Rs. 5 Crores.

Elevation National Research Center on Medicinal and Aromatic Plants to National Institute level

Medicinal and Aromatic Plants are gaining importance as alternate medicines for domestic and export markets. National Medicinal Plant Board has already identified 32 crops of great economic importance. The NRC for M&AP located at Anand, Gujarat with a limited manpower and infrastructural support is unable to cater needs of the country. ICAR has the mandate for development of cultivation practices including crop improvement of M&AP. **The existing NRC on M&AP is, therefore, to be upgraded as National Institute with one or two regional centers in potential agro-climatic regions,** to realize full potentialities of these crops.

Estimated budget: Rs. 7 Crores.

Tribal Horticulture

Horticultural crops including fruits, vegetable, root & tubers, medicinal and aromatic plants provide food security and livelihood support in tribal areas. In shifting cultivation (Jhum) areas of NEH, Orissa, and A.P. an alternate land use for horticulture many emerge up. In tribal areas, input use (particularly agricultural chemicals) is minimum and production is organic. Hi-tech horticulture does not fit well in tribal belts and there is need to develop separate package of practices for tribal areas, focusing organic farming with minimum chemical inputs, rainwater management, pest management technology etc.

At Ranchi (Jharkhand) there was Centre of Indian Institute of Horticultural Research (IIHR), Bangalore with good physical infrastructure. This center needs to be delinked from ICAR Research Complex and upgraded to an Institute with special emphasis on Tribal Horticulture to generate relevant technologies for tribal farmers of Jharkhand, M.P., A.P. and Orissa.

Estimated budget: Rs. 8 Crores.

Annexure-1

CONSTITUTION OF THE SUB-GROUP

The Sub-Group on Horticulture & Protected Cultivation was constituted as per the following composition and Terms and References: (ICAR Office Order F. No. 5(5)/2006-PIM dated 10-7-2006)

I. Composition:

(i)	Dr. Kirti Singh	Chairman
(ii)	Dr. S. P. Ghosh	Member
(iii)	Dr. K. V. Peter	Member
(iv)	Dr. B. S. Chundawat	Member
(v)	Dr. Vishnu Swarup	Member
(vi)	Dr. K. V. Ramana	Member Secretary

II. Terms of Reference:

(i) To make critical review of X Plan achievements in terms of horticultural research, in contrast to the objectives and targets set during X Plan.

(ii) To identify critical gaps in scientific infrastructure in frontier areas of technology and to suggest the ways to bhridge the gap, so as enable the ration to enhance its agricultural competitiveness in the context of WTO and IPR regime.

(iii) To draw/suggest specific schemes/programmes pertaining to horticultural research to address the problems of less privileged regions.

(iv) To critically review the status of post harvest management research, value addition and identify the priorities in terms of human resource development and institutional mechanism for attaining the desired results in this vital sector.

(v) To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

(vi) To identify institutional mechanism for strengthening, monitoring and evaluation system in horticultural research, and to suggest efficient measures for effective coordination of horticultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public private partnership.

(vii) To draw/suggest specific schemes/ programmes/ research area pertains horticultural research.

3 The Sub Group may also examine and address any other issues which are important but are not specifically spelt out in the ToRs or which were discussed and flagged in the First Meeting of Working Group held on 26.6.2006, the proceedings of which have already been circulated. The Sub Group may devise its own procedures for conducting its business/meetings.

4 The expenditure of the official members on TA/DA in connection with the meetings of the Sub Group will be borne by their respective Ministry/Department as per the rules of entitlement applicable to them. . In case of non-officials, the TA/DA will be borne by the Planning Commission as admissible under SR 190(a).

5 The Sub Group will be serviced by the Department of Agricultural Research and Education, Ministry of Agriculture.

6 The Sub Group will submit its Interim Report by the end of August, 2006 and the final Report by the end of September, 2006 to the Chairman of the XI Plan Working Group.

7 Dr.(Mrs.) Vandana Dwivedi, Joint Adviser(Agriculture)Planning Commission, Room No. 230, Yojana Bhavan, New Delhi-110001, Tel No. 011-23096730, Email: dwivediv@nic.in and FAX No. 011-23327703 will be the nodal officer of this Sub Group and any further query/correspondence in this regard may be made with her.

(K.S.Khokhar)

Member Secretary

Annexure-2

Proceedings of the First Meeting of the Sub Group "Horticulture & Protected Cultivation" of the Working Group on Agricultural Research and Education for XI Five Year Plan constituted by Planning Commission held on 17th July, 2006 at NASC Complex, Pusa, New Delhi.

The First Meeting Sub Group "Horticulture & Protected Cultivation" of the Working Group on Agricultural Research and Education for XI Five Year Plan constituted by Planning Commission was held on 17th July, 2006 under the Chairmanship of Dr. Kirti Singh to finalize the XI Five Year Plan document. The following attended the meeting.

Sub Group Members

1. Dr. Kirti Singh, Formerly Chairman, ASRB - Chairman
3. Dr. S.P. Ghosh, Formerly DDG(H), ICAR - Member
4. Dr. B.S. Chundawat, Vice Chancellor, Sardar Krushinagar Dantiwada Agricultural University, Sardar Krushinagar, Distt. Banaskantha-385 506, Gujarat- Member
5. Dr. Vishnu Swarup, Director (R&D), Indo-American Hybrid Seeds (I) P. Ltd., Mini Farm, DLF Mode, Chhattarpur, New Delhi-110030 - Member
6. Dr. Ramanand, SRO (Agri. Sci), Planning Commission, Yojana Bhavan, New Delhi-110001 – Nodal Officer.
7. Dr. K.V. Ramana, Assistant Director General (PC), Indian Council of Agricultural Research, Horticulture Division, Krishi Anusandhan Bhawan-II, Pusa, New Delhi-110012 – Member Secretary.

Special Invitees

1. Dr. G. Kalloo, DDG(H& CS), ICAR
2. Dr. S.N. Pandey, ADG(H), ICAR
3. Dr. M. Prabhar, IIHR, Bangalaore
4. Dr. Mathura Rai, Director, IIVR, Varanasi
5. Dr. George V. Thomas, Director, CPCRI, Kasaragod, Kerala
6. Dr. S.K. Pandey, Director, CPRI, Shimla (HP)
7. Dr. Shyam Singh, Director, National Research Centre for Citrus, Nagpur-440010 (Maharashtra)
8. Dr. R.N. Rai, National Research Centre for Mushroom, Solan-173213 (H.P)
9. Dr. R.L. Misra, Project Coordinator, AICRP on Floriculture, IARI, New Delhi.

At the out set the Member Secretary welcomed the Chairman, Members and Sp;ecial Invitees to the meeting and briefed the "Terms of Reference" of the Sub-Group.

The Chairman in his introductory remarks briefed the members the objectives and "Terms of Reference" of the Sub- Group and requested all the members to give critical inputs for the preparation of the document for "Horticulture and Protected Cultivation" for XI Plan period. He also stressed the need to assess the present structure and future requirement for the development of Horticuolture to increase production and productivity to meet domestic as well as expert needs. This was followed by presentation of the achievements in different horticultural crops by the Directors of ICAR Institutions. Dr. G.Kalloo, DDG(H) gave a brief account on the future needs of Horticultural crops for sustainable growth. All the members of the Sub-Group participated actively.

The details for the preparation of the document as per Terms of Reference set out by the Planning Commission were discussed thoroughly. It was decided that while preparing the document the following points may also be considered for research programmes envisaged in the XI Five Year Plan.

1. Reducing the cost of inputs for profitable Horticulture.
2. Development of underutilized fruits: humid tropical, tropical, sub-tropical, temperate and arid fruits.
3. Identification of more temperate fruits like leh berrey, kiwi fruit, plum, pear, cherry, etc for research.
4. Physiological aspects of mango biennial bearing, rejuvenation and mango malformation, etc.
5. High density orcharding, meadow orcharding in guava: basic, strategic and applied research.
6. Enhancing hybrid research/technologies in vegetable crops: molecular breeding.
7. Multiple resistance: gene pyramiding for biotic and abiotic stresses.
8. Bio-technological aspects including proteomics and genomics.
9. Genetics of nutrient use efficiency, physiological and biochemical research on nutrition of plants.
10 Functional genomics: mango, tomato, potato and coconut (structural genomics).
11 Research on secondary metabolites.
12. Management of eriophid mite in coconut.
13. Nucleic acid probe for coconut root (wilt) disease.
14. Apomixis for hybrids.
15 Varietal development for extending potato cultivation in non-traditional areas, for processing into various products and different maturity periods to suit to different cropping systems.
16 Micro-propagation techniques.
17. Protected cultivation.
18 Management of pesticide residues.
19 Utilizing microbes in nutritional management through substrate dynamics using biodynamics, micro and secondary nutrients and soil carbon and diseases management.
20 Dryland farming of arid fruits and vegetable crops.
21 Role of medicinal plants in the management and prevention of major diseases and identification of the principle compounds.
22 Establishment of post harvest technology units in all the Institutes/NRCs.
23 Developing varieties of flowers for export: hybrid flower technology and dry flower processing technology.

24 Speciality flowers like Bird of Paradise, *Curcuma* sp, wild ginger, Heliconia, Anthuriums, Asiatic lilly, etc.
25 Development of herbal gardens
26 Technologies for production of mushrooms for export, off season production and reduction in the cost of production of mushrooms.
27 Developing technologies for cultivation of mushroom in hot and cold regions.
28 Technology for cultivation of mushroom for small- scale production.
29 Water and nutrient management, including micro-irrigation, fertigation, etc.
30 Developing standards for Indian fruits and vegetables.
31 Developing models of farming system: Horticulture-animal husbandry-fisheries, etc.
32 Developing world –class infrastructure in the Institutes/NRCs.

The document is to be prepared commodity-wise focusing on the following aspects.

i) Identity critical gaps in the scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as to enable the nation to enhance its agricultural competitiveness in the context of WTO and IPR regime.

ii) Draw/suggest specific schemes/programmes to address the

problems of less privileged regions like hills/mountains, arid, coastal regions etc.

iii) Critically review the status of post harvest management research, value addition and identify the priorities in terms of human resource development and institutional mechanism for attaining the desired results in this vital sector.

iv) Critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

v) Identify institutional mechanism for strengthening, monitoring and evaluation system in horticulture research, and to suggest efficient measures for effective coordination of horticultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public- private partnership.

vi) Opening of new centers under the Institutes/AICRPs for further strengthening research activities particularly in NEH Region**.**

vii) Suggest specific schemes/programmes/research area pertaining to horticultural research.

It was decided that ADGs in Horticulture Division well obtain the relevant information from these respective Institutions/NRCs and prepare the document and circulate the all members for suggestions.

The meeting came to an end with vote of thanks to the Chairman, Members and Special Invitees by Dr. S.N. Pandey, ADG(H-I).

Yours sincerely,

Sd/-

(K.V. Ramana)

Annexure-3

Proceedings of the Second Meeting of the Sub Group "Horticulture & Protected Cultivation" of the Working Group on Agricultural Research and Education for XI Five Year Plan constituted by Planning Commission held on 15th September, 2006 at KAB-II, Pusa, New Delhi.

The Second Meeting of Sub Group "Horticulture & Protected Cultivation" of the Working Group on Agricultural Research and Education for XI Five Year Plan constituted by Planning Commission was held on 15th September, 2006 under the Chairmanship of Dr. Kirti Singh to finalize the Interim Report. The following attended the meeting.

Sub Group Members

1. Dr. Kirti Singh, Formerly Chairman, ASRB – Chairman.
2. Dr. S.P. Ghosh, Formerly DDG(H), ICAR – Member
3. Dr. B.S. Chundawat, Vice Chancellor, Sardar Krushinagar Dantiwada Agricultural University, Sardar Krushinagar, Distt. Banaskantha-385 506, Gujarat- Member
4. Dr. K. V. Peter, Vice Chancellor, Kerala Agricultural University, Vellanikkara, Trichur-680656, Kerala.
5. Dr. K.V. Ramana, Assistant Director General (PC), Indian Council of Agricultural Research, Horticulture Division, Krishi Anusandhan Bhawan-II, Pusa, New Delhi-110012 – Member Secretary.

Special Invitees

1. Dr. G. Kalloo, DDG(H& CS), ICAR
2. Dr. S.N. Pandey, ADG(H), ICAR
3. Dr. R. Srivastava, Director, CARI, Post Blair (A&N)
4. Dr. D.P. Singh, Principal Scientist (H), ICAR
5. Dr. Umesh Srivastava, Principal Scientist (Veg.), ICAR

The Member Secretary welcomed the Chairman and Members to the Second Meeting and mentioned that as per the decision of the First Meeting, the consolidated report on the achievements of Horticulture Division and the gaps identified were circulated to all the members.

The Chairman briefed to the Members on the document circulated to all the members. It was further discussed in detail and the draft of the Interim Report was prepared. The Chairman requested the Member Secretary to incorporate the suggestions made by the Group and submit the report to the Member Secretary (Working Group).

The meeting came to end with Vote of Thanks proposed by Dr. S. N. Pandey, ADG(H-I), ICAR.

Sd/-

(K.V. Ramana)

4. NATURAL RESOURCE MANAGEMENT

India has achieved remarkable growth in food production in the post green revolution period. The green revolution has, however, triggered many second generation problems of stagnating crop yields, rising and falling water tables, development of secondary salinity in major irrigation commands, residue management and contamination of natural resources and foods. A great deal of concern is already being voiced by planners, scientists, environmentalists and farmers alike on the emerging scenario threatening our food, livelihood and environmental security. We need to constantly monitor the state of soil and water resources and devise management strategies for sustained productivity and least environmental degradation. The general observations of the Working Group on NRM research are as follows:

Soil Survey and Land Use Planning :

The characterization of soil resources employing reconnaissance, semi-detailed and detailed surveys is essential for macro and micro level land-use planning. While notable achievements have been made in the generation of soil resource information at national, state and district levels, a lot more still needs to be done with regard to micro level land use planning. We need to develop decision support systems for evolving realistic and dynamic land use plans for different areas consistent with the prevailing socio-economic-environmental-market imperatives along with the bio-physical factors. The plans must be wedded to the strategies of diversification and integrated farming, seeking all round development of an area. There are immense opportunities to accomplish the task by employing state of art Remote Sensing, Geographic Information System (GIS) and Information Technology based approaches and tools. A strong R&D support in terms of methodologies and approaches for delineation, mapping and rehabilitation of 88 Mha of degraded lands in the next four plan periods (20 Mha in XI Plan) will be most desired, as envisaged by the Planning Commission.

Soil Fertility:

The declining soil health is often cited as one of the factors for stagnating yields. The inadequate and imbalanced nutrient use coupled with neglect of organic manures has caused deficiencies of secondary and micronutrients in many parts of the country. The falling organic matter levels in soils are affecting adversely the physical, chemical and biological processes. The replenishment of soils with essential ingredients is, therefore, indispensable for sustained production. The management of soil fertility is going to be more crucial in the near future in supplying the adequate amounts of nutrients to meet the targeted levels of food production, seeing the availability and pricing of feedstocks for the fertilizer industry. Alternatively, we have to lay more emphasis on enhancing nutrient-use efficiency through integrated nutrient management and appropriate soil management practices. A good amount of costly fertilizers (like phosphatic, potassic and zinc) could be saved and nutrient input-use efficiency enhanced in certain areas showing sufficient build-up of the nutrients with prolonged fertilizer use. Conversely, some low producing areas may indicate deficiencies of phosphorus and/or zinc (as farmers may be using largely nitrogen fertilizers) and would require balanced nutrient application. A survey investigation of this kind is most desired. There is also need to determine the equivalence of organic manures in terms of different nutrients for making precise substitutions of chemical fertilizers with manures. It may be stated that even when a soil (from a field of an acre) is tested once in 5 years, the capacity of our soil testing laboratories is sufficient only for 10 percent soils. To have generalized recommendations, the geo-referenced soil fertility maps need to be generated. The carbon sequestration potential of major soil groups should be modeled for maintaining appropriate carbon levels in soils. The blueprints should be developed for increasing production in low producing districts of the country having low fertilizer use. Such districts occur in the states of Uttar Pradesh, Bihar, Madhya Pradesh and Orissa.

Water Resources:

We have only 4.2 percent of world's fresh water resource to sustain 16 and 17 percent of world's human and animal populations, respectively. The per capita water availability in the country has declined from 5,000 m^3 in 1947 to 1860 m^3 in 2001 and is likely to be 1341 m^3 in 2025. The irrigation sector is the largest consumer of fresh water (about 83 %). Its share, however, is going to decline to 85 % by 2010 and to 75 % by 2050, given the growing competition from the industrial and domestic sectors. The future gains in agricultural productivity of the country, therefore, will be determined by proper development and utilization of surface and ground water resources. The indiscriminate use of water resources, presently, is giving rise to water logging, secondary salinity and fall in water tables. The situation has become grim in north western and southern parts of the country. The declining ground waters entail mounting costs to the farmers of tube well irrigated areas in the western states of Panjab, Haryana and Western U.P. in deepening their wells and installing submersible pumps as also requiring more power to lift water from increasing depths. The water use efficiency of canal irrigation is hardly 40 percent and requires to be enhanced to 60-70 %. Hence, we should have de novo examination of the existing water management practices on the touchstone of sustainable and efficient water management. While we should have adequate policy directives to regulate the use of canal and ground waters, emphasis requires to be laid on proper technology development for rainwater harvesting and its recharge, increased use of poor and waste waters, improved on-farm management and cost –effective micro-irrigation systems. The multiple use of water should be promoted on a large chunk of waterlogged/Tal/Diarra lands in eastern region by integrating agriculture, aquaculture and livestock.

Cropping and Farming System Research:

Both cropping and farming systems need a fresh look and appropriate experimentation. Lot of work has been done on cropping systems to improve crop production, restore soil health and control infectious weeds. Of late, the cereal-cereal based cropping systems practiced for long in the irrigated belt have started showing strains owing to soil fertility decline, excessive withdrawal of ground water and static family incomes. The emphasis needs to be laid on identification of alternative cropping systems with higher and stable yields and/or profit in different agro-ecological regions. The pulses and oilseeds need to be given due importance in diversification process to offset diminishing productivity and farm incomes and growing shortages of oilseeds and pulses.

A farmer would normally keep animals for milk and draught power. There are instances that he has a fish pond and pigs in a system that reduces wastages and increases farm incomes. There is an urgent need, therefore, to move from cropping system to integrated farming system approach to internalize synergies of different components for enhanced resource utilization, income and livelihood generation and minimizing environmental loading. A more diversified food basket will provide better food and nutritional security to the people. A modest beginning in developing IFSs has already been made at some places. The location specific IFSs need to be developed for all the distinct regions integrating agriculture, horticulture, fishery, livestock and a host of other agri-enterprizes. For developing diversification strategies, we need to constantly monitor and delineate shifts in cropping systems in different agro-ecological situations.

Polluted Soils:

Owing to lax administration of pollution control laws, increasing urbanization and growing industrialization, lots of toxic effluents are being discharged into the sewerage system and irrigation water. There is need to systematically catalogue the effluents being discharged into water bodies in selected urban settlements and to simultaneously examine their effect on build up of toxicities in soil-plant-animal-human chain in close proximity to these water bodies. The low cost pre-treatment technologies for industrial, municipal and agricultural waste waters need to be developed speedily. The existing test procedures for pollutants are complex and costly. The quick, cheap and easy to handle testing tools are required for the much needed public service.

Problem Soils:

The alkaline and saline soils offer excellent opportunity of adding to crop production and bettering the lot of resource- poor farmers owning them. Most of the more easily reclaimable alkali soils have already been improved. There is need to take up the lands that are hard to be reclaimed. More research is required on bio-drainage aspects and measures for reducing the cost of reclamation technology. Enough attention requires to be given to counter sea water intrusion and recover rice fish systems. The soils around the *Indira Gandhi Nehar Paryojna* should receive focused attention for production of fodder and fuel supplies for drought proofing of the area.

Tillage and Soil Management:

There is need to develop appropriate tillage and soil management practices for areas encountering adverse soil/edaphic conditions for increasing water, nutrient and energy use efficiencies. Soil-water-nutrient interactions also need a focused look for increasing resource-use efficiency.

Agro-Forestry:

The agro-forestry research requires to be linked to industry (like paper, pulp wood and herbal medicines etc based industries), bio-fuel/bio-diesel/energy plantations and carbon trading regimes etc to generate income & livelihood, reduce petroleum imports and ensure clean environment. Also, there is need to identify compatible trees and crops for adoption in space and time, to cater to the fuel wood needs of rural households using cow dung cakes presently for the energy needs. The cow dung could be saved for making valuable manure.

Agro-meteorological Research:

The Intercontinental Panel on Climate change (IPCC) has warned of impending climate change due to global warming. Understanding the direction and magnitude of changes, vulnerability of agricultural systems to such changes and mitigation strategies (crops, varieties, enterprises and practices) is, therefore, essential to safeguard food production. Simultaneously, there is need to strengthen weather based forewarning mechanism to escape insect pest/disease incidence.

Gene Based Ionic Uptake:
There is growing interest for developing cultivars resistant to aluminium toxicity, phosphorus deficiency, saline conditions and droughts. The productivity is hampered to a large extent on soils confronting such adverse situations. The genes responsible for these traits (QTLs-Quantitative Traits Loci) have been identified for some crops and work is underway for evolving desirable genotypes employing marker assisted breeding programmes. The aluminium tolerant cultivars have more secretions of organic acids in the rhizosphere that complex, immobilize and inhibit aluminium uptake. The phosphorus efficient cultivars have enlarged root system aiding more soil contact and ionic uptake. Multi-disciplinary teams of scientists comprising soil scientists, breeders and crop physiologists should work together for quicker results in the emerging field of research.

Objectives, Thrust Areas/Targets and Achievements of Tenth Five Year Plan

Objectives :
To develop eco-friendly conservation and management technologies for attaining the production and productivity goals ensuring sustainable use of natural resources and high efficiency of inputs.

Thrust Areas/Targets :

- Inventorization, characterization and monitoring of natural resources using modern tools and techniques.
- Development of Sustainable land use plans for each agro-ecological sub-region in the country.
- Devising cost effective methods of resource conservation and reclamation technologies.
- Enhancing fertilizer, water and other inputs use efficiency through monetary and non-monetary means.
- Integrated plant nutrient management combining inorganic fertilizers, organic manures/composts and bio fertilizers for sustained soil health and crop productivity.
- Multiple uses of water to enhance productivity and livelihood.
- On-farm water management to enhance water-use efficiency .
- Standardization of micro-irrigation and fertigation systems.
- Development of cost-effective drainage technology including bio-drainage for saline and waterlogged lands.
- Utilization of poor and marginal quality waters for agriculture.
- Development of location specific model watersheds in various agro ecological zones of the rainfed areas for resource conservation, enhancing productivity and livelihood generation..
- Agro-eco-zone specific diversification of agriculture .
- Developing package of practices for organic farming .
- Developing location specific integrated farming systems involving agriculture, horticulture, livestock and fisheries etc to enhance productivity, income and livelihood.

- Agroforestry systems to enhance tree cover on agricultural lands to support the supply of fodder, fuel, industrial wood and small timber on a sustainable basis.
- Agroforestry for biofuel.
- Technology development for coastal shelter belts.
- Development of weather-based expert systems for enhanced production and improvement in agro met advisory services.
- Monitoring of climate change and adaptation to mitigate its adverse effects on agricultural production systems.

Achievements :

Soil Survey and land Use Planning

- The digitized soil maps of 15 states (Madhya Pradesh, Maharashtra, Chhatisgarh, West Bengal, Rajasthan, Himachal Pradesh, Goa, Delhi and NEH states) on 1:250,000 scale were developed. Soil series have been identified and mapped for prospective land use planning.
- The soil series mapped at district level were for Pauri Garhwal and Almora districts of Uttaranchal, Meerut and Etah districts of Uttar Pradesh, Purulia district of West Bengal, Medak district of Andhra Pradesh and Tumkur district of Karnataka. Land use maps for Kamrup, Nalbari and Barpeta districts of Assam and soil landscape model for suitable cropping pattern for 4 districts of Tripura were prepared.
- Digitized maps of salt affected soils of the country (1:1million scale) and eight states (1: 2,50,000 scale) were prepared.
- Soil erosion maps (1:250,000 scale) and bulletins were prepared for West Bengal, Assam, Maharashtra, Madhya Pradesh, Gujarat, Uttar Pradesh, Himachal Pradesh, Tripura, Bihar, Chhatisgarh and Rajasthan .
- Database on Indo-Gangetic plain, and desertification map of southern part of western Rajasthan have been published.
- The water logged and salinity areas in irrigated semi-arid alluvial plains of Indira Gandhi Nahar Pariyojana in north -west Rajasthan were delineated and mapped.
- Soil resource inventory of major watersheds of Tista basin in Sikkim, namely, Ranikhola watershed and Rangit watershed was carried out and soil maps were prepared.
- The integrated watershed development programme in a participatory mode in Bundelkhand region was developed and implemented. It has increased the cropping intensity and crop yields (67-105%). The tribal dominated Kokriguda watershed was developed as model watershed for Eastern Ghat high land zone of Orissa.
- Studies on the impact of watershed management revealed that Peoples' Participation Index (PPI) in 15 DPAP watersheds of Coimbatore district of Tamil Nadu was 55, 44 and 27 per cent at the planning, implementation and maintenance stages, respectively suggesting, medium, low and very low level of peoples' participation. Benefit-cost (B:C) analysis of the project considering 10 years life at 10 and 15% discount rate gave a B:C ratio of 1.53:1 and 1.28:1 with 28% of internal rate of return (IRR). The credit utilization and repayment capacity improved as a result of watershed programme.

Soil Management :

- Sloping Agricultural Land Technology (SALT) – An appropriate technology for restoration of degraded lands proved to be most suitable for restoration of *Jhum* fallow/degraded lands in eastern Himalayas.
- Effectiveness of conservation furrows in moisture conservation and run-off management was demonstrated in10 on-farm trials in 5 villages of Nalgonda district of Andhra Pradesh. The area with conservation furrows stored 8-35% more moisture, thereby, resulting in 16-17% higher yield of castor and pigeonpea.
- The soil loss due to water erosion in the coastal belt of peninsular India worked out to be 5-40 t ha^{-1} yr^{-1}. The growth of cashew plants was better under bio-engineering measures than under vegetative barrier alone on the sea coast of Goa.
- Bed planting has been found to save time, labour, energy and water and, thereby, reduce cost of cultivation in Indo-Gangetic Plains (IGP).
- The zero-tillage technology for seeding wheat increased wheat yield by 7-8% in western U.P. with an additional return of Rs. 4355 ha^{-1}. The zero tillage also proved its worth on several other winter crops besides wheat after rice.
- Direct Seeded Rice (DSR) technology found to have a potential for improving the water productivity by 15-18% and system profitability by 10-15%.
- A technology package for amelioration of 25 million ha of critically degraded acid soils has been developed. Liming @ 2-4 q/ha along with the recommended fertilizers has potential to increase food grain production by 25 million tonnes per annum.
- Laser land leveling technology standardized for increased water productivity , nutrient use efficiency and crops yields in western Uttar Pradesh. .
- A cost effective amelioration technology with reduced dose of gypsum (@ 25 % of gypsum requirement) and growing of sodicity tolerant varieties (rice- CSR 13 and wheat - KRL 19) developed to ensure higher crop productivity in sodic soils.
- Fungal inoculums identified for bioremediation of heavy metals like lead, cadmium and chromium.

Cropping & Farming Systems

- Rice yield after berseem, chickpea and field pea was 9.3, 12.3 and 13.5% higher, respectively, than after wheat. This offers substituting wheat by legumes in rice-wheat cropping systems.
- Under sodic water irrigated conditions, rice-wheat cropping system was found to be better than rice-mustard, sorghum-wheat, sorghum-mustard and *Sesbani*a-wheat.
- Rice-potato-wheat cropping system was found more remunerative than rice-wheat cropping system.
- A single pre-emergence application of clodinaps (TOK) @ 60 g ha^{-1} 3-4 weeks after sowing effectively controlled wild oat in wheat at Jabalpur (M.P.).
- Inclusion of high yielding genotypes of finger millet and barnyard millet in the cropping system, increased the cropping intensity and total production in the rainfed north-west hilly region of the country.
- Crop diversification with maize cob, groundnut and pigeon pea in rainfed upland rice regions of eastern India fetched net return of Rs. 15,000/ha/annum.

- Sorghum + pigeon pea and castor + green gram intercropping proved highly remunerative even under situation of delayed monsoon for south-eastern Rajasthan.
- Intercropping of green gram-castor (4:1) doubled the net return in Agra region.
- A fish-pond-cum secondary reservoir was developed and constructed for economical and multiple uses of irrigation water in agricultural production system. Results revealed that dissolved oxygen level at 1.6 m below water level decreased continuously upto 6 days after water exchange and stabilized thereafter. For proper growth of fish, water has to be changed after every 5 days.
- A run-off recycling system was evaluated for multiple use for third year. It was found that an integrated farming system involving crops, fish, and horticultural crops can be developed around this system. The benefit-cost ratio with crops alone was 1.89 and increased to 2.27 with addition of horticultural crops and to 2.80 with addition of fisheries. It could be further raised if duckery was added as an additional component.
- A model farming system has been developed for NEH region introducing agri-silvi-horti-pastoral system at different hill slopes integrating fishery, piggery, duckery, poultry, apiculture and mushroom cultivation.
- Evaluated rice, coconut and rabbit based integrated farming systems for Western Ghats region.
- Evaluated multi enterprise farming system models for better livelihood in Sunderbans under Coastal agro-eco system
- Palm rosa (*Citronella martini*) was found to be a potential aromatic plant for sodic soils.
- A variety of plant species (131) comprising of herbs, shrubs and trees identified for herbal farming in arid region.
- Contingent crop-planning under delayed monsoon situations for rainfed areas was formulated.

Water Management

- Standardized alternate raised & sunken bed system to diversify crops in lowlands of eastern region. The system increased annual productivity of lowlands from 3.2to 21.6t/ha, irrigation efficiency from 26.6 to 212.9 kg/ha-cm and net return from Rs 1,552/- to Rs 57,710/- per ha.
- Aquifer characteristics (depth, thickness, discharge, transmissivity and storavity) of Balasore, Mahanadi delta and Kathajodi river basin of Orissa were studied.
- A pressurized irrigation system fed through a reservoir in adjunct to the canal system for irrigation either by pumping or by gravity was developed with benefit-cost ratio of 2.6. The system can act as a gravity-fed surface irrigation system during monsoon and as a pump based drip cum sprinkler irrigation system during post-monsoon season.
- An improved design of *khadin* for water harvesting and moisture conservation in arid lands formulated.
- A comprehensive land and water management system devised for super cyclone affected coastal districts of Orissa.
- Devised drip and sprinkler irrigation systems to save water (30-50%), labour (50%), fertilizer (30-40%) and increase yields (12-76%).

- Developed a model of rotational delivery schedules of canal water. The 7 and 15 days rotational scheduling during *rabi and kharif* seasons, respectively saved more water compared to prevailing continuous delivery schedule.
- Recharge filters of one metre thickness with coarse aggregate and sand were found to be effective in recharging sediment free runoff water in open and tube wells.
- Recharge from the Shingave percolation tanks in Maharashtra has been studied since 1992-93. The influence of percolation tanks was upto 750 m. The recharge due to percolation tanks was estimated to be 89% of inflow, while the average recharge over the period of 7 years was 86%. The total inflow based on the curve number technique was computed as 216 ha-m.
- Developed a database on water resources of Bihar & Jharkhand containing surface water and ground water including crop area, crop production, meteorological information using MS-Access.
- The norms for recycling of saline water for irrigation were developed. Application of FYM @ 20 t ha^{-1} decreased build up of salinity in soils irrigated with chloride and sulphate dominated waters.
- Dorovu technology for skimming fresh water overlying the saline water perfected.
- Integrated water management was developed for chestnut cultivation in shallow water-logged areas of coastal and tribal dominated districts of Orissa.
- A single life saving irrigation to cotton 21 days after sowing on a deep alluvial soil of Agra doubled the net income from the crop.

Nutrient Management

- The soil carbon stocks under different land use systems of the country documented.
- Digitized soil fertility maps (N,P,K) for Andhra Pradesh, Maharashtra, Orissa, Punjab, Chhattisgarh, Haryana , Karnataka and Himachal Pradesh were prepared.
- Delineated and mapped micronutrient deficiencies in the states of Punjab, Haryana, Bihar, Gujarat, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Uittar Pradesh and Uttaranchal.
- Sulphur deficient areas in the country were delineated. About 41 percent of 60,000 soil samples from different parts of the country were found deficient in sulphur.
- Developed ready reckoners for soil test based fertilizer recommendations for given yield targets of crops for different agro-ecological regions (AERs) of the country.
- Integrated nutrient management packages for major cropping systems in different AERs of the country compiled and passed on to respective states to promote balanced fertilization.
- Conjunctive use of inorganic and organic fertilizers improved the soil quality of Vertisols reflected in the build up of soil organic C, increase in microbial biomass and improvement of soil structure.
- Wheat residue incorporation/surface retention along with supplementation of 28 kg N ha^{-1} through FYM/poultry manure was more profitable than the practice of residue burning for subsequent soybean crop in wheat-soybean cropping system.
- Integrated Plant Nutrient Supply System packages for soybean-wheat and rainfed cotton on Vertisols and clusterbean-pearl millet cropping systems in arid zone were developed.
- Integrated nutrient management employing sulphitation press mud and FYM with sub-optimal NPK application increased the annual productivity of rice-wheat system.

- Incorporation of humic acid (2%) as an additive to lignite and vermiculite carrier based cultures improved the shelf life of bio-fertilizers.
- In situ incorporation of rice residue along with application of N-enriched phosphocompost 3 weeks before the sowing of wheat improved wheat yield, soil organic matter and availability of other nutrients.
- A technology of co-composting of poultry litter with rice straw, pyrite and rock-phosphate along with inoculation with cellulytic micro-organisms was developed to reduce ammonia volatilization losses by 40% during decomposition of poultry litter.
- Leaf Colour Chart (LCC), a simple device for nitrogen management, saved 15 kg N/ha in rice.
- Developed mixed Biofertilizer formulations with nitrogen fixers and phosphate solubilizers .
- Green manuring with sesbania and crotolaria spp. increased the yield of rice - wheat system by about 24%.
- Granular penta borate, a new boron source, found efficient for correcting boron deficiency in major crops in different agroecological zones**.**
- A rapid rice straw composting technique developed employing pre-treatment with aqueous salt solution for 48 hours (to break lignocellulosic complex) followed by composting for 21 days.
- Quality standards of biofertilizers and rural/urban composts formulated .

Agroforestry

- A comprehensive on-line database on agroforestry entitled "Agroforestry BASE" generated.
- Agroforestry systems viz. agri-silviculture, agri-horticulture, horti-pastoral and silvi-pastoral have been developed for rainfed and irrigated conditions.
- *Chironjee, Lasora, Bael, Ber and Aonla* have been successfully domesticated on degraded lands. Vegetative propagation techniques for these have been standardized.
- In situ moisture conservation practices conserved 10-15% higher moisture and favoured tree growth in aonla (*Emblica officinalis)* based agri-horticultural system.
- Nineteen provenances of *Acacia nilotica* were collected from central India. In addition, 21 tress having good tree form and 5 trees having high gum yield were also collected.
- The black gram yield in deep ploughed inter-space between 9 year old Shisham (*Dalbergia sissoo)* trees was 12.7% higher than normal ploughing.
- Ridge method of planting was found better than flat for survival and growth of trees. The maximum survival of 95.7% was recorded in menhdi (*Lawsonia inermis*) followed by agave (*Agave sisalana)* and Karonda *(Carissa carandus)*
- The planting of guava (*Psidium guajava)* alongwith a leguminous fodder *(Stylosanthese hamata)* in trenches gave a better performance of fruit component in degraded hillocks of eastern ghats of Orissa.
- The performance of fruit-based (*Karonda, aonla, bael)* agro-forestry system was satisfactory with saline water even on highly saline and calcareous degraded lands of Haryana.

- Under tree improvement programme, 247 accessions of *Jatropha*, 302 of *Neem*, 32 of *Shisham,* 63 of *Babul*, 16 of *Kardhai* and 138 of *Karanj* have been collected from various parts of the country for evaluation of productivity under different agroforestry systems.
- The teak based agri-silvicultural system showing pigeon pea as the most suitable inter crop up to five years and turmeric and ginger after five years evaluated at Parbhani.

Climate Change

- A network project on Impact, Adaptation and Vulnerability of Indian Agriculture to climate change has been initiated at 16 centres in the country with an outlay of Rs.10 crores.
- A website "Crop Weather Outlook" for agromet and weather based agro-advisories made operational at CRIDA, Hyderabad.
- Technical Bulletin on "Cold Wave 2002-03 and Heat wave 2004 depicting impact on agriculture brought out.

Research Gaps

Soil inventory and land use planning

- Appropriate methodologies for detailed resource mapping to take up priority treatment of 20 m ha of degraded lands as envisaged by the Planning Commission, Govt. of India.
- Creation of reflectance soil characteristic libraries for resource assessment and land use planning.
- Correlation of soil series at national level and indexing of national benchmark soil series register.
- Developing decision support systems for contingent/dynamic land use planning taking into consideration socio-economic-environmental-marketing-imperatives along with the bio-physical factors.
- Carbon-sequestration studies under different land use and management systems.

Soil management

- Monitoring and evaluation of watershed management programmes with the modern tools, viz., GIS, remote sensing and simulation modelin.
- Although vegetative barriers are cost-effective, the exact processes involved in moderating overland flow and stream flow for indigenous species are not properly analyzed.
- Earlier research efforts did not focus on synergies and complementarities of the joint management of arable and non-arable lands following integrated farming system approach on watershed basis.
- Although sufficient information on surface hydrology of small watersheds has been generated, research on sub-surface hydrology for evolving strategies of groundwater recharge and management is inadequate.
- Designing of water harvesting, storage and recycling structures for various land holdings and different agroecological situations is a multi-faceted problem. Designing issues focusing on sub-surface storage, aquifer recharge, tapping of sub-surface flows, on/off site effects, individual versus community participation etc., are yet to be resolved.
- There is a lack of institutionalized management of common property resources, an important watershed activity, which needs a participatory approach.

- Multiple objective decision support systems for watershed development in different agro-ecological regions are lacking.
- A proper methodology for quantification and valuation of intangible benefits of conservation technologies has not been evolved. Techniques to quantify and valuate intangible benefits in terms of social and environmental aspects applicable to micro-watershed management programmes are lacking.
- The technologies developed are multi-disciplinary and holistic. However, different departments adopt sectoral approach, which adversely affects the integrated development of the watersheds. Hence, policy guidelines are needed to strengthen coordination among departments under a single umbrella.
- Cost effective agroforestry, silvipastoral and agri-horti systems have been developed but due to improper transfer of technologies and lack of initiatives from implementing agencies, these could not reach the end users.
- Value addition and ITK have not been focused on developing low cost technologies for soil and water conservation, especially in rainfed areas.
- The top-down approach of promoting technologies has not paid desired dividends. The bottom-up approach of people's participation with multiple linkages needs a fair trial. Research in infrastructure in the area of socio-economics, policy planning, resource economics and gender issues need to be strengthened.
- Olericulture (vegetable farming) and horticulture are the two major options for diversification of hill farming. However, the need based information particularly on permutation and combinations of the options under agroforestry systems are not available.

Cropping and Farming system

- Delineation of secondary and micro-nutrient deficiencies (intensity and severity) in Indian soils, especially in high production areas.
- Dynamics of soil microbial flora and fauna under integrated nutrient supply systems.
- Degree of on-farm responses to different nutrients (including secondary and micro nutrients) in major cropping systems.
- Long-term effects of enhanced mechanization and resource conservation technologies (such as zero-tillage, conservation-tillage, laser assisted land leveling etc.) in different cropping systems on crop productivity, water requirement, weed flora, disease and pest complex and soil health.
- Development of efficient farm machinery, suited to Indian farming situations, for direct drilling of rice and wheat under residue cover in combine harvested fields.
- Development of site-specific and precision input management techniques for major cropping systems so as to optimize resource use and enhance efficiencies.
- Development of cashew based farming systems.
- Modification of agricultural production and practices in tune with the growing agro-tourism.
- Effective utilization of rainwater for profitable production systems.
- Achieving self sufficiency in milk and meat production through advanced

techniques.

- Establishment of live demonstration models covering different farming systems in uplands, mid lands and lowland ecosystems.
- Protection and enhancement of mangrove eco-system for disaster management, bio-diversity and resource utilization.

Water Management

- Develop water use efficient cropping methods and systems for varying ecologies
- Development of efficient irrigation methods for hilly and slopy lands
- Exploitation of ground water reserve for augmenting capacities of canal irrigation commands
- Studies on water balance in canal commands
- Studies on participatory irrigation management
- Location specific drainage technologies .
- Adoptability of bio-drainage systems for coastal areas.
- Water resources and their management can influence employment generation and poverty alleviation livelihood options of farm family. Therefore, a study exploring water-poverty-livelihood linkage will help in suggesting policy interventions to secure a safe and viable rural livelihood.
- For overall development of farm family the roles of farm women in different farm activities including irrigation water management need to be analysed so that research and extension efforts can focus the gaps and empower farm women.
- Micro-irrigation system holds great promise for enhancing nutrient use efficiency for which fertigation technology has not adequately developed. It is necessary to develop drip irrigation-canal water adjunct to eliminate uncertainty in canal water availability during moisture stress periods and to develop multiple uses of water strored in auxiliary reservoirs.
- Fresh water availability is declining while poor quality waters are being increasingly generated. Technologies are not adequately available for managing and utilizing such waters. There is a need to develop appropriate technology for utilization of such waters in conjunction with fresh water available from different sources.
- Information technology for meteorological data needs has not been developed so far to give daily crop evaporation needs on media to create awareness and help in planning irrigation of crops on scientific levels.
- Technology solution of water related problems has not taken cognizance of social economic imperatives. To develop sustainable technologies and strategies for agricultural water management, accommodation of socio-economic constraints is essential. This will evolve the study of socio-economic and policy issues in relation to agricultural water management.
- Use of Geographic Information System (GIS) and Remote Sensing techniques in groundwater resource assessment.
- Research needs to be taken up in artificial recharge methods, including Aquifer Storage and Recovery (ASR) for augmentation of groundwater resources.
- Models for the assessment and management of groundwater resources and pollution in porous and fractured medium needs to be developed.

- The impact assessment due to high tides like Tsunami waves on groundwater environment and the disaster management aspects such as impacts of flood, cyclone, drought etc. on groundwater are to be studied.
- The economic aspects of water in relation to Agricultural products; water Pricing and its problems; issues related to legislation of groundwater abstraction and sustainable development of water resources are essential to be studied.
- Absence of integrated location-specific, need based Farming System Modules encompassing land and water, crops, fisheries, livestock and other income generation activities towards enhancing the income of different categories of resource poor, small and marginal farmers of the eastern Region.
- Low cropping intensity (140%) and lack of research on diversification options viz. agricultural crops, agro-forestry, agri-horticulture, backyard poultry, piggery, peri-urban agriculture, inland fisheries and aquaculture.
- Under developed multiple uses of water incorporating fish, agriculture, horticulture and Makhana reasobly flooded and flood prone areas and poor utilization of wetlands, Tal and diara lands for aquatic agriculture.
- Poor on-farm water management in canal commands resulting in low productivity of available water resources and lack of participatory irrigation water management mechanism.
- Under developed conjunctive use of rain, surface and ground waters for timely sowing and raising of kharif, rabi and summer crops.
- Lack of preparedness measures/contingent strategies to alleviate damage due to natural disasters like floods, droughts by enhancing resilience of the farming systems in the frequently disaster affected eastern region.
- Lack of quality cultivars of agricultural and horticultural crops for global competitiveness in view of WTO, PVP, IPR and TRIPS guidelines.
- Lack of post-harvest technologies for value addition of important agricultural and horticultural crops of the region.
- Poor focus on empowerment of rural women and technology suitable for women cultivators through Self Help Groups.
- Lack of effective institutional arrangements for private-public-NGO partnerships to strengthen national and regional capacities for producing research results of public and private goods and services

Nutrient Management

- The use efficiency of N (30-50%) and P (15-25%) continues to be low and needs further research attention. In the context of renewed government policy to enhance farm income on one hand and the growing environmental quality concerns on the other, minimizing nutrients inputs while maximizing their use efficiency becomes a priority area of future research.
- As an essential indicator of soil quality, the soil organic carbon plays critical role in sustaining the productivity of most agricultural systems. Though several attempts were made to unravel the complexities SOC dynamics and C-sequestration, the management guidelines for optimum "C" sequestration/maintenance are yet to be developed.

- Inadequate research on of IPNS recommendations to suit different soils and crops in different agro eco-regions.
- Lack of integration of STCR technology with modelling approaches.

Agroforestry

- Understanding the causes and processes of biophysical issues related to productivity and resource sharing under agroforestry system is still inadequate.
- Paucity of methods to assess the tangible and intangible benefits of sustainable agroforestry from the social and cultural angle.
- Limited commercialization of potential technologies.
- Agrotechniques of biofuel species are to be standardized.

Climate Change

- Impact of climate change / variability of rainfed regions on biotic, edaphic and hydrological resources; crop response to elevated Co_2
- Extreme weather event analysis.
- Development of early warning systems for strengthening the Agro-advisory Network Program.

Thrust Areas of Research of NRM during XIth Plan

Soil Survey and land Use Planning

- Appropriate methodologies employing GIS and remote sensing for detailed soil resource mapping and land use planning at watershed level. The exercise is desired for taking up priority treatment of 20 Mha of degraded lands envisaged by the Planning Commission, Govt. of India.
- Land use planning for efficient management of natural resources
- Assessment of soil /land degradation
- Application of remote sensing and GIS techniques for delineation, characterization and planning of watersheds.
- Establishing Participatory integrated watershed models for different agro-ecological regions.
- Evaluation of vegetative barriers for resource conservation and multiple outputs.
- Evaluation of intangible benefits of watershed programmes
- Establishment of soil loss tolerance limits for different agro climatic zones

Soil Management

- Evolving resource conservation technologies for major crops/cropping systems.
- To develop appropriate tillage and soil management practices for areas encountering adverse soil/edaphic conditions for increasing water, nutrient and energy use efficiencies.
- To increase the resilience capacity of soil, efforts should be focused on conservation agriculture, residue application/recycling, ways and means of carbon sequestration in the soil, quality of residues and organic matter.

- Reclamation and management of problem soils
- Research for holistic management of coastal area.

Cropping & Farming Systems

- Developing blue prints for increasing crop production in low producing districts of the country having sufficient potential of irrigation water but low fertilizer use, employing remote sensing and GIS tools.
- Documentation of farming systems prevalent in different agro-climatic regions of the country and quantification of synergetic contribution of components of the system in terms of water, nutrient, energy, total productivity and economic gains.
- Re-orientation from cropping systems to farming system research mode and development for integrated location-specific, multi-commodity farming system modules involving field crops, horticulture, aquaculture, fisheries, livestock and other enterprises for different categories of farmers in different agro-eco regions of the country to increase farmer income and generate export.
- identification of alternative cropping systems in different agro-ecological regions for need based crop diversification to minimize risk and enhance income.
- Evolving suitable cultivars againstr abiotic stresses due to Al toxicity, Salt concentration, P-deficiency and moisture deficit etc through mapping of quantitative trait loci (QTLs) and marker assisted breeding programmes.
- Identification of suitable crop and varieties to bring fallow lands under cultivation using residual soil moisture to raise cropping intensity.
- Increasing cropping intensity through intercropping.
- Upgradation/improvement of improvement of the existing farming systems using component based innovative technologies.
- Commercialization of farming systems to achieve higher total factor productivity.
- Socio-economic and policy research in farming system and formulation of policy guidelines for governance of resource management.
- Value-addition, post harvest processing and economically viable disposal mechanism for farming system produce.

Water Management

- Assessment of basin-wise groundwater potential through regional water balance studies; geo-engineering techniques; and mathematical modeling using remote sensing and GIS tools.

To evolve management strategies for safe development and utilization of groundwater either as a single resource or in combination with rain and other sources of water in different soil and hydro-geological formations for sustainable crop production.

To develop technologies for augmenting groundwater supplies through enhanced recharge in hydrologically critical areas.

- To devise efficient equipment and structures for groundwater abstraction.

- To study groundwater pollution arising from different sources (viz. agrochemicals, agro based industries, municipal and other waste waters, seawater intrusion etc.) and develop its control and ameliorative techniques for the safe use of polluted water in agricultural production system.
- Assessment of groundwater, its quality and development for preparation of database and development of regional planning for optimal utilization/allocation of groundwater.
- Development of groundwater recharge techniques for encouraging artificial recharge.
- Location specific possibilities for conjunctive use of rain, surface and groundwater and their potential to enhance the agricultural production.
- Appropriate technologies for reduction in energy consumption in groundwater.
- Planning of conjunctive use of models under multi-resources irrigation systems with special consideration to aquifer characteristics for rabi and summer cropping.
- Groundwater pollution due to agro-chemicals, industrial effluents of agro and non-agro based industries and sea water intrusion – their prevention and cure.
- Identification of cause of failure of tube wells, dug well and its eradication.
- Design and development of energy efficient pumping systems.
- Effective utilization of groundwater for maximization of efficiency through standardized pressurized irrigation techniques.
- Use of non-conventional energy resources for exploitation of groundwater.
- Identification of socio-economic constraints for groundwater utilization and its probable solutions.
- Management of shallow water table and sea water intrusion
- Drainage design criteria and feasibility of bio drainage
- Improvement of water use efficiency and water productivity through mu;tiple water use for diversified agriculture.
- Evolving irrigation and drainage criteria in canal commands.
- Improvement of water utilization pattern and cropping systems for efficient conjunctive use of surface & subsurface water resources.
- Development of low cost pressurized irrigation system for resource poor farmers
- Sustainable Management of groundwater resources in deficit and excess rainfall areas with social justice.
- Rainwater management through equitable water harvesting technology on participatory approach.
- Consumptive use of poor quality water

Integrated Nutrient Management

- Assessment of soil health under major production systems and management practices.
- Development of soil health/quality index
- Assessment of soil C- sequestration under different land use and management systems.
- Formulation of soil test & farmers' resource based IPNS system for dominant crops/cropping system in various agro-ecological regions.
- Development of geo-referenced state soil fertility maps.

- Monitoring nutrient build up like P, K, Zn etc. in soils under prolonged fertilizer use and nutrient deficient areas for judicious fertilizer use.
- Enhancing input use efficiency and factor productivity for sustainable crop production.
- To develop simple and rapid tests to analyze soils, plants, water, manures and fertilizers to provide quick and effective soil/fertilizer testing service and quqlity control on agricultural products.
- Development of stress tolerant efficient biofertilizer strains.
- To determine the equivalence of organic manures in terms of different nutrients for making precise substitutions of chemical fertilizers with manures.
- Development of composting technology and quality standards for farm and city wastes.
- Increasing shelf life of biofertilizers and development of quality standards.
- Inventorization and quality assessment of available bio-organic resources.
- To document existing ITK on bio-dynamic farming.
- Development of Technology Package for Organic Farming
- Screening of plant species for phytoremediation of heavy metal contaminated soils. Evaluation of chemical and phytoremediation methods for decontamination of polluted soil, water and urban wastes.
- Assessment and mitigation of heavy metals / pollutant elements' toxicities in soils, water and food.

Agroforestry

- To develop agroforestry systems in mitigating wind and water erosion, desertification, problem soils, degraded/wastelands for rehabilitation.
- The development of biofuel species such as Jatropha, Pongamia and other TBO's based agroforestry systems for different agroclimatic conditions and to develop complete package of practices for cultivation of biofuel species.
- To develop agroforestry systems for different agro-climatic regions of the country for higher productivity, sustainability and better economic returns.
- To upgrade and refine the already identified agroforestry models / practices for value addition, quality improvement and quick returns.

Climate Change

- Periodic monitoring of climate change parameters in agricultural systems.
- Listing of crops, commodities, enterprises likely to be vulnerable to predicted change in climate.
- Risk analysis and Management strategies under dynamics of climate change, drought and floods through development of decision support system for efficient crop production and input management.
- Developing weather-crop/cropping systems/ commodities/enterprises models and weather based forewarning for pests and diseases
- Upgradation of weather based forewarning mechanism and provision of value added agromet advisory service.

- To develop contingent plans for food, fodder and fuel supplies during severe drought/ floods.

New schemes / initiatives proposed

- AICRP on groundwater utilization does not have any centre in North-eastern Hilly region and in east coast of India. Hence it is proposed to have a new centre at College of Agricultural Engineering and Post Harvest Technology, CAU, Ranipool, Gangtok, Sikkim, to cater to the needs of north eastern region. Another new centre is proposed at College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, Orissa to cater to the needs of eastern coastal region.
- During the XI-Plan period it is proposed to start two new centres of All India Coordinated Research Project on Water Management one each at IIT Kharagpur (West Bengal) and A.N.G.R Agricultural University, Hyderabad (Andhra Pradesh) catering to the water management research needs of Kangasavati and Nagarjun Sagar command areas, respectively. Kharagpur centre will develop technologies to enhance water productivity through multiple-use of different source waters and the Hyderabad centre will evolve technologies to enhance water-use efficiency in water scarce area through pressurized irrigation systems.
- With changed scenario on determinants of food requirement and natural resource use, a paradigm shift is foreseeable. The future agricultural systems would be guided not only by the compulsion of improving food security, but also by the concerns of food quality, environmental protection, resource sustainability and system profitability. With the improvement in national economy and enforcement of world trade order, value of commerce in agriculture would be appreciated and farmers' decisions on land use would be increasingly based on competitive advantages rather than on subsistence needs of the farm households. Therefore, we may further expect a major shift in agricultural production from food grains to oilseeds, vegetables, fruits, and flowers. Because of integration of world markets, urbanization and rising personal incomes significant shifts in cropping systems and other farm enterprises may also take place due to increased production and availability of fruits, vegetables, milk and other animal products. In fact, there would be more growth in the demand for pulses and milk, relatively slow growth for cereals and decline in per capita demand for root and tuber crops. Under aforementioned compulsions, the conventional approach of cropping systems research will have limited success in achieving the anticipated goals. Therefore, to bridge the gap between the 'desired' and 'achieved' and to bring quantitative as well as qualitative improvement in fulfilling the national food needs, to sustain the agricultural resource base, and to provide livelihood security to millions of rural masses; a form of agricultural research that goes beyond 'cropping systems' and that respects the integrity of ecosystems while humans meet their food need, will be unavoidable. The future research in agriculture will be required to inculcate the new concepts of alternative agricultural production systems such as; multi-enterprise farming systems, organic farming, crop diversification, conservation agriculture, site-specific input management and precision agriculture, which will require in-depth studies to harness their

full benefits. And, to meet the ensuing challenges of agriculture, hardcore research in above mentioned alternative agricultural production systems, eventually the PDCSR should develop into a national level institute with more scientific and technical manpower and well equipped laboratories for soil and plant chemical, biochemical, pesticide-residues and microbiological analyses, physiological studies and facilities for determination of crop-weather relationships, GIS and indicators of environment. It is proposed that the PDCSR should be upgraded into an Institute and renamed as "Indian Institute of Alternative and Sustainable Agriculture Systems".

- In addition, there will be one post of Project Coordinator for Cropping Systems Management Programme (currently AICRP on Cropping Systems), and following two Network Programmes with 15-20 centres each:

a. Network Project on Organic Farming requires continuation and further strengthening in terms of centers and research facilities.

b. Network Project on Farming Systems Research to be initiated.

- The cold arid areas occupy 75,000 km^2 in Jammu & Kashmir and Himachal Pradesh. The areas characterized by harsh physiographic and climatic conditions face acute shortages of food, fodder, fuel and minor timber. A substantial area is under mountain wastelands and pastures. The economy of the region is basically agri-pastoral. The areas still lack adequate research and development support. A modest start has been made by SAUs and DRDO. A greater R&D effort is required on aspects of snow melt harvesting, production of off-season vegetables and aromatic and medicinal plants, green-house production, pasture development, agro-forestry, livestock improvement, agro-processing and value addition etc. The diverse problems of the region could be addressed to by establishing a Regional Centre of CAZRI, Jodhpur in the cold arid region. The applications of science and technology by the centre would herald much desired food and ecological stability in the region.

Research Programmes for Tribal Sub Plan :

- Soil resource mapping and delineation/characterization for planning of watersheds in tribal areas.
- Assessment of soil /land degradation and management options.
- Developing participatory integrated watershed models for tribal dominated areas of the country.
- Managing natural resources in coastal tribal areas for increasing productivity, livelihood generation and environmental conservation.
- Development for integrated location-specific, multi-commodity farming system modules involving field crops, horticulture, aquaculture, fisheries, livestock and other enterprises for tribal dominated areas of the country to increase income and livelihood.
- Drought proofing in arid/dryland areas.
- Identification of suitable crop and varieties to bring fallow/degraded lands under cultivation using residual soil moisture.
- Development of groundwater recharge techniques for augmenting groundwater .
- Improvement of water use efficiency/water productivity through mu;tiple water use.

- Participatory water harvesting for rainwater management.
- Formulation of soil test & farmers' resource based IPNS system for dominant crops/cropping systems of tribal areas.
- To develop agroforestry systems including biofuel crops for tribal dominated regions of the country for higher productivity, sustainability and better economic returns.
- Risk analysis and management strategies for droughts and floods to enhance productivity of tribal areas.

Budget Requirement

A budget of Rs.1800 crores is proposed for the plan period under different programmes.

Programme	**Budget requirement (2007-12) (Rs. in Crores)**
Soil Survey and Land Use Planning	100
Soil Management	150
Cropping & Farming System Research	750
Integrated Water Management	350
Integrated Nutrient Management	250
Agroforestry	150
Climate Change	50
Total	**1800**

Summary

Improving agricultural productivity and economy is foremost priority of the Government. Although achieving desired rate of growth in agriculture has been difficult due to number of production constraints, it could be accelerated to a great extent by proper conservation and management of natural resources. The indiscriminate use of resources is causing decline in soil health, rise and fall in water tables, development of secondary salinity and alkalinity and pollution of natural resources. The effect of resource degradation is evident on declining crop productivity, low input-use efficiency, rising cost of cultivation, shrinking livelihoods, contamination of foods and deterioration of environment. We need to constantly monitor the state of soil and water resources and devise management strategies for their sustainable use. The summary recommendations are as follows:

- Land use planning is fundamental to the development of agricultural sector. A lot more still needs to be done with regard to micro level land use planning. We need to develop decision support systems for evolving realistic and dynamic land use plans for different areas consistent with the prevailing socio-economic-environmental-market imperatives along with the bio-physical factors.

- The soils need to be supplied adequately with essential nutrients for sustained production. The integrated nutrient management packages and appropriate soil management practices need to be devised for different agro-ecological situations. The geo-referenced soil fertility maps are required for precise fertilizer recommendations. The carbon sequestration potential of major soil groups should be modeled for maintaining appropriate carbon levels in soils. The blueprints for raising production in low producing districts of the country should be prioritized. The gene based ionic uptake studies require to be initiated to mitigate aluminum toxicity, phosphorus deficiency and abiotic stresses due to salinity and droughts.
- The irrigation sector is going to face grim competition from the industrial and domestic sectors in near future. The gains in agricultural productivity of the country are, obviously, to be determined by proper development and utilization of surface and ground waters. The low water use efficiency of 40 % of canal irrigation requires to be enhanced to 60-70%. The ground waters depleting alarmingly in north western and southern parts of the country need to be judiciously utilized. We require technologies for rainwater harvesting and its recharge, increased use of poor and waste waters, improved on-farm management and cost-effective micro-irrigation systems. The multiple use of water should be promoted on a large chunk of waterlogged/Tal/Diarra lands in eastern region by integrating agriculture, aquaculture and livestock.
- There is need to identify alternative cropping systems with higher and stable yields and/or profit in different agro-ecological regions. The integrated farming systems internalizing synergies of different components for enhanced resource utilization, income and livelihood generation and minimizing environmental loading need to be developed for different agro-ecologies. A more diversified food basket will provide better food and nutritional security to the people.
- The effluents discharged into the sewerage and irrigation water need to be catalogued and examined for the build up of toxicities in soil-plant–animal-human chain. There is need to develop low cost pre-treatment technologies for waste waters and quick cheap and easy to handle testing tools for contaminants.
- More research is required on bio-drainage, measures for curtailing cost of reclamation technology and preventing sea water intrusion.
- Appropriate tillage and soils management practices need to be developed to increase water nutrient and energy use efficiency.
- The agro-forestry research is required to be linked with industry, bio-fuel/energy plantations and carbon trading regimes to generate income and livelihood, reduce petroleum imports and ensure clean environment.
- The adaptation and vulnerability of agricultural systems to climate change and appropriate mitigation measures need to be studied. The weather based forewarning mechanism to escape insect-pest/disease incidence need to be strengthened.

- *Open centers of AICRP on Groundwater Utilization, one each at College of Agricultural Engineering and Post Harvest Technology, CAU, Gangtok and College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, to cater to the needs of NEH and eastern coastal region.*

- Two Centres of AICRP on Water Management, one each at IIT, Kharagpur and ANGRAU, Hyderabad.
- A center of CAZRI, Jodhpur for agricultural research and development in most disadvantaged and, hitherto, unrepresented cold arid region.
- PDCSR, Modi[puram to be upgraded to an institute and renamed as "Indian Institute of Alternative & Sustainable Agriculture Systems".
- Starting Network Project on Farming Systems Research.
- Total financial outlay proposed for the Plan is Rs. 1800 crores.

5. CLIMATE CHANGE, RISK AND DISASTER MANAGEMENT

The foodgrain production in the country has been static during the last 10 years and is hovering around 210 mt. The stagnation in food production can be attributed to various technical and socio-economic factors. In addition, the weather variability during the crop season has played a key role in determining the agricultural production. The extremity in weather events during the past decade such as cold and heat waves, un-seasonal rainfall, hailstorms, reduction in number of cyclones and low pressure has adversely affected agricultural production. The inability to predict such events in advance has significantly contributed to the plateau of agricultural production. More frequent droughts in the recent past have also contributed significantly towards the decrease in water availability from major, medium and minor irrigation systems; which has adversely affected irrigated agriculture.

BOX: 1 CLIMATIC RISKS

Weather has a pervasive impact on food production and its sustainability. Over the past decade, the extremity in weather events has adversely impacted agricultural production. Our *inability* to predict adverse weather events in advance, has significantly contributed to the plateauing of our agricultural production.

There is an urgent need to establish a wide interlinked network of automatic weather stations with real time data dissemination across the country, particularly in the eco-regions important for food security.

2. Dwindling of foodgrain buffer stocks in the recent years from 60 mt to 18 mt is a cause of great concern and have compelled the Government of India to import 8 mt of wheat during the year 2006; it has shattered the confidence of agricultural scientific community on meeting the future food demands.

The population is expected to reach 133 crores by 2020 which means more food and water security are needed. The projected foodgrain requirement by 2020 is 260 - 300 mt, thus there is an urgent need to review the strategies of agricultural research programs in relation to our understanding of the climate phenomena responsible for variable production and for sustaining food production and forward planning. In order to meet country's food and nutritional security there is a need to increase the current production levels by about 40% in another 15 years. This increment has to be achieved through improvements in harnessing natural resources *interalia* technological and genetic interventions. In order to implement the programs for efficient natural resource management, it is necessary to address agrometeorological issues for weather-wise agricultural management. For a majority of India's population, the staple diet is of plant origin and there is need to continually grow agricultural food crops and also increase their productivity levels. With the shrinkage in arable land due to industrialization and urbanization, the demand to produce more food per unit of land per unit time, will increase in future. Intense land use systems including cropping pattern may further deteriorate the quality of environment, soil and water, if these natural resources are not use more prudently.

3. Agro-climate of a region has a pervasive impact on its crop production and food security. The data of over the past 100 years shows, that anthropogenic induced climate changes have occurred in form of global warming (due to increased levels of $C0_2$ and other greenhouse gases), which has multiple effects on all the agriculturally important meteorological parameters. The quantum of rainfall, its intensity and its temporal distribution have become increasingly variable at many locations. The global mean air temperature was almost 0.7°C above the normal at the end of the 20th Century. Last decade of the past century was observed to be the warmest as shown by the records maintained since 1860. Recently, the year 2003 was observed as the warmest year. During this year, large number of causalities was reported due to heat wave across the country, particularly in the states of Orissa, Andhra Pradesh, Bihar and Uttar Pradesh. In the northern parts of India, diurnal temperature difference has shown a decrease, as a result of which an increase in night temperatures at twice the rate of day temperature has been observed. Recent studies show that 2005 has been even more warmer. During 2005-06 the 4° - 6^{o}C increase in mean temperatures during February had led to a 17% decline in wheat production in northwestern India. Intensive research and development efforts are thus needed to understand how such changes are likely to affect the Indian agriculture in the future and to work out the strategies to cope with them and make our agriculture more resilient to climatic aberrations.

BOX: 2 CLIMATIC CHANGE IMPACTS

Climate change due to anthropogenic activities has resulted in global warming. It has multiple effects on agriculturally important meteorological parameters. The global mean air temperature was observed to be almost 0.7°C above the normal at the end of the 20^{th} century.

In India according to SAC Survey, as many as 127 glaciers of less than 1 sq. km. size have lost 38 percent of their geographical area since 1962. Larger glaciers are progressively getting fragmented and have receded by about 12 percent.

United Nations Environment Programme (UNEP) and the Kenyan Green Belt Movement have reported that Africa's two highest mountains will soon lose their ice cover [within 25 to 50 years]. Ice will disappear from Mount Kilimanjaro and Mount Kenya, if deforestation and industrial pollution-led global warming is not *halted*. Kilimanjaro has lost 82% of its ice cover over the past 80 years, while Mount Kenya has lost 92% of its ice cover over the past 100 years. Similar changes are occurring in India. This will have serious consequences for water availability, which is a matter of great concern. We need to redouble our efforts to study the snow cover and glaciers in the Himalayan region and put-in-place means to conserve them

4. Further, the climate change is also leading to rise in sea level due to melting of polar snowcaps, which is likely to have serious impacts on coastal agriculture and related-aqua ecosystems. In addition, melting of the glaciers and the deforestation of the Himalayan regions is already influencing the hydrological balance of the Himalayan basin in the Indo-Gangetic Plains (IGP). All of these changes are primarily due to increased human activities and associated climate change / variability impacts. In the recent past India has experienced an increment in extreme weather events such as very heavy localized precipitation, abnormal temperature regimes particularly over IGP and frequent droughts, which emphasize the urgency to carry out extreme events analyses on a continued basis.

BOX: 3 MORE JOBS FOR THE WOMEN

We need to improve our understanding of climate variability / change. All the historical climatic databases need to be digitized and made available to the research institutes / universities so that favourable agricultural production regions are delineated for sustained ever-green agricultural production. Further, our agro-meteorological research programs are hitherto mostly crop-oriented. This research should be extended and enlarged to include horticultural crops, livestock management and fisheries production.

The computerization and management of meteorological database is a labour-intensive work. It would open-up hundreds of new job opportunities, particularly for women.

5. The extreme events are directly associated with global climatic change and are reducing agricultural production through their direct and indirect effect on crops, soils, livestock, pests and diseases. An increase in carbon dioxide (CO_2) content of the atmosphere promotes growth and productivity of C_3 crops. However, $C0_2$ induced rise in atmospheric temperature can bring a new equilibrium between soils, crops and pests. Indirectly, these processes may also affect land use. Higher temperatures coupled with degradation in quality of precipitation are likely to influence significantly the soil quality and nutrient cycle particularly nitrogen balance. The land use boards should be revived and is vital for water management research programs. There is every likelihood that reactive nitrogen levels will be altered, for which specific studies need to be initiated during the XI plan period.

BOX: 4 REACTIVE NITROGEN POSES HEALTH HAZARDS

Due to intensive use of nitrogenous fertilizers in the 'green revolution' areas, large amounts of nitrogenous compounds have built-up in the soil water, ground water, drainage water, water flowing in our rivers, and reactive N_2 in the atmosphere.

The reactive N amount needs to be documented, methods to manage it need to be found, and better use of N-fertilizers needs to be formulated and the new knowledge needs to spread to the farmers, industry, extension workers and environmentalists. Indian Nitrogen Research Center needs to be established.

6. The impacts of climate variability on food as witnessed in the form of steep rise in the prices of onions in 1998 and again in 2005, and the glut in vegetable production, have triggered some far reaching political and social changes. This has emphasized the need for a better understanding of crop- weather-relations as well as documentation of weather sensitive farm operations to meet such unforeseen circumstances. Therefore, it is essential to distinguish clearly between climate and climate variability and to assess the direct and indirect consequences of climate change and its variability on agricultural production systems and water resources that contribute significantly towards food security of the country.

7. Research conducted at Central Research Institute for Dryland Agriculture (CRIDA) during X Plan has conclusively demonstrated that accelerated seedling growth and a 15-20 percent yield increase in groundnut, greengram, sorghum, castor and sunflower occurs in glass house / poly culture under elevated CO_2 levels. Insect-pests also recorded an increase in larval length and weight under enriched CO_2. This shows that in the future environmental conditions will be more favourable for the proliferation of insect-pests in warmer climates. Hence, agricultural crops are likely to be more exposed to biotic stress leading to quality and quantity of agricultural produce.

BOX: 5 NORTHEAST AND ISLANDS NEED SPECIAL ATTENTION

The northeastern eco-regions of our country represent undulating topographies. These are highly prone to soil and water erosion. A special cell in our agro meteorological research program needs to be established to collect, compile and analyse agro-meteorological databases for this risk-prone farming region of our country. Since the climate is highly impacted by orography, a very substantial network of weather observatories will have to establish there.

It is purposed that the northeast and Island regions of India be given a priority emphasis for agro-meteorological research and applications during the XI Plan.

8. For a better understanding of climate variability/change and for future agricultural planning, evaluation of climatic resources supported by crop and soil parameters at micro-level is necessary in view of the changes with respect to demand/market driven agricultural practices. Hence, there is an urgent need to strengthen the existing agromet databases for delineation of favourable agricultural production regions for sustained production**. Agrometeorological Research Programs hitherto are mostly crop-oriented and are limited to the mainland agricultural regions of the country. This research can be further extended towards horticultural and livestock management including islands and**

northeast regions of the country with the establishment of separate research centres of AICRPAM at those locations.

BOX: 6 NATIONAL AGRO-ADVISORY SERVICE SUGGESTED
The existing Agro-Advisory systems need to be value-added and developed for application as an operational tool, so that weather related un-certainties are managed wisely. **ICAR, SAU'S, IMD and NCMRWF should join hands as strategic partners in developing a National Agro-Advisory Service. This service should be embedded within ICAR and made operational during the XIth Five year plan.**

9. The use of modern research tools like Remote Sensing and the Geographical Information systems (GIS) should be intensively utilized. Development of computer-aided packages such as systems modeling and Decision Support Systems (DSS) in agro-meteorological research should be given a priority. As no research work on crop insurance has been carried out so far emphasis should be given for conducting research applicable to both irrigated and rainfed farmers. Similarly, development of simulation models for risk analysis. forewarning of weather-based pest/disease and their use in Agro-advisory Network should be given high priority. The existing Agro-advisory Systems need to be value- added and developed for application as an *operational tool,* so as to manage weather related uncertainties in a prudent manner. This calls for development of a National Agro-Advisory Service with ICAR, SAUs, IMD and NCMRWF as key-strategic partners. For such a network to be operational, a series of automatic weather stations across the country should be established and linked on-line for near real time monitoring of crop and weather conditions, and for issuing of value-added agro-advisories at district level. Public- private partnership for monitoring crop and market information and the dissemination of agro-advisories at farm level through rural knowledge kiosks managed by rural youth as local facilitators using ICT must be progressively promoted.
To implement the above program successfully during XI Plan period, it is important to establish an Institute on Agrometeorology should be accorded priority.

10. Information on climatic resource characterization for identifying suitable crop growing environments over hill and mountain regions is limited. Therefore, more studies need be initiated. Similarly, the climate variability which alters hydrological cycle of the region and its impact on agriculture should be given priority. The mountainous Himalayan regions, which are more prone to natural disasters, landslides, avalanches and forest fires, will need immediate attention in view of the climate change.

11. Contributors to the discussion and formulation of recommendations are as follows:

1. Dr. S.M. Virmani, Retd. Climatologist, ICRISAT, Hyderabad
2. Dr. L.S Rathore, Head, Applications Division, NCMRWF, Noida
3. Dr. Y.S. Ramakrishna, Director, CRIDA, Hyderabad
4. Dr. P.S.N. Sastry, Retd. Principal Scientist (Ag. Met.), IARI, New Delhi
5. Dr. G.G.S.N. Rao, Project Coordinator (Ag. Met.), CRIDA, Hyderabad
6. Dr. R.M. Bhaghat, Professor, HPKVV, Palampur
7. Dr. P.K. Agarwal, Head, Division of Environmental Sciences, IARI, New Delhi
8. Dr. U.S. Victor, Principal Scientist (Ag. Met.), CRIDA, Hyderabad
9. Dr. V.U.M. Rao, Principal Scientist (Ag. Met.), CRIDA, Hyderabad
10. Dr. N.N. Srivastava, Principal Scientist (Ag. Met.), CRIDA, Hyderabad
11. Dr. A.V.M. Subba Rao, Scientist Sr. Scale (Ag. Met.), CRIDA, Hyderabad
12. Dr. V. Geethalakshmi, Professor, Dept. of Agrl. Meteorology, TNAU, Coimbatore
13. Dr. Y.P. Abrol, Professor, Society for Conservation of Nature, New Delhi

The final recommendations of the Committee are appended.

12. Total Budget Requirement during XI Plan

Climate change, Risk, and Disaster Management

S.No.	Name of the Project		Rs. in Crores
	Existing AICRPAM Units*	→	18.00
1.	Climatic Resource Characterization for Managing Climatic Variability and Change	→	22.00
1.1	Management of reactive N in Agriculture, Industry and Environment	→	40.00
2.	Climatic Risk and Disaster Management	→	20.00
3.	Weather-based Agro-advisories	→	25.00
4.	Agrometeorological Instrumentation	→	15.00
5.	Expansion of Agromet R & D Network	→	30.00
	Total	→	**170.00**

*The existing AICRPAM Units located at 25 SAUs need further continuation of research activities during XI Plan. It is also required to open such units in newly created Agricultural Universities and also the Island and Mountainous Regions of the country. They will need about Rs.18 crores during XI Plan period to carry out the assigned research activities proposed in the Plan. This has been included in the total budget requirement of the Climate and Agriculture Program.

Summary

The Climate Change, Risk and Disaster Management, Agroclimatic Research Programs to be taken up during the XI Plan period at the ICAR were formulated in Sub-Group headed by Dr. S.M. Virmani, Retd. Climatologist, ICRISAT and supported by eminent scientists from different organizations, viz., NCMRWF, HPKVV, IARI and CRIDA which are given in footnote. The program was coordinated by Dr. Y.S. Ramakrishna, Director & Member-Secretary*.

* Drs. PK Agarwal, PSN Sastry, RM Bhagat, LS Rathore, YP Abrol, GGSN Rao, VUM Rao, US Victor, V Geethalakshmi, Shri NN Srivastava, Shri AVM Subba Rao

The Committee has identified five thrust areas, viz., (1) Climatic Resource Characterization for Managing Climatic Variability and Change, (2) Climatic Risk and Disaster Management, (3) Weather-based Agro-advisories, (4) Agrometeorological Instrumentation, (5) Expansion of Agromet Research and Development Network, with a financial outlay of Rs.170 corers. The recommendations emanating from the discussions are summarized below:

1. *Climatic Resource Characterization for Managing Climatic Variability and Change*

- Block level agroclimatic, land use and socio-economic data collection and analysis should be carried out on priority.

- Impact of climate change on agriculture through experimental and modeling studies, assessment and mapping of geographical shifts on crop and horticultural regions and other vegetation due to climate change, need to be studied.

- Detailed agroclimatic analysis for northeastern hill and island regions should be taken up.

- Strengthening and expansion of Agromet Databank for providing information on real time basis should be taken up.

- State-wise Agroclimatic Atlases should be prepared on priority.
- New potential areas for crop production in mountain regions need to be identified.

- Food security analysis using crop simulation models and crop production strategies for future should be strengthened.

To implement the above programs, an amount of Rs.22 crores is estimated. This includes collection and compilation of databases on agroclimatic, land use, socio-economic, water resources of the entire country and creation of computing facilities, inter-linking of AWS and web-based linking, upgradation of the existing Databank at CRIDA, development of regional agromet database and advanced GIS facilities at State Agricultural Universities, etc.

1.1. Management of Reactive N in Agriculture, Industry and Environment

- A system needs to be created to tackle the issues of reactive N.
- A decision support system needs to be developed for generating policies for relevant sectors.

- A planned research program needs to be undertaken to enhance our understanding of N – cycle at eco regional level due to climate change.

To implement the above program, an amount of Rs.40 crores is estimated, which is inclusive of Establishment of **Indian Nitrogen Research Centre** to conduct research, develop, evaluate policy and disseminate research results in a synergistic manner to policy-makers.

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2. **Climatic Risk and Disaster Management**
   - Vulnerable eco-regions for short and long term climatic fluctuation should be identified.

   - Impact of climate fluctuations on agri - horti - aqua and livestock sectors and suggesting appropriate farming systems strategies should be carried out.

   - Development and validation of crop simulation models and operational models for forewarning of pests and diseases be given priority.

   - Development of prediction models for the occurrence of droughts & DSS-based mitigation strategies need to be taken up.

   - A national level drought monitoring and management unit should be established on priority.

   - The existing national agricultural weather based insurance policy should be strengthened and diversified appropriately to cover the risk of rainfed farmers/crops.

   - Monitoring of glacier recession, water resources, soil erosion and associated impacts on agricultural production in mountainous region should be taken up and appropriate contingency plans developed.

   - Mapping of disaster prone-areas and pest & disease hotspots using GIS and remote sensing technologies may be taken up.

To operate the above program, an amount of Rs.20 crores has been provided for creating infrastructure facilities, such as, acquiring the remote sensing imageries, training the scientific personnel in modelling studies, establishment of **National Drought Management Unit** and separate **Centre for Disaster Management for Mountain Regions** particularly in NE India.

3. **Weather-based Agro-advisories**
   - Value addition to the agrometeorological information should be carried out.
   - Near real-time monitoring of weather through AWS networking for preparation of contingency crop plans be given priority.

   - District level agromet advisories need to be strengthened.
   - Links with local village networks such as Rajiv Internet *kiosks*, Mission 2007 rural network, *Gyan Choupals,* etc. for on-line dissemination of Agrometeorological advisories through local level facilitation using ICTs need to be established.

   - Developments of regional language websites and integrating them to a National level Agro-advisory System should be taken up on priority.

   - A National Agro-advisory HRD Center should be established.

An amount Rs. 25 crores has been provided to implement the above research programs. Infrastructural facilities like online connectivity with village networks, linking and establishment of AWS, establishment of National Agro-advisory HRD Centre are planned under this study.

4. Agrometeorological Instrumentation

- **Central Agromet Instrument Laboratory** for maintaining, calibration, and repairing facilities of agromet field instruments should be established.

For implementing the above program, creation of Agrometeorological Instruments Laboratory for calibrating and testing the equipment is planned with an estimated outlay of Rs.15 crores.

5. Expansion of Agromet Research and Development Network

- A separate National Institute on Agrometeorology should be established.
- Establishment of centers of excellence at five locations (Raipur, Bangalore, Hisar, Jorhat and Anand) should be taken up by upgrading the existing Agromet Centres.
- Upgradation of staff at 13 centres of AICRPAM established during VIII Plan on par with 12 old centres to maintain the uniformity need to be taken up.
- Strengthening of the existing agromet units of ICAR institutes and the establishment of Agromet units at the ICAR Institutes and SAUs currently not having Agromet Units may be taken up.
- New centers with exclusively focus on horticulture, livestock, besides island regions should be established.

An amount of Rs.30 crores are worked out for initiating the above research program by creating infrastructure facilities, such as, establishment of **National Institute of Agrometeorology**, establishment of **Centre of Excellence at 5 locations and strengthening of the manpower at existing 13 AICRPAM centres, new centres for horticulture, livestock besides island regions** and the **establishment of Agromet Network at ICAR and SAUs**.

Appendix

Recommendations of the Sub-group on Climate and Agriculture

THRUST AREA-1: *Climatic Resource Characterization for Managing Climatic Variability and Change*

Current Status and Gaps	**Recommendations**	**Infrastructural Requirements/ Changes**	**Budget Needs (Lakhs)**
1.0 Micro-level agricultural planning using climatic resources have not been carried out. Therefore, there is a need to study climatic parameters and their changes with respect to both space and time ▪ Limited information on Agroclimatic characterization with respect to northern states and islands is available. Hence there is need to strengthen further	▪ Block level Agro-climatic, land use and socio-economic data collection and analysis is to be taken up on priority basis ▪ The impact of climate change scenarios on agriculture need to be further strengthened through experimental and modeling studies ▪ Study of Northeastern India & island Agrometeorology should be taken up	▪ Collection, compilation and digitization of historical agro-climatic, land use and socio-economic data through outsourcing ▪ Advanced computing facilities including climate & crop models, use of RS data and GIS and also sophisticated laboratory facilities and human resources development of the agrometeorologists and climatologists ▪ Establishment of new agromet centers in islands and in NE India	▪ Expenses for the collection and compilation of natural resources datasets for all 25 States. **= 150** ▪ Establishment of Advanced agro climate systems laboratory including HRD **= 400** ▪ Establishment of new agromet island center and a centre in Northeastern India = **100**

THRUST AREA-1: ***Climatic Resource Characterization for Managing Climatic Variability and Change*** contd..

Current Status and Gaps	Recommendations	Infrastructural Requirements/ Changes	Budget Needs (Lakhs)
▪ Central facility of Agromet databank operating at CRIDA need to be continued in the XI Plan for supporting the agricultural research programs of ICAR ▪ State Agroclimatic atlases for micro level agricultural planning using layer wise micro regional information has not been done. Therefore there is a need to bring out state wise agroclimatic atlases	▪ The existing agromet databank needs to be further expanded, updated and made operational on real-time basis. The infrastructure for this should be strengthened by providing permanent staff ▪ Preparation of state-wise Agroclimatic atlases should be take-up.	▪ Creation of facilities for interlinking AWS and web based linking for maintaining online database ▪ Upgradation of the existing databank at CRIDA ▪ Advanced GIS software and training	▪ Installation and establishment of network communication with latest software at 25 locations having an operational capacity to link with the headquarters = = **800** ▪ Additional manpower at CRIDA ▪ Principle Scientist (Agromet) ▪ Sr. Scientists (6) in Agromet, IT, RS & GIS, soils & land use planning, plant protection and social sciences= **250** (salaries+contng+N RCs) ▪ GIS software along with systems at all agromet centers = **250**

THRUST AREA-1: ***Climatic Resource Characterization for Managing Climatic Variability and Change*** contd..

Current Status and Gaps	**Recommendations**	**Infrastructural Requirements/ Changes**	**Budget Needs (Lakhs)**
▪ Information on climatic characterization for identifying the suitable crop growing environments over the hill and mountainous regions is scarce and needs to be strengthened ▪ Climatic variability which alters hydrological cycle of the region thus effecting the agricultural production	▪ Niche-based farming, identifying new potential areas and affected crops in mountain regions. ▪ Assessment and mapping of geographical shift in crop and horticulture regions and other vegetations due to climate change ▪ Mapping of indicators of regional unsustainability. ▪ Food security analysis using crop simulation models and crop production strategies for future	▪ Collection & compilation of databases on water resources, agricultural production systems, agroclimatic, land use, socio-economic of mountainous regions ▪ Advanced GIS facilities and modeling training for hill & mountain regions	▪ Operational costs for acquiring climatic / snowfall data from respective sources – **50** ▪ Digital data layers from Survey of India – **100** ▪ Establishment of RS / GIS Labs – **100** **Total =150+400+100+800+250+250+50 +100+100=2200**

THRUST AREA-1: ***Climatic Resource Characterization for Managing Climatic Variability and Change*** contd..

Current Status and Gaps	**Recommendations**	**Infrastructural Requirements/ Changes**	**Budget Needs (Lakhs)**
1.1 Accumulation of reactive nitrogen from farm and non-farm sources is one of the emerging concerns for global climate change, environment and public health. Hence priority should be given to develop a separate research unit to carryout the impact of climate change on the nitrogen balance	▪ A system needs to be created to tackle the issues of reactive N. ▪ A decision support system needs to be developed for generating policies for relevant sectors ▪ A planned research program needs to be undertaken to enhance our understanding of N – cycle at eco regional level due to climate change	▪ Establishment of Indian Nitrogen Research Centre (INRC). This centre will research, develop, evaluate policy and disseminate research results in a synergistic manner to policy makers	▪ For assessment of reactive N = **300** ▪ Consolidation of available knowledge into databases = **300** ▪ Development of DSS = **400** ▪ Policy research = **200** ▪ Basic sciences research = **1000** ▪ Pilot experiments = **800** ▪ Technology development = **900** ▪ Dissemination of Technology = **100** ▪ **Total cost = 4000** ▪

THRUST AREA-2: ***Climatic Risk and Disaster Management***

Current Status and Gaps	Recommendations	Infrastructural Requirements/ Changes	Budget Needs (Lakhs)
• Extreme weather events can have long term implications on regional food security. Hence there is an urgent need to assess the climatic extremes / climatic variability and change and the risks involved in the management of natural resources for agri - horti - aqua and livestock sectors for sustainability. Limited work on development and validation of crop, pest and disease models • Drought is a regular phenomenon in one or the other part of the country and there is no effective mechanism to predict, monitor and management.	▪ Identification of vulnerable eco-regions for short and long term climatic fluctuation. ▪ Impact of climate fluctuations on agri - horti - aqua and livestock sectors. ▪ Suggesting alternative cropping strategies ▪ Development and validation of crop simulation models and operational models for forewarning of pest and disease ▪ Development of prediction models for the occurrence of droughts & DSS-based mitigation strategies. ▪ Establishment of a national level drought management unit.	▪ Advanced statistical tools for extreme value analysis ▪ Appropriate crop and pest disease models for operationalizing the databases on land use, water resources, agricultural production systems, pest disease information, and socio-economic status for sustainable agricultural production. ▪ Establishment of a national drought management unit for assessment, monitoring and prediction of drought	▪ Operational costs for acquiring and digitization of necessary remote sensing and other data & equipment = **200** ▪ Manpower for development of crop-weather models and decision support systems. Training & modeling initiatives = **400** ▪ Establishment of a national drought management unit **= 900**

THRUST AREA-2: ***Climatic Risk and Disaster Management*** contd..

Current Status and Gaps	**Recommendations**	**Infrastructural Requirements/ Changes**	**Budget Needs (Lakhs)**
• Crop risk management through crop insurance is not covered for all crops and all regions • Climate change impacts on glaciers and associated fresh water flows and bio diversity in mountainous areas needs critical study	• Strengthening of national agricultural weather based insurance policy. • Monitoring of glacier recession, water resources, soil erosion and associated impacts on agricultural production. • Mapping of disaster prone areas and pest & disease hotspots	• Development of a standard mechanism for assessing the impact of weather on crop loss for insurance claim • Establishment of a Centre of Excellence of Disaster Management for mountain regions. • Trainings for scientists. • Procurement of latest satellite imageries. • Collection of existing data including terrestrial and aerial photographs, records, met. Data	• Satellite imageries, aerial photographs for mountain region = **200** • Advanced computing systems =**100** • Establishment of a Centre for Disaster Management for Mountain region = **200** • **Total = 200+400 +900+200+100** **+200 =2000**

THRUST AREA-3: ***Weather-based Agro-advisories***

Current Status and Gaps	Recommendations	Infrastructural Requirements/ Changes	Budget Needs (Lakhs)
• There is a need to improve the existing AAS system for sustainable agricultural production through value added agroclimatic information, dissemination of agro advisories through local languages using ICT *via* KVKs / *Gyan Choupals* / knowledge kiosks	• Value addition to the agrometeorological information. • Near real-time monitoring of weather through AWS networking for preparation of contingency crop plans. • Strengthening district level agromet advisories. • Establishment of links with local village networks such as Rajiv Internet *kiosks*, Mission 2007 rural network, *Gyan Choupals* etc for on-line dissemination of Agrometeorological advisories using ICTs. • Developments of regional language websites and integrating them to National level agro-advisories.	• Online connectivity, web hosting and maintenance and linkages with local / village networks (Mission 2007). • Linking and establishment of optimal network of AWS for improving the efficiency of forecast	Operational system for linking KVKs , ICAR Institutes and AMFUs for better dissemination of value added agro-advisories at district / block level = **1000**

THRUST AREA-3: ***Weather-based Agro-advisories*** contd..

Current Status and Gaps	**Recommendations**	**Infrastructural Requirements/ Changes**	**Budget Needs (Lakhs)**
• The scientists manning the AMFUs/ KVKs are not well versed in the discipline of meteorology and weather forecasting techniques. Hence training in these subjects is essential	• Establishment of National Agro-advisory HRD Center	• Establishment of HRD cell for Agromet in consortium mode by ICAR, DST, NCMRWF & and IMD. Advanced trainings for interpretation of image data and glaciological aspects.	• Establishment of National Agro-advisory HRD Center **= 1500** • **Total=1000+1500 =2500**

THRUST AREA-4: ***Agrometeorological Instrumentation***

Current Status and Gaps	**Recommendations**	**Infrastructural Requirements/ Changes**	**Budget Needs (Lakhs)**
• Most of the agromet instruments are not manufactured in India and the technical backup and supply of spares is most undependable. • Therefore, establishment of a design and development unit, calibration and repairing agromet instruments facility needs priority.	• To establish central agromet instrument laboratory for maintaining, calibration, and repairing facilities of agromet field instruments	• To establish central agromet instrument laboratory at CRIDA	• Creation of Infrastructure including laboratory, workshop and test equipment **= 1000** • Manpower = **500** • **Total=1000+500 = 1500**

THRUST AREA-5: ***Expansion of Agromet R & D Network***

Current Status and Gaps	Recommendations	Infrastructural Requirements/ Changes	Budget Needs (Lakhs)
• The AICRPAM is operating for over 20 years with significant achievements in the field of agroclimatic characterization, crop weather relationships and operational agricultural meteorology. To strengthen and streamline the research activities a separate national level institute is needed to cater the national agromet requirements.	• A separate national institute on Agrometeorology should be established	• National Institute on Agrometeorology	• Establishment of National Institute on Agrometeorology **=1800**
• Strengthening of agromet research at regional levels through establishment of centers of excellence.	• Establishment of centers of excellence at **five** locations (Raipur, Bangalore, Hisar, Jorhat and Anand).	• Establishment of center of excellence at the **five** locations	• Center of Excellence at the five locations = **200**
• There is a non-uniformity in the staffing pattern of the existing AICRPAM Units	• Up gradation of staff at 13 centres of AICRPAM established during VIII Plan on par with 12 old centres to maintain the uniformity	• Strengthening of the existing AICRPAM centres	• Strengthening of manpower at the 13 existing AICRPAM centres **= 300**

THRUST AREA-5: *Expansion of Agromet R & D Network* contd..

Current Status and Gaps	Recommendations	Infrastructural Requirements/ Changes	Budget Needs (Lakhs)
• Currently agromet research is carried out only in few ICAR and SAUs. Hence there is a need to Establish Agromet units at all the ICAR Institutes and SAUs including those based on crop, livestock and fisheries	• Strengthening of the existing agromet units of ICAR institutes and the establishment of Agromet units at the ICAR Institutes and SAUs currently not having Agromet Units.	• Establishment of New Agromet units at the ICAR Institutes and SAUs.	• Strengthening of the existing agromet units of ICAR institutes and establishment of Agromet units at the remaining ICAR institutes & SAUs **= 500**
• There is also a need to expand the activities of Agrometeorology to horticulture, agro forestry, livestock, floriculture	• Establishment of new centers exclusively for horticulture, livestock, besides island regions	• Establishment of new centers for horticulture, livestock.	• Establishment of new centers exclusively for horticulture and livestock **= 200** • **Total=1800+200+300 +500+200=3000**

6. RAINFED AGRICULTURE

Spread over 87 million ha of net cultivated area, rainfed areas contribute 40% to national food basket and support 40% of human and 60% of livestock population. Despite the availability of a number of technological options, rainfed agriculture continues to be complex, diverse and risk-prone. Main bio-physical and socio-economic constraints include: I) erratic and deficient rainfall, ii) land degradation and poor productivity, iii) low levels of input use and technology adoption, iv) inadequate fodder availability and poor health of livestock, and v) resource poor farmers and inadequate credit availability. For improved productivity and higher profitability through value addition, researchable issues, enabling mechanisms for farmers to absorb improved technologies and appropriate policy initiatives were the focus of deliberations of the sub-group on "Rainfed agriculture". Main thrust areas and the associated researchable issues and actions were prioritized as follows:

1. Water Conservation and Management

- A long-term networked operational watershed farming system based programme to be launched across various agro-eco regions of the country in partnership with farmers
- Comprehensive research leading to a revival of the traditional water storage systems (e.g., tanks) and the utilization of defunct open wells as recharge structures for augmenting the ground water to be later extracted for life-saving or come-up irrigation
- Investigations at about 15 benchmark watershed sites representing 750-1100 mm rainfall regions to understand stability, productivity and profitability in response to various development inputs and technological interventions
- Strengthening of geo-hydrological studies and hydrological monitoring to facilitate community regulation against over-exploitation of ground water and their recharge on landscape basis

2. Soil Quality

- A comprehensive research programme on (i) diagnosis and management of secondary- and micro-nutrient deficiencies and (ii) amelioration of excess alkalinity/acidity.
- Research on farmers' fields to restore lost soil quality, resource conservation practices, and native biomass production and its application.
- Focused research on integrated nutrient and pest management and carbon sequestration in rainfed ecologies.

3. Organic Farming

- Research data on commercially successful organic farming particularly for the tribal and hilly regions of NE-India, semi-arid and arid regions are not available. An operational scale multi-location research programme in cooperation with SAU's by CRIDA is proposed
- Development of simplified organic farming practices which should largely depend upon native inputs, bio-fertilizers, bio-pesticides, appropriate crop varieties/hybrids and other resource conservation systems.

4. **Integrated Farming Systems and Alternate Land Use**

- Research strategies for areas receiving less than 500 mm rainfall should be primarily livestock based, 500-700 mm crop-livestock based, while areas between 700-1100, crop – horticulture – livestock – poultry based and those with > 1100 mm should have enterprises based on multiple use of water (water for inland fisheries, aquatic plants and irrigation of arable crops/horticulture).
- Dryland horticulture, medicinal, aromatic and seed spices, fuel, oil and wood yielding trees and bushes have immense potential to augment the income of farmers in rainfed areas. Thus, concerted research efforts are required to improve the productivity of these crops both as sole crops and in different intercropping systems.

5. **Farm Mechanization**

- Design and development of tools and machinery for conservation tillage, weed control, loss-free harvesting, primary processing and value addition at farm level.
- Promote tenets of precision agriculture and simultaneously enhance livelihood opportunities for rural youth by setting up of custom hiring centres at selected *Panchayats* on pilot basis.

6. **Biodiversity Conservation and Genetic Enhancement**

- Promote conservation, registration and use of local land races of crops (including grass and tree species) through community participation (to be facilitated by NBPGR taking the help of NGO's, KVK's, farmers, grass root level workers).
- The local germplasm from chronically drought prone areas of the Deccan plateau (for millets, pulses and small ruminants), (ii) central Indian landscapes extending from Telangana in A.P. to southern Chhattisgarh (for rainfed rice, millets and poultry) be characterized for unique biotypes possessing elite characteristics.
- Enlarge the concept of participatory plant breeding and participatory varietal selection for genetic enhancement in resource-poor, low input dryland agriculture environments. Emphasis needs to be on locally accepted self-pollinated crops.
- Intensify the use of molecular biology tools by introducing biotic and abiotic stress tolerance and infusing organoleptic characters in rainfed crops. Indigenous plant types that inherently possess genes responsible for higher nutritive value (more protein, micronutrients etc) need to be identified and used for enriching nutrients in rainfed crops. Development and introduction of suitable hybrids of short duration maize, pulse and oilseed crops will be a highly rewarding strategy - both from economic and social angle.

7. **Training and Education – Use of ICT**

- Build capability and competence to undertake high intensity agricultural activities like mixed farming emphasizing multiple and vertical use of land, water and vegetation.
- Create skill and knowledge empowered individuals who can diversify conventional farming through low volume high value agriculture or who can initiate off-farm agri-ventures to create employment for self and others.

- Strengthen and equip existing KVKs to provide vocational training to youth in micro-enterprises and upskill their competence in modern technologies and methods of rainfed agriculture.
- Build ICT mediated village knowledge economy by developing institutional mechanisms that involve and overarch the information demands and activities of all stakeholders (e.g., research institutions, development departments, farmers clubs, self help groups and local and regional markets).

8. New Paradigms for the Development of Rainfed Areas

- Emphasize production systems in place of narrow component/disciplinary considerations and technology options should be based on a blend of exogenous and indigenous knowledge.
- Integration with community-based organizations for extension activities, seed production and creating livelihood resource centers
- Consider policy on subsidizing hybrid seed, planting materials, fishlings and soil ameliorants like lime and bio-inputs.
- Formulate low premium crop insurance scheme suiting rainfed farmers and farming so as to ensure minimum livelihood security.
- To undertake these challenging tasks, the group suggested to upgrade Central Research Institute for Dryland Agriculture into a full fledged national institute not only to serve the rainfed regions of the country but also the other SAARC countries.

Budgetary Requirements during the XIth-Plan : Rs. 950 crores.

RECOMMENDATIONS OF SUB-GROUP ON "RAINFED AGRICULTURE" FOR RESEARCH AND EDUCATION PRIORITIES DURING XITH FIVE-YEAR PLAN

The Research and Education for sustaining Rainfed Agriculture programmes proposed to be taken up during the XI-Plan period at the ICAR were formulated in Sub-Group led by Dr. J.C. Katyal, Vice-Chancellor, CCS HAU, Dr. S.M. Virmani, Retd. Agro- Climatologist (ICRISAT), Dr. S.P. Wani, Principal Scientist (Watersheds), ICRISAT, Dr. N.K. Sanghi, Consultant (WASSAN) and supported by eminent scientists from different organizations, viz. CRIDA, CAZRI, NAARM, ICRISAT, ICAR – RCNEH (Annexure-I). The programme was coordinated by Dr. P.S. Minhas, ADG (IWM) and Member Secretary.

RAINFED AGRICULTURE – RESEARCHABLE ISSUES AND ACTIONS

Background

Indian agriculture spreads over 142 million hectares of cultivated land. Out of this 40% is irrigated and accounts for about 60% of the food production. Agriculture on remaining 60% is rainfed, which contributes 40% to total agricultural output. Rainfed agriculture is complex, diverse and risk prone. Despite technological inputs rainfed agriculture continues to depend on traditional methods of crop husbandry and livestock based farming systems. It follows fragmented precision methods, uses low levels of inputs and produces dismally poor yields. Left to nature and exposed to vagaries of monsoon, rainfed agriculture suffers from wide variations in water availability and instability in yields. Poor state of agriculture is complicated further by the dominance of tribal, small and marginal farmers, who have less land and more number of dependent household and livestock support system. They have very limited marketable surplus and hardly any livelihood security for eight out of 12 months of the year. Poverty and unemployment force them to migrate to cities in large numbers (~ 80% of the population) leaving behind infirm and elderly to look after their meager assets and livestock. Need is to contribute sustainably for substantial growth in a productive, income and employment generating stable agriculture leading to overall livelihood security of rainfed farmers.

Research on rainfed agriculture development has, therefore, to respond to mitigate risks by soil and water conservation including land treatment and mixed cropping/farming systems, avoiding high use of purchased inputs, reliance on crop varieties that mature earlier than the soil moisture exhausts and produce quality grain for household and fodder for cattle. Since farmers are many and farms are small, low volume high value agriculture needs specific emphasis. In all, rainfed agriculture needs to follow multi-institutional arrangement with a system perspective and problem solving orientation for higher productivity, greater income and more employment. Inclusion of farmers' perceptions and responses to ground realities of rainfed agriculture while conceiving and firming up research agenda is necessary.

Technology generation and dissemination processes for rainfed areas have necessarily to be different than those for the irrigated areas. Having said that it does not mean that the basic inputs of green revolution technology (i.e., water, fertilizer nutrients, high yielding varieties and precision agronomic practices) are irrelevant for rainfed agriculture. In fact, water, soil fertility, improved crop varieties and precision agriculture remain the best bet for the development of rainfed agriculture. However, heterogeneity of these regions in terms of rain and terrain characteristics on the one hand and farmers' needs and perceptions on risk-distributing conventional mixed farming practices, know-how on precision agriculture and capacity and confidence to invest in natural resources improvement on the other limit applicability, acceptance, sustenance and impact of these technological interventions. Ignoring these imperatives, wholly or partially, is at the root of non-replication of green revolution in rainfed agriculture. How to bridge the divide between the scientific and technological offerings generated through research and their acceptance by the dryland farmers is the foundation on which programme and activities during XI-Five Year Plan are proposed to be built. Past research findings and achievements have been liberally employed to strengthen this goal. The broad objectives of the rainfed agriculture programmes may be as follows:

i. Define agro-ecological conditions to capture nuances of water, soil and climatic heterogeneity, bio diversity and societal disadvantage to provide a strong basis for conventional agricultural intensification

ii. Identify and develop agro-ecological driven but farmer focused inputs (largely native) and internally (family and animal support system) and externally (consumers and markets) preferred outputs (produce quality)

iii. Lay greater emphasis on action research in real life farmers' field situations than depending wholly on scientific findings obtained from on-station research

iv. Move from single discipline or commodity centered research / development to system's focused problem solving research

v. Search for issues and actions that strengthen farmers' resolve to modernize conventional techniques and practices leading to productive, profitable and stable rainfed agriculture

Main Areas of Thrust and Recommendations

1. Water Conservation and Management

Success of rainfed agriculture is dependent upon adequate and timely availability of rainwater. Primary availability of rainwater occurs due to SW monsoon activity (June-September). It is generally received in about 20 rainy days. Events of heavy rainfall and no rain periods of varying length are of common occurrence. Although significant efforts and investments have been made on management and development of rainwater, the outcome has hardly been commensurate to that. Generally, value of introduced rainwater conservation technology is realized up to the point of demonstration and financial support from the government. Then there is hardly an instance where success story of rainwater conservation at one watershed showed automatic replication at another. Not only that, as the time passed the rainwater conservation structures also crumbled and washed away because beneficiary farmers were uncertain about the ownership and rationale of what was demonstrated and developed. With the failing rainwater conservation efforts and no possibility to provide life-saving irrigation, dangers of drought return year after year and uncertainty of success looms large as ever. While rainwater management, drought or no drought, remains the main plank of sustainable development of rainfed agriculture, maximum productivity and profitability will only occur, if each drop of harvested water is used precisely (through loss-minimizing use-effective practices) and efficiently (low volume high value crops).

Appropriate technology and government support apart, one clear lesson that emerges from the successful and sustainable experiences is the presence of a village based socio-stimulant (one who knows about the problems of farming and farmers and works as a non-profit seeking volunteer NGO). It was he who was responsible for motivating local action and community participation for initial rainwater harvesting and development and subsequent equitable sharing, management and maintenance. Anna Saheb Hazare in Maharashtra and Rajender Singh in Rajasthan are the well-known socio-stimulants who changed the face of rainfed agriculture. It is the dedicated individuals belonging to this class who provided necessary hand holding initially and then could sensitize and sustainably influence infusion of improved rainwater conservation, management and other technological options. Need is to identify, develop and involve such individuals, who are institutions by themselves. Recommendations emanating from the discussions are:

- Water is the most critical input for sustainable development of rainfed agriculture and watershed remains the unit of rainwater harvesting and management. Watershed based productivity and income enhancement with emphasis on rainfall and land capability-based farming, a mix of conventional as well as alternate land uses including multiple-diverse farming systems need to be implemented in all their aspects. Combined application of these interventions on watershed-based systems not only helps conserving soil, water and biotic resources but also provides insights into issues related to developing land use plans and equitable sharing of water resources. The research conducted during the past decade has demonstrated that fragile dryland areas dominated by poor people and infertile soils are more suited for livestock and perennial agriculture-based production systems.
- Watershed framework helps in recharging ground water resources on a landscape basis. However, reliable studies, particularly in the farmer's field situations, on the status of ground-water development are lacking. Long-term geo- hydrological experiments and hydrological monitoring may specifically be strengthened to facilitate community regulation against over-exploitation of ground water. A net-worked operational-scale watershed-based farming systems development programme, in partnership with the farmers, needs to be launched covering major rainfed ecologies. The selected watersheds should be large enough to represent real life situations.
- There is an urgent need to initiate comprehensive research leading to revival of the traditional water storage systems (e.g., tanks) and the utilization of defunct open wells as recharging structures for augmenting the ground water (and also to be used as open wells where possible) for life-saving or come-up irrigation (particularly for *rabi* crops). Location specific land capability-based methodologies stressing equitable and sustainable use of surface and ground water need to be evolved. Limited data on the conservation efficiency of such water revival systems are available for rainfed agricultural ecosystems. Incentives for adoption of low water requiring crops need to be ensured.
- It is proposed to select a handful of benchmark rainfed agro ecozones to study the revival impacts of traditional tank systems by, (1) desilting and use of silt for building soil fertility and useful biology, (2) control of perennial weeds / vegetation, and (3) repair of defunct wells. It is suggested that these experiments should be conducted on operational-scale watersheds and treated as long-term benchmark investigations to understand stability, productivity and profitability in response to various development inputs and technological interventions. Provision and installation of state of the art equipments, groundwater measuring, and sample collecting devices and hydro-meteorological monitoring facilities would be necessary. Economic, social and environmental response to various development interventions and application of most appropriate and efficient agricultural practices on multiple uses of water would be an integral component of this study. About 15 representative benchmark locations spread across 750-1100 mm rainfall zone of the country may be selected in the first phase. At each benchmark site, setting up of a state-of-the-art laboratory for natural resources characterization with additional manpower and suitable support systems is necessary.

Budget : Rs. 200 crores.

2. Soil Quality

Soils of rainfed tracts are generally of poor quality (low fertility, high erodibility, and susceptibility to loss of physical integrity). These soils have very weak buffering and resilience capacity. Their depth is shallow, physical state is fragile and fertility is marginal in most cases. In addition to universal deficiency of nutrients like nitrogen, insufficiency of nutrients like sulphur, calcium, zinc and boron is emerging across diverse rainfed areas. These soils also suffer from excess of salts (saline-alkali soils) in arid and semiarid areas and acids (acid soils) in sub-humid and humid regions.

Well-known methods of soil fertility management include liberal dressings with organic manures and/or treatment with chemical fertilizers. Virtues of organic manure in restoring lost soil fertility and building soil quality are unquestionable. But non-availability in quantities to accomplish that limits their usefulness. Generally, a rainfed farmer tends to concentrate organic manure use with cash crops, which he sells and earns money rather than on cereals, which he and his family eat. Result of this imbalanced attention is infertile soils, nutrient deficient crops and mal-nourished people and livestock. This vicious cycle is possible to break by promoting balanced use of chemical fertilizers. Level of fertilizer consumption is, however, dismally low since it follows development of irrigation.

Soil fertility management has, therefore, to necessarily depend upon organic manures. In situ field generation of organic manures (e.g., green manures raised non-competitively out of main season or on fallow parcels of arable land and through perennial vegetation) is one practicable option to maximize their availability. Research efforts on this aspect are grossly misplaced. Also, for organic input and infusion to take place, incentive to farmers adopting green manuring seems to be a pre-requisite. Costing on this could be part of norms on NWDPRA. A policy change in this direction is necessary.

Enhancing use efficiency of available quantities of organic manures to build natural resource quality for higher productivity is another viable strategy. Researchers' focus on enhancing use efficiency of organic manures is highly fragmented or a blatant miss. On this aspect, a cue need to be taken from the native wisdom, which is based upon concentrating application of whatever limited quantities of organic manures are available to the planted site in place of spreading on the entire field area. Developing efficient practices to infuse organic farming is a pro-farmer and pro-nature strategy that the researchers must popularize and strengthen. Following recommendations are made for restoring lost fertility and building resilience in soil quality.

- A comprehensive research programme on (i) diagnosis and management of secondary and micronutrient deficiencies and (ii) amelioration of excess alkalinity/acidity is of urgent priority.
- Extensive efforts for soil testing and suggesting measures to minimize imbalanced use of fertilizers and ameliorants is suggested to be taken up during XI Plan. In fact surveillance of drylands on area specific secondary- and micro-nutrient needs and inclusion of ameliorants specifically lime, are a typical miss of various soil management programmes.
- Apart from treatment with man made chemicals to restore lost soil quality, resource conservation practices and native biomass production and its application is another strategy in

that regard. Research on farmers' fields is needed to quantify the potential for biomass production and the economic feasibility of its incorporation.

- Developing holistic strategies on efficient use of off- and on-farm generated organic materials need to be a front ranking area of investigation and scientific inquiry. Suitable policy incentives need to be introduced to encourage on-farm biomass production and its incorporation as a means of improving soil fertility, biology and physical health. In addition, natural resource quality management in all its aspects will also focus on integrated nutrient and pest management approaches.
- The research-base on the minimal but most efficient use of chemical fertilizers (including micronutrients) should be enlarged. Carbon stocks would need to be monitored on a regular basis so that sequestering practices are followed like other recommendations on water conservation and input use.

Budget : Rs. 100 crores.

3. Organic Farming

The National Academy of Agricultural Sciences has suggested that rainfed eco-regions located in the northeast, tribal and hill areas (which are currently using little chemical fertilizers) are most suited for organic farming. Based on the recommendations of Planning Commission Task Force, a national program on organic production (NPOP) has been in operation since 2001. Accordingly, tribal rainfed areas ought to receive high priority under NPOP so that certified organically produced foods (which are value-added) become progressively available for export. Further, encouraging public-private partnership is expected to help in maximizing benefits from organic farming. The production systems, espousing organic farming practices to be successful, will have to be tailored to infuse mixed farming practices. Native biotic resources and livestock would be important components of such diversified farming systems, so that organic inputs are available on a regular basis. Thus the recommendations include:

- Research data on commercially successful organic farming particularly for the hilly regions of NE-India and arid regions are not available. An operational scale multi-location research programme in cooperation with SAU's by CRIDA needs to be established during the XI Five-Year Plan. In order to extrapolate point-studies into area action plans, authenticated data on quality of natural resources in response to various inputs and conservation practices under organic farming need to be generated.
- Establishing market intelligence research and linkages are of prime importance to succeed with organic farming. Specifically, sustaining and supporting an uninterrupted supply of all organic inputs will be a priority area of research studies. Employing total organic practices and processes is necessary to capture and meet the quality demands of export markets for certified organic produce. However, simplified organic farming practices may be evolved which should largely depend upon native inputs, bio-fertilizers, bio-pesticides, appropriate crop varieties/hybrids and other resource conservation systems. This approach is likely to attract and motivate resource-poor rainfed farmers by lessening the cost of cultivation without fall in productivity and profitability.

Budget : Rs. 50 crores.

3. Biodiversity Conservation and Genetic Enhancement

Since majority of the farmers are small and marginal landholders, they have hardly any marketable surplus - at least of food grain crops. In native set up, they generally grow food crops for household consumption and feeding their livestock. Apart from short duration, farmers adopt those varieties/hybrids, which satisfy organoleptic characters like quality of cooked product and taste and physical looks of their liking and generate fodder that fulfills the needs of their animal support system. Since conventional plant breeding identifies varieties on the basis of yield and duration, basic quality needs of small and marginal farmers therefore remain ignored. No wonder, varieties generated through conventional plant breeding have low acceptance and more importantly relatively short residence time of adoption. Often, residence time of conventionally bred varieties seldom stretches beyond mini-kit stage.

Apparently, need is to shift to participatory plant breeding (PPB), which involves farmers during identification and development of crop varieties. This methodology integrates needs, knowledge and experience of farmers and technological expertise of scientists during varietal development. Varieties bred through PPB and further evaluated through participatory varietal screening (PVS) create a natural ownership and ready acceptance by the farming community of the material developed. As a consequence of these virtues the PPB/PVS reduces the research lags (years to first adoption) by at least three years and minimizes adoption lags (years to reach potential levels of adoption) by maximizing adoption. Above all, adoption levels are maintained or are likely to increase, if seed supply measures up to demand.

Multiplication of seed of the PPB bred/identified varieties has also to be participatory and village based. Emphasis need to be placed on production of quality seed in place of certified seed. This is necessary since farmers are financially constrained to pay high premium on seeds of certified varieties. On the pattern of credit/market SHGs, seed SHGs may be established who can ensure quality seed production, storage and distribution. They will, however, require start up financial support on training, setting up of seed multiplication plots and structures for seed storage. This suggestion is justified since seed is among the predominant barriers to raise production and productivity of rainfed crops and benefits of its availability become visible immediately after adoption. As it exists, rainfed farmers remain deprived of State support on fertilizers and irrigation (power), which are stashed by irrigated farmers. It is also recommended that efforts to bring NGOs into the seed supply business is stepped up, drawing maximum from their experience in mobilizing community support and group action. They play significant role in identification, generation, assessment, refinement and diffusion of 'appropriate and right' technology.

Apart from farmer preferred varieties, site and crop-specific potential of hybrid technology needs to be further assessed and harnessed. Hybrids of pearl millet, maize, cotton and certain oilseeds have exhibited definite acceptance and promise in enhancing productivity and profitability. Need is to consider providing case incentives to those who adapt hybrid seeds.

In rainfed areas climatic risks are high. In addition to precipitation uncertainty, dangers of global warming are rising at an unprecedented pace; so are the hazards of these aberrant climatic phenomena. These are known to exert adverse influence on the sustenance of terrestrial biodiversity. Increasing dependence on plant varieties with narrow genetic base is another adversary of shrinking biodiversity. Chances for loss of biodiversity from dryland regions are high because of fragility of land and life. In view of this vulnerability, it is suggested that measures to conserve agro-biodiversity are developed and infused for halting any future loss and extinction on the one hand and use of elite biotypes for genetic enhancement for food and nutritional security on the other. Some specific suggestions on research and development in the area of biodiversity preservation and conservation and genetic enhancement are as follows:

- Promote conservation, registration and use of local land races of crops (including grass and tree species) through community participation (to be facilitated by NBPGR taking the help of NGO's, KVK's, farmers, grass root level workers).
- Focus on characterizing local-agro biodiversity in priority areas identified by the National Biodiversity Authority). Some of the suggested eco-regions are: (i) contiguous areas of the Deccan plateau (for millets, pulses and small ruminants), (ii) central Indian landscapes extending from Telangana in A.P. to southern Chhattisgarh (for rainfed rice, millets and poultry). Characterize unique biotypes for elite (e.g. high nutritive value, good cooking quality, stress tolerance etc.) characteristics.
- Encourage public-private partnership for enhancing genetic potential and acceptability of commercial varieties of crops / animals. However, long-term goal should be to build competence in the public system to use the native bio-diversity for genetic enhancement.
- Enlarge the concept of participatory plant breeding and participatory varietal selection for genetic enhancement in resource-poor, low input dryland agriculture environments. Emphasis needs to be on self pollinated locally accepted dominant crops. Also need is to develop village based and locally supportable seed storage methods and structures to maintain a creditable SRR.
- Intensify the use of molecular biology tools by introducing biotic and abiotic stress tolerance and infusing organoleptic characters in rainfed crops. Specific programme for exploring indigenous plant types that inherently possess genes responsible for higher nutritive value (more protein, micronutrients etc) need to be identified and used for boosting nutrients in rainfed crops. In the near terms emphasis should be on conventional breeding methods to bring the high nutrition gene into the commonly grown coarse cereals. Development and introduction of suitable hybrids of short duration maize (single cross), pulse and oilseed crops will be a highly rewarding strategy - both from economic and social angle. Extend direct or indirect support for adoption of hybrids like subsidy is extended to those who adapt HYV seeds.
- Initiate a major project for studying below ground biodiversity in the stressed rainfed agricultural eco-systems. Apart from direct contribution to plant nutrition, another goal should be to build soil physical health and maximize carbon sequestration for minimization of global warming. Simultaneously efforts should be launched for bio-remediation of heavy metal-polluted areas and reclamation of acid/alkaline wastelands.

- Establish a research network on soil metagenome characterization from major rainfed production systems with the main focus of prospecting for novel genes for stress tolerance and high nutrition.

  Budget : Rs. 150 crores.

5. Integrated Farming Systems and Alternate Land Uses

Guided by natural resource limitations and with changing demand portfolio of various commodities diversification of the farming systems has become imminent in drylands. Lands constrained to support regular arable farming and those under current fallows can be utilized for raising of energy plantations, which are of topical relevance. Research strategies for areas receiving less than 500 mm rainfall should be primarily livestock based, 500-700 mm crop-livestock farming systems, while areas between 700-1100, crop – horticulture – livestock – poultry based and those with > 1100 mm should have enterprises based on multiple use of water (water for inland fisheries, aquatic plants and irrigation of arable crops/horticulture). Institutional and social mechanisms for improvement and utilization of CPRs for fodder production should receive high priority. Increasing nutritive value of feeds and fodders, improvement of indigenous breeds and disease control are important researchable issues to succeed with integrated farming systems. Institutionalization of a special policy on regulated grazing and sustenance of grazing lands will go a long way in maintaining soil-livestock continuum. Different farming systems modules for small and marginal farmers need to be developed and validated both on-station and on-farm so that the key drivers of high income generation in each of the modules can become the strategic interventions in development programmes across diverse agro-eco conditions. Dryland horticulture, medicinal, aromatic and seed spices, and fuel, oil and wood yielding trees and bushes have immense potential to augment the income of farmers particularly in areas receiving more than 700 mm annual rainfall. Significant possibilities exist to enhance income through processing and value addition. Concerted research efforts are required to improve the productivity of these crops both as sole crops and in different intercropping systems.

Budget : Rs. 100 crores.

6. Farm Mechanisation

Precision agriculture - promoting timeliness of agricultural operations, seed priming for maximizing germination and initial quick start and minimizing damage from soil borne pests/weeds, maintaining optimum plant population and their geometry and intercropping having pre-designated row ratios of companion crops – is one among the prominent strategies to stabilize and sustain growth of rainfed agriculture. Design of tools and machinery for conservation tillage, weed control, loss-free harvesting, primary processing and value addition at farm level will further contribute to precision agriculture and enhanced farmers' income. In pursuance of these goals, small-scale mechanization becomes critical for timeliness and precision of various agricultural operations and reducing cost of cultivation. Hence, a continued thrust, on designing, developing and popularizing farm implements that can be used by small holders is necessary. Public-private partnership for indigenous production ensuring local availability will go a long way in furthering mechanization of rainfed agriculture. Since farms are small and farmers are poor, many among them may not be able to invest even in low cost implements. Therefore, to promote tenets of precision agriculture and simultaneously enhance livelihood opportunities for rural youth, setting up of custom hiring centres at selected *Panchayats* need to be explored on pilot basis.

Budget Rs. 150 crores.

7. Training and Education- Use of ICTs'

Over the years, a large volume of knowledge and know how on the productive, profitable and stable management of rainfed agriculture has been developed. Despite the availability of knowledge and know how on the ways rainfed agriculture has to be managed and developed, that knowledge and know how has not been and is not being applied in effective manner. This concern is justified since rainfed agriculture continues to depend on traditional methods of crop husbandry and livestock based farming systems. Its fate is left to nature and exposed to vagaries of monsoon. As a consequence, benefits of whatever technology is adopted pendulates between climatic risks i.e., between adequacy and inadequacy of precipitation. Apart from rainwater risks, concerns of dryland farmers on their needs and perceptions, land tenancy laws, credit constraints and poor market links are among the causes contributing to poor adoption of rainfed technologies. Inadequate and inappropriate technology transfer methods and resultant ignorance of farmers on new knowledge is at the root of poor state of rainfed agriculture. In addition to working jointly with farmers to find solutions to problems faced by them in accepting and adopting recommended techniques and technologies, education and training are seen to strengthen their resolve to modernize conventional farming techniques and practices leading to productive, profitable and stable rainfed agriculture. Not only that, education and training are also expected to encourage more mobility, expand opportunities and decrease the dependence on agriculture as the sole source of livelihood for people in rural areas. These positive outcomes help farmers escape poverty by raising their output as farmers in farming and as workers in off-farm employment. Thus, building knowledge and skill economy through education and training is the fundamental step to harness a vast array of opportunities for employment leading to livelihood security. What is needed is to; (i) build capability and competence to undertake high intensity agricultural activities like mixed farming emphasizing multiple and vertical use of land, water and vegetation and (ii) create skill and knowledge empowered individuals who can diversify conventional farming through low volume high value agriculture or who can initiate off-farm agri-ventures to create employment for self and others. In pursuance of these objectives, it is necessary to invest in human capital through education and training for cultivating knowledge and skills to broaden horizons of farming for more income and employment. Initiatives on agricultural education and training leading to spread of off-farm vocations is far more crucial in rainfed regions where farming is seasonal and unemployment is endemic. Major aims of the programmes on farmers education and training for in- and out-farm vocations are as follows:

- To identify employable vocations and skills for which there is general shortage
- To impart training in identified vocations and skills as will enable rural youth to take up self-employment
- To inspire prospective young entrepreneurs to learn and up-skill competence in modern techniques and methods of farming

- To enable youth to set up and successfully run micro-enterprises in conformity with local skills and demands for goods and services

It is proposed to strengthen and equip existing KVKs to provide vocational training in the areas listed above. In order to succeed in this initiative, it will be necessary to provide training to research and extension staff to build their competence as master trainers. It is also aimed to create a class of socio-stimulants who will champion the cause of sustainable development of rainfed agriculture with watershed as the operational unit. Such individuals should be given specific reward and service incentives.

Training and extension is also necessary for farmers getting more and more integrated with open markets, information flow on input and output prices. Also access to information and knowledge on consumer preferences is necessary to link small farm holders with markets. Rainfed farmers also need continuing information and advisories on weather so that they are able to manage their crops and resources most efficiently. Flow of information has to be: (i) fast, continuous and latest, (ii) available any place any time, (iii) reaching as many farmers as possible and (iv) effortlessly accessible and easily usable. Modern ICT tools and techniques can meet these multifaceted demands and provide a link to GOI supported common service centres. In order to succeed there is a need to build ICT mediated village knowledge economy by developing institutional mechanisms that involve and overarch the information demands and activities of all stakeholders (e.g., research institutions, development departments, farmers clubs, self help groups and local and regional markets.

Budget Rs. 200 crores.

8. **New Paradigms for Development of Rainfed Areas**

The rainfed areas have been by-passed by the green revolution witnessed in the irrigated areas of the country. Here are some key features of suggested new paradigms for the development of rainfed areas:

- Emphasize production systems in place of narrow component/disciplinary considerations and technology options should be based on a blend of exogenous and indigenous knowledge.
- Participatory approaches should be embedded in formulating strategic research extension plans for technology generation, assessment and adoption.
- Extension systems should be integrated increasingly with community-based organizations.
- Launch special programme on sustainable development of wastelands through integrated land use options supporting the cause of landless poor and their animal support system.
- Establish seed, grain, fodder and other common interest groups including credit self-help groups.
- Encourage community-based livelihood resource centers, which may become self-reliant in due course.
- Consider policy on subsidizing hybrid seed, planting materials, fishlings and soil ameliorants like lime and bio-inputs.

- Formalize user rights over common property resources in favour of multiple stakeholders.
- Regulate community based development and management of ground water resources
- Formulate low premium crop insurance scheme suiting rainfed farmers and farming so as to ensure minimum livelihood security.
- Upgrade the status of CRIDA to that of a National Research Institute for providing technical support and hand holding for SAARC and African countries through ICAR and CGIAR systems.

All the above new paradigms suggested need a socio-economic research base.

Total Budgetary Requirements during XI-Plan

Sl.No.	Thrust Area	Budget (Rs. in crores)
1.	Water Conservation and Management	200
2.	Soil Quality	100
3.	Organic Farming	50
4.	Integrated Farming Systems and Alternate Land Uses	100
5.	Biodiversity Conservation and Genetic Enhancement	150
6.	Farm mechanization- ICT's	150
7.	Training and Education – ICT's	200
8.	New paradigms for development of rainfed areas	NA
	Total	**950**

List of Contributors of the Sub-Group on "Rainfed Agriculture"
For formulation of XIth- Five Year Plan Priorities

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a. Committee Members

1. Dr. J.C. Katyal, Vice Chancellor, CCS HAU, Hisar and Chairman.
2. Dr. S.M. Virmani, Ex.Agroclimatologist, ICRISAT, Hyderabad
3. Dr. N.K. Sanghi, Consultant, WASSAN, Hyderabad
4. Dr. S.P. Wani, Regional Coordinator, ICRISAT, Patancheru, AP
5. Dr. P.S. Minhas, ADG(IWM), ICAR, New Delhi and Member Secretary

b. Special Invitees

6. Dr. Y.S. Ramakrishna, Director, CRIDA, Hyderabad
7. Dr. V.M. Mayande, ZC, Zonal Coordinating Unit V, Hyderabad
8. Dr. K.P.R. Vittal, Project Coordinator, AICRPDA, Hyderabad
9. Dr. G.G.S.N. Rao, Project Coordinator(Agromet), CRIDA, Hyderabad
10. Dr. B. Venkateswarlu, Head, DCS, CRIDA, Hyderabad
11. Dr. G.R. Korwar, Head, DRM, CRIDA, Hyderabad
12. Dr. K.V. Subrahmanyam, Head, TOT, CRIDA, Hyderabad
13. Dr. Y.V.R. Reddy, Head, SDA, CRIDA, Hyderabad
14. Dr. J.V. Rao, Head, Agroforestry Cell, CRIDA, Hyderabad
15. Dr. M. Osman, OIC, RCMU, CRIDA, Hyderabad
16. Dr. G. Subba Reddy, Principal Scientist, CRIDA, Hyderabad
17. Dr. G.R. Maruthi Sankar, Prl.Scientist, CRIDA, Hyderabad
18. Dr. S. Desai, Sr.Scientist, CRIDA, Hyderabad
19. Dr. I. Srinivas, Sr.Scientist, CRIDA, Hyderabad
20. Dr. C.A. Rama Rao, Sr.Scientist, CRIDA, Hyderabad
21. Dr. S.S. Balloli, Sr.Scientist, CRIDA, Hyderabad
22. Dr. K. Srinivas, Sr.Scientist, CRIDA, Hyderabad
23. Dr. J.V.N.S. Prasad, Sr.Scientist, CRIDA, Hyderabad
24. Dr. Y.G. Prasad, Sr.Scientist, CRIDA, Hyderabad

7. MECHANIZATION, POST HARVEST PROCESSING AND ENERGY MANAGEMENT

SUMMARY

1. In formulating its recommendations, the Sub-Group kept in view the need to
   - achieve sustainable growth in land, livestock and fisheries productivity,
   - reduce production and processing costs,
   - reduce production and post harvest losses,
   - upgrade value addition technology to achieve high quality products, and
   - develop technology for economic utilization of production agriculture and processing by-products & waste.

2. The Sub-Group emphasized that the engineering/technology intervention to achieve the above listed objectives should be so made as to ensure access for all land holding size groups of farmers and land less workers to the benefits accruing from these interventions.

3. For maximizing the returns from the R&D programmes of agricultural mechanization and post harvest technology development, the focus during to XI plan should be on the following major commodity groups

a.	Cereals	:	rice, wheat, maize and bajra
b.	Pulses	:	gram, tur (arhar) and soybean
c.	Oil seeds	:	groundnut, rape seed and mustard
d.	Cash crops	:	sugarcane and cotton
e.	Vegetables	:	potato, onion, tomato and turmeric
f.	Fruits	:	mango, banana, citrus and apple
g.	Plantation crops	:	coconut

4. The focus in agricultural mechanization R&D should be on
   - timeliness of operation, and
   - precision in the use and application of inputs (seed/ seedlings, energy, water, fertilizer, plant protection chemicals). **"Precision Agriculture" in Indian Context should connote quantitative, spatial and temporal precision in the use of inputs to increase utilization efficiency and minimize ill effect on product and environment.**

5. The focus in post harvest processing R&D should be on
   - reduction of losses in quality and quantity of harvested product through primary processing, proper storage and handling,
   - development of technology and pilot plants for processed plant and animal products suitable for adoption and setting up in production catchments without compromising on standards particularly in respect of food quality and safety, and
   - improvement of product quality and hygiene in rural agro-processing units.

6. In order to achieve the objectives of R&D programmes of agricultural mechanization and post harvest processing and obtain timely and useable outputs, following is recommended:

a) The major R&D projects should be considered for implementation in mission mode to make use of the expertise and facilities at ICAR Institutes and SAUs.
b) A multi disciplinary team is likely to be required at each participating institution to implement a major R&D project. The teams should be identified and involved from the stage of project document preparation.
c) Scientists should be encouraged to specialize in the mechanization/ processing of one or two major commodity groups.
d) Each team should interact with teams/groups working on other aspects of the same commodity in other ICAR Institutes.
e) Each team should identify its priorities keeping in mind the basic objectives listed under 1.
f) Each team should use the best available hardware/process and build on it to achieve the output of planned specifications.
g) Use of the expertise and facilities available at specialty institutions on consultancy /contract basis should be encouraged.

7. Work stress, safety and comfort of workers, particularly of women, should receive proper consideration in the design and development of hardware and processes for mechanization and post harvest processing.

8. Management of energy and machinery in production agriculture and process management in post harvest processing need more attention to obtain better/ more output at lower cost. Start should be made with a major project on farm energy and machinery management for one of the commodity groups during the XI five year plan. Multi farm management of power and machinery, important for providing access for small land holders to mechanization, should be given priority.

9. Mechanization of horticulture has made limited progress. Two major R&D projects should be launched in XI five year plan, one on mechanization of horticulture in plains and the other on mechanization of horticulture in hill region. Development of prime movers should be an integral part of these two projects.

10. Three new areas of R&D are recommended. These are:

a) **Bio-residue management** to develop hardware and package of practices for recovery, densification, handling, transport and storage of agricultural and processing waste so that these become available in sufficient quantity and at reasonable cost for further utilization.
b) By using its vast resources of plant and animal products, by-products and wastes, the rural sector has the potential to develop immunity from the impending energy crisis due to depleting hydrocarbon resources. It can also mitigate the energy problems of

transport sector by producing and supplying alternate liquid fuels. A major initiative needs to be taken in XI five year plan through an R&D programme with the objective of producing **Biofuels** like producer gas, biogas, bio-oil, plant oils and their esters (bio-diesel), ethyl alcohol and hydrogen using thermo-chemical and biological conversion routes. There has been a break through recently in the conversion of dry crop residues into methane and compost. Same kind of development needs to be targeted to obtain alcohol from cellulosic by-products and wastes. This requires

- development of core strength (programmes, expertise and R&D facilities), at least as a directorate, either at Central Institute of Agricultural Engineering, Bhopal or at Central Institute of Post Harvest Engineering and Technology, Ludhiana. Manpower available in the Division of Agril. Energy and Power and AICRPs on Renewable Energy Sources and Utilization of Animal Energy may be pooled to ensure sufficient manpower in Directorate,
- net working of the core group with the institutions having programmes in the area of bio-energy, and
- interaction with institutions engaged in the development of new technologies like fuel cells and micro turbines.

c) A major project should be taken up on the **application of environment control techniques** to enhance quality and yield of high value crops (protected cultivation) and improve comfort level in animal shelters.

11. A highly trained manpower, well informed on the latest developments and current research programme in the relevant areas is the core requirement for successful implementation of the recommended programmes and projects. The young scientists and engineers at the Institutes and in the coordinated projects should have the opportunity to work for 3 months to 1 year at selected institutions of advanced research to keep up with new research methods and interact with reputed counterparts in these institutions. This calls for a comprehensive training programme for the young scientists. They should be required to work in the area of their respective training/specialization for 3-5 years after the completion of training.

12. The procedure for transfer of technology developed at the Institutes and in the coordinated projects should be standardized keeping the following in view

- test procedures for testing each type of equipment/ process and for the system as a whole should be developed (if not already available) and used uniformly,
- minimum level of performance to allow transfer of technology for commercialization should be stated for all equipment and processes,
- the technology recipient, group or individual, should have the required facilities, expertise and resources to commercialize the technology, and
- technology generating Institute should commit technical support and guidance to facilitate technology promotion and acceptance by end user.

13. Engineering inputs are invariably required to convert results of scientific research into usable technology. For example, the practice of minimum or zero tillage could be integrated into wheat production system only after a zero till drill became available. The engineering inputs in most cases have to be crop and agro-ecology specific. This requires a high level of engineering capability at each commodity center. This may not be practical in the near future. Therefore a closer working arrangement should be developed between the engineering units at the commodity institutions and the Central Institute of Agricultural Engineering/Central Institute of Post Harvest Engineering and Technology. To make a start, the engineers at ICAR institutions and their counter parts in the two Central Institutes (CIAE and CIPHET) should get-to-gather to formulate their programmes of research and development for the XI Plan and meet each year to monitor and incorporate improvements in these Plans.

14. The Sub-group recommends a plan **allocation of Rs.300 crore during the XI five year plan** for the implementation of its recommendation. In case of reduced allocation, the suggested programme should also be curtailed to avoid imbalance between the committed programme and the financial resources. Out of this at least **Rs. 50 crores should be earmarked for competitive grants**.

15. There is an urgent need to synchronize the agricultural engineering education with the expectations of agriculture and the progress in engineering in order to meet the emerging R&D challenges. A committee may look into the ways and means for this up-gradation and a sum of **Rs. 100 crore may be earmarked during the plan to implement the recommendations of the committee**.

16. A realistic plan **for IT empowerment for the Council and the NARS** has been proposed with a **cost estimate of Rs. 500 crore**. While the activity is indispensable, the allocation of funds will determine the extent of empowerment possible during the XIth Plan period.

1. INTRODUCTION

The sub-group on Mechanization, Post Harvest Processing and Energy under the XI Plan Working Group for Agricultural Research and Education of Planning Commission, Government of India was constituted vide O/O No. 5(5)/2006-PIM dated 10-7-2006 . The sub-group under the chairmanship of Dr. BS Pathak, Director, Sardar Patel Renewable Energy Research Institute, Vallabh Vidyanagar, Gujarat has Dr. AM Michael, Dr. Anwar Alam, Dr. NSL Srivastava and Dr. Pitam Chandra as members with Dr. Pitam Chandra serving as member-secretary of the sub-group. The sub-group met twice to deliberate and finalize the report. The Terms of Reference of the sub-group are given in Annexure 1 and the Proceedings of the two meetings are given in Annexures 2 & 3.

While finalizing the report of the sub-group, cognizance has been taken of the Xth Plan thrust areas, progress made by the institutes and schemes under the subject matter Division of the ICAR, recent developments in agriculture and engineering, socio-economic & environmental challenges faced by agriculture, and vision for future. A summary of major achievements under the ICAR programmes in the areas of mechanization, post harvest processing and energy is given in Annexure 5.

There has been a paradigm shift in the Indian agriculture scenario during the past five years. The protection that Indian agriculture enjoyed by virtue of assured domestic market has vanished due to the dismantling of quantitative restrictions on imports in the wake of globalized marketing regime. In order to compete with the imported agricultural commodities, the Indian products have to be cost competitive and of high quality. The western models of achieving cost and quality competitiveness in agricultural production and post harvest processing are not readily applicable due mainly to the size of land holdings, the number of people dependent on agriculture in this country and inadequate supply of power. Indian agriculture has never enjoyed unrestricted fuel and electrical power supply for production and post harvest practices leading to restricted farm mechanization and on-farm as well as off-farm value addition. The sharp rise in hydrocarbon fuel prices in the recent years has further added to the difficulties in sustaining development in the rural sector

There has been a clear consumer preference for natural, free from synthetic chemicals, pure and healthy products leading to the revision or even complete overhaul of production and processing procedures. Quality and safety aspects of agricultural and food products along with the cost factors have become the guiding principles for sustained marketing. Labeling and traceability on packaged items are becoming essential for organized marketing. Colors are important but natural colors are preferred. Flavors and fragrances still tickle human senses but those derived from natural sources command premium. In addition to just meeting the gross human nutrition, if the food could double-up as health supplement and medicine, consumers are ready to pay more.

The fast changing national and global agriculture scenes provide immense potential for growth in Indian agriculture sector, especially, considering where we are at present. Our yields in most commodities are lower than even world averages. Our production and post harvest operations require considerable realignments for efficiency. Our quality assurance mechanisms for both inputs and outputs need to be in place. Adequate public and private finances need to be invested for infrastructure. Above-all, farmers and agricultural workers need to be knowledge empowered for efficiency and quality.

The XIth Plan Approach paper of the Planning Commission adequately echoes the concerns of the present day Indian agriculture. The possible action plan among other things does talk about increasing farm mechanization, post harvest processing, gender related issues of women workers, by-products utilization and utilization of surplus biomass for energy and power.

A note emanating from PMO on **Increasing Productivity Growth Rate in Agriculture** presents a 10 point action plan. Farm mechanization is one of these ten points targeted to achieve the growth rate. The note, specifically, makes a strong case for increased use of farm machinery and equipment for timely operations along with the logistics of large scale manufacturing and easy availability. This is achievable through promotion of farm implement manufacturing, large scale demonstrations and effective financial incentives. Region and commodity wise implement packages are being developed by the ICAR. It is possible to increase the productivity by 10- 15% by way of higher input use efficiency through appropriate mechanization and reduction in post harvest losses. The availability of equipment for mechanization should, however, be ensured for all farmers through custom-hire, cooperative farming or any other mechanism.

The PMO note considers the supply of bio-control agents and bio-pesticides as one of the bottlenecks. High quality and adequate quantity availability of such bio-pesticides, bio-control agents and even bio-fertilizers could be ensured if bio-manufacturing of these commodities is promoted, preferably near the production catchments. For example, vermi-compost production needs to be mechanized and automated for both quality and quantity. Similarly, the production of other bio-compounds would need to be put into commercial production mode.

The note indicates the need to intensify efforts in the area of Bio-fuel. In addition to diverting surplus agricultural production for meeting the fuel requirements, it is important that surplus agro-residues are utilized for bio-fuel production and establishment of decentralized power generation systems to meet the power and energy needs of agricultural production and processing. According to current estimates, about 125 million tonnes of agro-residues is available for such activities.

Linking farmers to markets (LFM) is essential for both input supply as well as sale of output. This linking can go a long way in improving the profitability of production and post harvest processing activities and reducing undue post harvest losses. Cooperatives and self-help-groups need to be promoted along with the participation of organized private sector.

Major thrust on Horticulture has been envisaged in the note since it addresses several issues collectively including nutritional security, high growth rate, export earnings, employment opportunities, etc. Quality of produce and subsequent post harvest management & value addition are keys to profitability. Protected cultivation technologies in the form of mulching, low tunnels, greenhouses etc increase both productivity and quality of produce. Adequate emphasis on the development of location and crop specific technologies and their large scale adoption is essential.

Livestock sector needs considerable inputs for mechanization and quality assurance both for feed as well as animal husbandry. While crops sector has received mechanization inputs, livestock and fishery sectors requires much more attention in near future.

Improved efficiency through matching the input delivery with requirements in time and space coordinates is now possible through IT enabled electronics and mechanical systems, popularly called as precision agriculture, for precise assessment of demand, metering, and placement mechanisms. An in-house multidisciplinary R&D team with a definite time frame needs to be organized for phased growth in this sector.

The most important is the knowledge empowerment of farmers and entrepreneurs through Agricultural Training Institutes with each farmer monitored on real time basis. The present infrastructure of KVKs is inadequate to meet the skill development activity of the farmers. Either the number of KVKs is considerably enhanced or they are complimented with Agricultural Training institutes to ensure customized attention to each farmer. What has been outlined in the note needs to be implemented, monitored, analyzed and mid course corrections made. Development of agriculture and agro-based industry in India is of paramount importance for long term sustainable growth.

The recent success of zero till drill in ensuring about Rs. 3000/ ha saving in the cost of cultivation of wheat in rice-wheat production system has been well received. Although zero till drill had been developed three decades ago, the equipment could gain importance only recently because of changed perceptions in the globalized economy. Several other similar agricultural machines are now available for different crops and regions that require effective demonstrations and promotion extensively to make the Indian crop production system more remunerative

To achieve cost competitiveness, the efficiency of inputs application is being increasingly targeted since it leads to not only lower cost of production but also healthier environment. It is a common knowledge that seeds, fertilizers, agro-chemicals, water and energy get wasted on account of poor application processes and equipment. Although the concern had been realized even 35 years back, the possible solutions were either not available or there was little effort and incentives to adopt them. Remote sensing, wireless communication, information technology and electronics today permit real time assessment of actual demand for inputs and precise applications to optimize the application and subsequent use of the inputs. The development and expanding use of laser guided levelers in paddy cultivation has been well received. Equally important is the growing awareness of the environmental issues and resource depletion problems created by unscientific use of inputs and the increasing cost of energy. A few specific areas of contemporary concern are being mentioned below with a view to underscore the need for addressing them during the XIth Plan and beyond.

Agricultural and Food Nanotechnology

Recent emergence of agricultural and food nanotechnology promises further improvements in input delivery and process effectiveness. A number of projects around the world are exploring the use of nano-particles/ nanotechnology on the farm for purposes other than pesticides - from enhanced photosynthesis to better germination and soil management. Applications of nanotechnology in agro-processing sector are many. Some of the relevant developments have been summarized below for a quick reference. A detailed note, however, is contained in Annexure 4.

Table 1: A few potential nano-technological interventions in agriculture sector

S. No.	Application	Brief description
1	Buckyball Fertiliser	A method of producing ammonia using buckyballs for farm use
2	Seeding Iron	To improve the germination of tomato seeds by spraying a solution of iron nanoparticles on the fields
3	Soil Binder	A nanotech-based soil binder as a quick-setting mulch
4	Electrospinning Nanofibres	To produce low cost, high-value, high-strength fiber from a biodegradable and renewable waste
5	Clay Nanoparticles to Improve Plastic Packaging for Food Products	Clay nano-particles are dispersed throughout the plastic film and are able to block oxygen, carbon dioxide and moisture from reaching fresh meat or other foods
6	Embedded Sensors in Food Packaging	Embedded sensors can detect substances in parts per trillion and would trigger a colour change in the packaging to alert the consumer if a food has become contaminated or if it has begun to spoil
7	Nanotech Bioswitch	A nanotechnology based bioswich to release a preservative if the food within begins to spoil
8	Smart treatment delivery system	A smart treatment delivery system could be a miniature device implanted in an animal that samples saliva on a regular basis. Long before a fever develops, the integrated sensing, monitoring and controlling system could detect the presence of disease and notify the farmer and activate a targeted treatment delivery system.
9	Computerized control of environment	With many of the monitoring and control systems already in place, nano-technological devices for Controlled Environment Agriculture (CEA) that provide "scouting" capabilities could tremendously improve the grower's ability to determine the best time of harvest for the crop, the health of the crop and questions of food security such as microbial or chemical contamination of the crop.
10	Nanoparticles to Speed Up the Growth of Fish	Young carp and sturgeon exhibited a faster rate of growth (30% and 24% respectively) when they were fed nanoparticles of iron.

Precision Agriculture

Precision Agriculture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving production and environmental quality. The success in precision agriculture depends on the accurate assessment of the variability, its management and evaluation in space-time continuum in crop production. The practical feasibility of precision agriculture has been intuitive, depending largely on the application of traditional agricultural recommendations at finer scales. The success of precision agriculture has been quite convincing in crops, livestock and fisheries sectors. Successful implementation of precision agriculture depends on numerous factors, including the extent to which conditions within a field/ population are known and managed, the adequacy of input recommendation and the degree of application control.

The enabling technologies of precision agriculture can be grouped into five major categories: Computers, Global Positioning System (GPS), Geographic Information System (GIS), and Remote Sensing (RS) and Application control. A precision agriculture programme may include one or more of these technology groups to deal with variability of the soil resource base, weather, plant genetics, crop diversity, machinery performance and physical, chemical and biological inputs used in crop production.

It is usually presumed that precision farming is only applicable to large holdings as seen in the developed countries. Flexibility is an inherent feature of precision farming and hence type and size of farms are no hindrances in the adoption of a well-designed precision farming system. It offers the opportunity to improve agricultural productivity and product quality. Timeliness is one of the built-in advantages of precision farming and helps to maintain punctuality despite local and farm level variability in sowing, application of fertilizers and pesticides and harvesting.

Food Safety and Quality

Quality and safety issues have never been as important as they are now. Constant vigil and fool-proof procedures are required to guarantee the desired level of quality and safety of inputs, application processes and outputs. Formulation of standards, high speed monitoring of quality, risk analysis and advance warning systems are required to protect people against trans-national contaminations, diseases and pests. Ensuring quality and safety parameters through the production and processing chain ultimately leads to consumer satisfaction and higher returns to everyone through the value chain. Food safety & quality parameters for each agricultural produce need to be specified.

Food quality in agricultural production is influenced by the quality and quantity of inputs, genotypes, protocols and the environment. Therefore, it is important that the produce quality parameters are linked with the independent production parameter to devise suitable strategies for quality assurance in the production processes. Besides identifying the quality parameters for different commodities, adequate quality assessment infrastructure would need to be put in place. The knowledge, thus, obtained will be utilized to fine-tune the production packages so that the quality is also assured in addition to the quantity of the produce. The knowledge will also provide the feed back for reorientation of genetic improvement and agricultural production programmes.

Food quality and safety parameters undergo significant changes during the post harvest management, processing and value addition activities. The parameters of quality & safety appropriate for different commodities are essentially required to be mapped through out the value chain and correlated to the management and processing parameters for understanding the causes and effects of the variations. While the knowledge should lead to the selection of practices and equipment to reduce the loss in quality and maintain safety of the food, it will also permit the development of the quality augmentation processes.

The complete knowledge on food quality and safety parameters through the agricultural production & processing activities will permit the formulation of scientific standards and policies for food trade. Therefore, a programme may be envisaged to cover raw & processed food grains, fruits, vegetables, meat, milk and milk products, eggs and marine products where food safety and quality is investigated through the production and processing activities.

Functional Foods and Nutraceuticals

Food is being increasing perceived by enlightened customers to provide nourishment to body, mind and soul. Wholesome food ensures that health related expenses are greatly reduced and the quality and performance of human life improves. Agricultural production and processing activities need to take cognizance of these contemporary societal changes that also promise higher income to the farmers and agro-processing entrepreneurs because consumers derive additional benefits.

A ***functional food*** is similar in appearance to, or may be, a conventional food that is consumed as part of a usual diet, and is demonstrated to have physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions, i.e. they contain bioactive compound. A ***nutraceutical*** is a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with foods. A *nutraceutical* is demonstrated to have a physiological benefit or provide protection against chronic disease. Functional Foods/Nutraceuticals may be

- **(i)** **Basic Foods** (carrots containing the natural level of the anti-oxidant beta-carotene and processed foods - oat bran cereal containing the natural level of beta-glucan);
- **(ii)** **Processed Foods with Added Ingredients** (calcium-enriched fruit juice);
- **(iii)** **Food enhanced to have more of a functional component via traditional breeding, special livestock feeding or genetic engineering (**tomatoes with higher levels of lycopene , oat bran with higher levels of beta glucan, golden rice);
- **(iv)** **Isolated, purified preparations of active food ingredients in dosage form (**isoflavones from soy, omega-3 from fish oils)

There is a need for efforts to identify, produce and process such functional foods and nutraceuticals. The relevant issues are: identification of naturally occurring basic foods as functional foods, development of fortified processed foods, need and special techniques for production of functional foods, and processing for extraction/ purification of active food ingredients.

Breeders from Crops, horticulture, animal science and fisheries need to be involved in the programme along with biochemists, microbiologists, biotechnologists and agril./ food processing engineers.

A short term and a long term vision to harness the potential benefits of the production and processing of functional foods and nutraceuticals may be developed and an implementable programme may be finalized. We may begin with the characterization and documentation of products available under category I above and prioritizing efforts under the other three categories with well identified target groups, stakeholders and time frames in a network mode.

Biomanufacturing

Biomanufacturing, the making of biological products from living cells, is an essential link in the chain to make the bio-engineered or genetically modified material of desired quality specifications available in adequate quantities. A biomanufacturing programme is an innovative vehicle for the delivery of much needed expertise and manufacturing capability to early stage biotechnology product development programmes. Such a programme leads to the development of entrepreneurship as well as HRD to support the manufacturing activities.

The present agricultural biotechnology programmes in India need to be expanded to include mass production of developed products. These scaling up operations for mass production require engineering inputs. Even tissue culture programmes in the country lack the scaling up efforts. There is a need for a strong Bio-manufacturing programme in India, be it for biofertilizers, biopesticides, bio-control agents or any other bio-engineered product.

Agricultural Residue & Byproduct Management

Agricultural Residues and processing byproducts are presently used for various purposes such as fodder, rural domestic fuel, construction material for rural housing, packaging, substrate for some agro-industries, etc. With every one tonne of usable produce, almost two tonnes of residues are generated through photosynthesis. With increasing production, the amount of crop residues generated each year has increased and a significant portion of this residue becomes surplus. Subsequent post harvest processing and value addition activities for the usable portion create byproducts that do not find much economic and environment-friendly uses. Proper management of this biomass for the fuel and non-fuel purposes has been necessitated by economic and environmental considerations and requires adequate R&D attention.

It has been estimated that around 70 Mt of residues of rice, wheat, sugarcane, groundnut, and mustard and cotton crops is burnt every year in 9 states (Punjab, Haryana, UP, Rajasthan, MP, Maharashtra, Karnataka, TN & AP). Besides, around 78 million tonnes of biomass is available from various agro-industries. Using a modest conversion efficiency of 20%, half of the crop residues burnt in the fields and the unused processing waste can sustain generation of 6000 MW power in rural sector. Besides, 3500 MW potential is available through co-generation of bagass in about 500 sugar mills.

While agriculture generates such huge amounts of surplus biomass, it starves of thermal and motive power for production and post harvest processing activities. Liquid fuels for the tractors, power tillers and irrigation pumps are required to meet the growing demand. Agro-processing activities in production catchments require dependable power availability. The surplus biomass could be utilized through combustion, gasification, fast pyrolysis, alcoholic fermentation and anaerobic digestion to generate gaseous and liquid fuels. In addition to fuel uses, applications of the surplus biomass for production of fortified feed, wood-replacement materials, bio-colors, bio-active compounds, bio-fertilizers and other value added products need to be studied.

The fields of agriculture and engineering are growing continuously. The effectiveness of linkages between agriculture and engineering would decide the level of competition that Indian agriculture could face in the globalized market regime.

Information and Communication Technology

To harness the power of emerging Information and Communication Technology (ICT) for the benefit of agriculture Research and Education sector in India, a programme called Agricultural Research Information system (ARIS) was started by ICAR about a decade ago. The ARIS programme was funded initially by National Agricultural Research Project (NARP) and then by National Agricultural Technology Project (NATP) – both World Bank (WB) projects. ARIS cells to manage the ICT facilities at local level and Local Area Networks (LANs) have been established at about 400 locations in NARS including ICAR institute, National Research Centers (NRCs), Project Directorates (PDs), State Agricultural Universities (SAUs), Colleges, regional stations of ICAR institutes and SAUs. Basic essential hardware (H/W), Software (S/W) and trainings were provided to these institutions. ARIS cells are managing the IT infrastructure, organizing trainings and helping in digitized content development. **The'ICAR-Net' connecting 274 locations, using LLs, SCPC VSATs & BBVSATs on ERNET backbone with bandwidth (b/w) ranging 128 kbps to 2 Mbps has been created under NATP.**

Wider user base, increasing applications and greater dependency on ICT in NARS calls for more intensive efforts in this direction. Specific activities relate to strengthening of 'ICAR-Net', secured Intranet, National Agriculture Research Portal, Content development, Knowledge management, e-learning, e-Library, Financial Management System (FMS)/ Management Information system (MIS) and an effective Communication and Public Awareness system. Substantial support during XIth Plan is required for ICT enablement of ICAR and NARS.

2. REVIEW OF ON-GOING R&D PROGRAMMES

During the second meeting of the sub-group, all the Directors, Project Director (SPU), and Project Coordinators were invited to participate and present their achievements during the Xth Plan in relation to the targets. They also presented the priorities for the XI Plan. The summary of Xth Plan achievements is included in Annexure 5. The sub-group expressed its general satisfaction over the Xth Plan progress. However, several suggestions emerged from the deliberations to expand and strengthen the programmes if the expectations are to be met. The following comments/ observations are in relation to the on-going programmes.

- Farm mechanization level needs to be increased considerably from the present level. Emulating zero till drill, other farm implements and machines with proven performance may be identified for large scale demonstrations.

- Soybean processing entrepreneurship in both rural and urban settings has found favor. This activity needs to be promoted extensively for human nutrition, income and employment. An all India network on soybean processing may be conceived.

- As the level of mechanization is increasing, there is greater need for effective management of the machinery and prime movers for maximizing the benefits.

- There is a need for constant attention on energy inputs and outputs in different agricultural production systems in order to maximize the returns.

- Machinery design should employ precision tools like computer aided design for competitive product development.

- Crop residues and other agricultural by-products need greater mechanization and processing inputs for deriving economic and environmental benefits.

- There is a need to develop core competence in machinery design, processing unit operations, production and processing system simulations, non-destructive and rapid quality assessment, biomanufacturing, food quality and safety assurance.

- Ergonomics and Safety in Agriculture programme should aim at the minimization of occupational hazards for the workers engaged in agricultural production as well as post harvest processing activities

- Utilization level of draught animals for farm and off-farm activities needs to be enhanced and necessary equipment needs to be made available. Even conjunctive use of animal power along with other power sources may need to be considered to obtain best results.

- Post harvest loss reduction, value addition and byproducts utilization for enhanced income and employment generation should be the basis for developing region and commodity specific packages of post harvest technology.

- Activity domain of Indian Lac Research Institute, Ranchi may be expanded to include natural resins and gums for increasing the relevance of the institute in the region where it is located and the output in relation to the commodities that have remained largely unattended so far.

- The programme on Application of Plastics in Agriculture needs to be reoriented to better meet the protected production technology needs of horticulture, livestock and fisheries sectors.

- Higher resource allocations are required for FLDs, multi-location trials, technology assessments in collaboration with industry and other outreach activities so that the ultimate users of technology are benefited without long gestation periods.

- The importance of information technology, decision support systems and statistical tools in agricultural R&D, production, processing and marketing is expected to increase for knowledge based activities. There is a need to strengthen the activities of information acquisition, analysis and communication for faster and informed decisions.

The sub-group has carefully considered the presentations made by the functionaries of Agricultural Engineering programmes in ICAR, the current expectations of agriculture, socio-economic basis for technology interventions and trade to propose the major thrust areas for the XI Plan.

3. THRUST AREAS FOR FOR XIth PLAN

Precision Machinery in Important Cropping systems

Precision machinery for the farming systems based on Rice-wheat, sugarcane, cotton, pulses, etc for timely and efficient placement of seeds and seedlings at desired depth and for timely and precise application of inputs as per the needs of the crops to achieve higher productivity at lower cost of production. These may include,

1. Resource conservation technologies for maximizing the efficiencies of agricultural inputs and enhancing the organic content of the soil by incorporating crop residues.
2. Development of high capacity, efficient equipment for use by all categories of farmers either individually or through custom hiring.
3. Efficient utilization of motive power (animal, power tiller and tractor individually or in combination) through development / adoption of matching implements for various field operations.
4. Design, development and field evaluation of irrigation equipment and systems to improve overall water use efficiency.
5. Design, development and field evaluation of drainage machinery and technology for sustainable improvement of crop productivity.
6. Development of Farm machinery management models for efficient and economic use of farm machinery.

7. Refinement of existing designs of farm tools and equipment by using CAD and involvement of manufacturers.

Occupational Safety and Comfort in Agricultural Production and Post Harvest Processing

1. Minimization of accidents and severity of injuries to agricultural workers through engineering, enforcement and educational interventions.
2. Design improvements/ development of agricultural tools and equipment using anthropometric and strength data of agricultural workers for better productivity, efficiency, safety and reduced drudgery.
3. Studies on operator's workplace in tractor and self-propelled machines to improve the operator's comfort and productivity through proper control locations, better acoustics and reduced vibrations.
4. Ergonomical studies on important operations in agriculture and horticulture to assess the physiological cost of work and drudgery involved and finding out solutions for their reduction.
5. Occupational health and safety problems in agro industries eg. Dal mills, Cotton gin, rope making industry, cashew nut processing, coconut dehusking.

Women-Friendly Farm Equipment

- Development/ refinement of women friendly tools and equipment for reducing drudgery and occupational health problems in agricultural, horticultural and fishery activities.

Development / Adaptation of Equipment For

- Precision farming for enhancing input use efficiency in agriculture
- Mechanization of fodder crops
- Straw management (collection, incorporation handling and mulching)
- Agricultural operations performed by woman workers.
- Fish pond aeration system
- Deweeder for aquatic conditions
- Fish-feed plant and fish feed dispenser
- Hill agriculture

Mechanization of Seed Production & Processing

Seed availability in the country is going through a sea change in the sense that seed production and processing activity is being decentralized for higher availability of quality seed to ensure higher seed replacement rate. Machinery for both production and processing is essential to facilitate the activity. Adequate efforts need to be made to provide the relevant engineering inputs for the production-processing continuum in the production catchments.

Mechanization of Horticultural Crops

Vegetables, fruits and flower production in the country needs mechanization inputs for economy of inputs, efficiency of operations, higher yields and better quality of produce. Central Institute of Agricultural Engineering, AICRP on FIM, AICRP on UAE and AICRP on ESA should develop a specific crop and region plan for the activity during the XIth Plan period.

Hill Agriculture

Steep slopes, undulating terrain, very small holdings, socio-economic conditions and the choice of crops present a different scenario for farm mechanization as compared to the plains. Several useful efforts including a light weight power tiller, and implements have been developed and found to be acceptable. These efforts need to continue for more crops and specific geographical conditions to benefit more hill farmers.

Effective Utilization of Animal Power

- Development of animal drawn prime movers for high speed applications in rotary mode for electricity generation, water lifting and post harvest operations;
- Animal drawn tool carrier with matching attachments for energy efficient field operations;
- Matching equipment package specific to the site and breed of animals for cultivation operations with increased work and power output.

Protected Cultivation Technology and Environmental Control

Considering the potential growth prospects in horticulture, National Horticulture Mission and Micro-irrigation Mission have been launched with the expectation of doubling the production of fruits and vegetables in the country to meet domestic as well as export demands. Protected cultivation technology has been recognized as an important intervention towards achieving the goals. The sub-group considered that indigenous efforts to develop area and crop specific solutions to the requirements of protected cultivation structures, environmental control and real time system management were essentially required to successfully utilize the technology. There is a need to carry out structural changes in the existing programme of AICRP on APA to better address the contemporary issues.

Experience in livestock and aquaculture sectors has clearly indicated the advantages that are accruable through environmental control in terms of yields and quality. It is therefore essential that adequate engineering inputs are made available in the livestock and aquaculture sectors for increasing the profitability of these production sectors. These interventions may include

- Performance of vegetables and flowers as influenced by plastic mulches and row cover in greenhouse and under open environment condition
- Evaluation of biodegradable plastic mulching on yield and quality of vegetables.

- Studying the effects of colored plastic mulches and shade nets on yield and quality of produce from horticultural crops
- Soil solarization for vegetable nursery production and its on-farm demonstration.
- Development of Greenhouse Technology for Flowers and Vegetable Cultivation in Tropical Regions
- Round the year vegetable production using greenhouse Technology
- Production of fish seed, fingerlings and adults under protected environment conditions
- Development of protective structures to alleviate environmental stresses on livestock

Post Harvest Processing and Value Addition

- Development of region and commodity specific technology packages for post harvest loss reduction, processing, product diversification and value addition for agricultural produce with a view to promote agro-processing in production catchments.
- Development of test facilities and protocols including HACCP & QACCP for agro-processing activities in production catchments and SMEs to assure food quality and safety.
- Mechanization of agricultural Produce markets for efficient handling, storage, packaging and transport activities.
- Development of suitable technologies for long distance transport and handling of fruits and vegetables.
- Development of cool and cold chains for perishable agricultural produce
- Development of commodity and activity specific packaging for longer shelf life
- Post harvest studies on large capacity storage systems -for cereals, pulses and oilseeds - in collaboration with organized sector
- Technology package for modernization of jaggery manufacture
- Technology package for modernization of dal milling
- Technology package for modernization of oil milling
- Technology package for modernization of fruits, vegetable and flowers markets.
- Technologies for utilization of Soybean as dal, a protein supplement in designer and traditional foods, alternate environmental and health friendly solvent for oil extraction and nutraceuticals.
- Technologies for economic utilization of processing by-products
- **Enzyme manufacturing** for efficient pulse processing, oil expression, higher quality milling of rice and other value addition activities.
- **Value added products/ functional foods** such as probiotics, biocolours, cellulase, bioactive compounds, fortified foods, etc.
- **Food Safety**: Biosensors, in-situ control of toxins and pathogens.

Natural Fibre Processing

- Physical and chemical characterization of fibres, yarns and fabrics
- Development/management of energy efficiency in ginneries including development of ginning machines

- Yarns and fabric production and finishing including blends of cotton with other natural fibres
- Development and dissemination of efficient retting processes for jute
- Composites with jute fabric, geo-textiles and other diversified products
- Development of suitable fibre processing machineries
- Nano technology and biotechnology for processing of natural fibres
- Minimization of steps for jute processing with automation

Natural Resins and Gums

- Improved methods of tapping and collection for increased yield and minimizing injury to producing trees
- Improved methods of handling, processing, purification, storage and packaging for increased recovery, reduced processing costs, and enhanced keeping quality.
- Documenting available and desired quality specifications for developing standards and other value added products to augment production and export of quality produce

Energy and Power

- Design, development and demonstration of family and community size biogas and producer gas plants using different feedstocks, for thermal and power applications.
- Reduction of fresh water requirement for bio-gasification and thermo-chemical gasification through proper treatment and recycling.
- Development of technology for production of ethyl alcohol from cellulosic biomass with emphasis on the identification and development of genetically manipulated organisms which can produce cellulose at lower cost compared to the present options.
- Standardization of plant oil trans-esterification, dewaxing and degumming techniques and utilization of the bio-products and wastes of these processes.
- Development of technology and systems for production of bio-oil through fast pyrolysis route.
- Decentralized power generation using crop residues as basic fuel.
- Development of processes and pilot plants for recovery of hydrogen from biogas and producer gas through steam reformation and through bio-treatment of biomass.
- Testing and adaptive development of new energy suppliers and converters like fuel cells and micro turbines.
- Field evaluation and demonstration of solar dryers, crop residue based gasifiers, biogas plants and liquid bio-fuels for farm and agro-industrial operations.

Transfer Of Mechanization Technologies

- To conduct ORP trials, frontline demonstrations and village saturation programmes of improved farm implements and machinery in different regions in collaboration with KVKs for bridging the identified mechanization gaps
- To promote custom hiring services through entrepreneurship development for use of high capacity farm equipment to ensure timeliness of operation and reduction cost of operation.
- To generate information on manufacturers, their product range and standard parts used for the production of agricultural equipment in different regions of the country.
- To conduct training for SMS, trainers, users, service providers and manufacturers of farm equipment.
- To organize business meets with manufacturers, designers, development officers for manufacture and promotion of newly developed agricultural equipment.

Information and Communication Technology

Strengthening of 'ICAR-Net' : The activities proposed are Security solution deployment and secured data centre, Deploying a unified Mail Server, Web Server and Knowledge Servers, bandwidth Support, development of a National Agriculture Portal, provide Video-conferencing and IP-telephony, human resource development.

Strengthening of ICT infrastructure at all institutions

Knowledge Management : Domain knowledge existing in the form of print media, traditional knowledge, voice, video, text, PowerPoint presentations, success stories, package of practices, training modules, learning modules, databases, decision support systems, expert systems, web content and human experts all will have to be integrated into a digital knowledge management system in that domain to serve all the stake holders.

e-Learning: **It is proposed that the e-learning infrastructure and content may cover all deemed universities, SAUs and CAU.**

e- library: **Support for union catalogue, digitization of old journals, books, thesis, dissertations, local publications and other resources and hosting them on intranet server would be required. There is a need to form a e-journal subscription consortia and pay for e-journal subscription centrally for which funds would be needed in XIth Plan.**

4. SUGGESTIONS REGARDING IMPROVING STANDARDS OF RESEARCH AND EDUCATION

(i) Potential users of equipment/process should be identified and their requirements should be clearly identified before taking up new R & D projects.

(ii) In order to meet the desired requirements, product specifications should be finalized very carefully. Time frame and details of activity should be worked out and monitored properly. Any deviation from the original schedule should be reported with reasons.

(iii) If BIS approved test procedures and performance standards are not available for some equipment/process, ICAR should develop interim procedure and standard and it should be ensured that the newly developed equipment/process meets the performance standards before it is released or transferred for commercialisation.

(iv) Continuous monitoring of technological developments in other countries should be done. Whenever any promising machine is identified, it should be imported and evaluated for usefulness/adaptation.

(v) As in most other fields of research, the distinction between good and poor performance has faded in agricultural (and Agril. Engg.) research also. ICAR should lay down criteria for career promotion which act as a source of motivation for the researchers to give of their best.

(vi) In order to keep with technological developments and advancements in Instrumentation and research techniques intensive workshops of research workers including Principal Scientists should be organized at appropriate institutions as frequently as needed.

(i) Course curricula for graduate and post-graduate programmes should be reviewed every 5 years and when required the content revised to update the curriculum and courses.

(ii) Short duration training/workshops should be organised to upgrade skills of teachers and to keep them abreast with new developments.

5. EFFECTIVE PROGRAMME MONITORING

The sub-group is of the opinion that in this era of competitiveness and quality, there is no scope for complacency. The six monthly monitoring of the ICAR scientists has begun showing results. Similar performance monitoring of AICRP cooperating centers is essential to ensure adequate output and outcome. Performance of the cooperating centers of the coordinated projects should be thoroughly reviewed and those centers which have failed to perform up to the required level may not be continued during the 11th Plan.

6. MANPOWER REQUIREMENT

Adequate human resource is essential to carry out the mandated programmes of the Council as well as those in the field. It is also important that the human resource of desired quality is made available. Keeping the Government policy to curb additional recruitments, the sub-group is not making a recommendation about adding the positions of agricultural engineers during the XIth Plan. Instead, the sub-group strongly recommends that all the positions lying vacant may be filled as quickly as possible so that the envisaged programmes could be pursued effectively.

In view of the challenges ahead, Agricultural Engineering education in India needs a complete overhaul. An agricultural engineer is a hybrid between agriculture and engineering and, as in the case of any hybrid, only F1s are preferred for maximum vigor. In any effective educational programme to produce agricultural engineers, both agriculture and engineering faculties are necessary. A cursory look at the present agricultural engineering programmes in the country clearly brings out the fact that in most cases, the right parentage is missing. This lack of adequate support from either agriculture or engineering or both leads to agricultural engineers who are not prepared to assume the desired responsibilities. While the role of engineering in agriculture can not be overemphasized, adequately trained agricultural engineers are essentially required. There is an urgent need to rectify the situation by appointing a committee to look into the present agricultural engineering education in the country and then by implementing the recommendations so that the mismatch between the demand and supply of agricultural engineers in India is corrected.

7. BUDGET

The budgetary support for Mechanization, Post Harvest Processing and Energy programmes during the Xth Plan period has been about 4% of the ICAR budget. There was almost a four-fold increase in the budget of AICRP on Post Harvest Technology with expansion in its mandate and the number of centres. As a result, PHT programmes have been provided adequate strengthening during the Xth Plan.

Considering the on-going programmes and the new envisaged activities in R&D sector, the sub-group recommends that six percent of ICAR budget may be allocated for programmes in Mechanization, post harvest processing and energy during XI Plan period. In absolute terms, the budget requirement for Mechanization, Post Harvest Processing and Energy Management programmes during XIth Plan period is estimated at Rs. 300 crore. The enhanced budget will be duly utilized for capacity building, R&D programmes, demonstrations, outreach programmes and trainings. Out of this allocation, a sum of Rs. 50 crores may be earmarked for projects to be invited on competitive basis in basic and strategic research areas.

The sub-group deems it appropriate to recommend a sum of Rs. 100 crores during XI Plan for reorienting and strengthening agricultural engineering education in India so that the engineering needs of agriculture are adequately met. The ICT component of the XIth Plan programme of the ICAR requires a budgetary support of Rs. 500 crore. Therefore, the **total funds required for the R&D, education and ICT are Rs. 900 crore**.

ANNEXURE-1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

KRISHI BHAWAN, NEW DELHI- 110001

Dr. K.S. Khokhar
Asstt. Director General(PI&M)

F.NO.5(5)/2006-PIM Dated: 10-7-2006

O R D E R

Subject: Sub Groups constituted by XIthe Five Year Plan (2007-2012) Working Group on Agricultural Research & Education.

In pursuance of the Order No. M - 12043/02/2006 - Agri. dated 9th May, 2006 of Planning Commission regarding constitution of Working Group on Agricultural Research & Education for XIth Five year Plan (2007-2012). The Working Groups in its first meeting held on 26-6-2006 has constituted Sub Group on **Mechanization, Post Harvest Processing and Energy Management** as per the following composition and Terms and References:

I. Composition:

(i)	Dr. B.S. Pathak, Director, Sardar Patel Renewable Energy Research Institute, P.B.No.2 Vallabh Vidyanagar 388 120 E-mail: Director@spreri.org	Chairman
(ii)	Dr. Anwar Alam, Vice Chanceelor, Sher-E-Kashmir University of Agricultural Science & Technology, Shalimar Campus, Srinagar, J&K 191 121	Member
(iii)	Dr. A.M. Michael, (Ex.- VC, KAU), 27/38 Vattekunmnarm, Methanam Road, Edappally North , Cochin-682 024	Member
(iv)	Dr. N.S.L. Srivastava, Joint Director, Sardar Patel Renewable Energy Research Institute, P.B.No.2 Vallabh Vidyanagar-388 120	Member
(v)	Dr. Pitam Chandra, Asstt. Director General(PE), ICAR, KAB-II, Pusa New Delhi-110 012 E-mail: pitam@icar.org.in; pc1952@gmail.com	Member Secretary

II. Terms of Reference

(i) To make critical review of Xth Plan achievements in terms of agricultural research in mechanization, post harvest processing and energy management in contrast to the objectives and targets set during Xth Plan.

(ii) To identify critical gaps in scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as enable the nation to enhance its agricultural competitiveness in the context of WTO & IPR region.

(iii) To draw/suggest specific schemes/ programmes pertaining to agricultural research in mechanization PHT & energy management to address the problems of less privileged regions.

(iv) To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

(v) To identify institutional mechanism for strengthening, monitoring and evaluation system in agricultural research, and to suggest efficient measures for effective coordination of agricultural research in SAUs, ICAR and private sector including the steps to be taken for strengthening public-private partnership.

(vi) To draw/suggest specific schemes/programmes/research area pertains to agricultural research in mechanization, PHT and energy management.

2. The Sub Group may also examine and address any other issues which are important but are not specifically spelt out in the ToRs or which were discussed and flagged in the First Meeting of Working Group held on 26.6.2006, the proceedings of which have already been circulated. The Sub Group may devise its own procedures for conducting its business/ meetings.

3. The expenditure of the official members on TA/DA in connection with the meetings of the Sub Group will be borne by their respective Ministry/Department as per the rules of entitlement applicable to them. . In case of non-officials, the TA/DA will be borne by the Planning Commission as admissible under SR 190(a).

4. The Sub Group will be serviced by the Department of Agricultural Research and Education, Ministry of Agriculture.

5. The Sub Group will submit its Interim Report by the end of August, 2006 and the final Report by the end of September, 2006 to the Chairman of the XI Plan Working Group.

6. Dr.(Mrs.)Vandana Dwivedi, Joint Adviser(Agriculture)Planning Commission, Room No. 230, Yojana Bhavan, New Delhi-110001, Tel No. 011-23096730, Email: dwivediv@nic.in and FAX No. 011-23327703 will be the nodal officer of this Sub Group and any further query/correspondence in this regard may be made with her.

(K.S.Khokhar)
Member Secretary

To

1. The Chairman and all Members (including Member-Secretary) of Sub Group.
2. Chairman, Working Group on Agricultural Research & Education for the XIth Plan Five Year Plan
3. Dr.(Mrs.)Vandana Dwivedi, Joint Adviser(Agriculture)Planning Commission, Room No. 230, Yojana Bhavan, New Delhi-110001

ANNEXURE-2

Sub-Group on Mechanization, Post Harvest Processing and Energy
Eleventh Plan Working Group on Agricultural Research and Education.

Subject: Proceeding of the First Meeting of the Sub-Group.

1. The first meeting of the Sub-group on **Mechanization, Post Harvest Processing and Energy** of the XIth Plan Working Group on Agricultural Research and Education was held on August 21, 2006 in Room 407, Krishi Anusandhan Bhawan II, Pusa Campus, New Delhi.

2. The meeting was chaired by Dr. B.S. Pathak and was attended by Dr. A. Alam, Dr. NSL Srivastava and Dr. Pitam Chandra. Dr. A.M. Michael could not attend the meeting due to precommitments Dr. Nawab Ali and Dr. S.K.Tandon also attended the meeting

   The Sub-Group took notice of the Terms of Reference given by the Working Group of the Planning Commission. The 10^{th} Plan achievements and Eleventh Plan targets communicated by the institutes and the AICRPS were discussed. The essence of the deliberations is summed up in the following observations

2.1. It is important that the R&D Projects in the Institutes and in the AICRPs should have suitable linkages with industry users to provide forward linkage for technology commercialization.

2.2. The State Governments find it difficult to extend the mechanization and post harvest technologies owing to the shortage or complete absence of the suitable human resource as well as infrastructure. Therefore, the State Governments need to be convinced to create necessary infrastructure and human resource to facilitate the adoption and absorption of Agricultural Engineering inputs for cost effective agriculture.

2.3. Agricultural Engineering activities need to be expanded to meet the needs of present day agriculture. This includes greater emphasis on IT, instrumentation, biomaterials, bio manufacturing, nanotechnology etc. For example, the process of composting including vermi-composting could be mechanized for higher productivity and assured quality of the output. Similarly, manufacturing of biofertilizers, biopesticides and bio control agents need engineering inputs.

2.4. A programme on Biofuels (liquid gaseous and solid) needs to be formulated and implemented for rural and agricultural applications.

2.5. Considering the current and the near-future scenarios of electrical power availability, emphasis needs to be given for decentralized Biofuels based energy and power supply systems for meeting the agricultural production and processing requirements

2.6. To create greater awareness, more emphasis is required in the XIth Plan on demonstration as well as outreach programmes on mechanization, agro processing and renewable energy technologies. While zero till drill has become quite successful, some other promising technologies need to be demonstrated extensively to benefit Indian farmers. Some of these technologies are raised bed planting, rice transplanting, chiseling, agro-processing in production catchments and biogas.

2.7. There is need for creating specialized groups of scientists in the Institutes in order to create excellence and long-term sustainability in R&D activities. Accordingly, groups such as soil working and planting machinery, weeding and plant protection, irrigation and drainage, harvesting & threshing in the area of farm mechanization are needed. Similarly, groups on food grains, oilseeds, fruits and vegetables, jaggery and khandsari, spices and condiments. meat and meat product, milk & milk product, etc. in the area of post harvest processing would need to be set up. These groups will not only maintain an upto date status of the technological developments in their specific areas of activity but also carry out basic, applied and strategic programmes of research.

2.8. A critical review of the achievements so far and the on going programmes is required with a view to clearly come out with the activities that require due emphasis during the XIth Plan. The routine and unproductive activities must be offloaded right away to create spare capacity for productive activities.

2.9. The problems of custom operation in farm mechanization should be studied and suitable R&D Programme an farm machinery management should be undertaken to address adequately the concerns of custom hiring and hiring services. All test codes and methods need to be revisited for their adequacy. Wherever needed, efforts should be made to modify these test codes and methods.

2.10. Agricultural prime-movers at present are quite inefficient. Testing of prime-movers and their technical up-gradation is important for reducing the agricultural production costs.

2.11. Each ICAR institute and SAUs must have state of the art mechanization on their farms and the agricultural produce needs to be suitably value added before selling it off.

2.12. To facilitate mechanization and post harvest processing in the commodity institutes, a group of 2-3 agricultural engineering scientists alongwith five technicians should be posted with a clear mandate. These agricultural engineering scientists in commodity institutes should find suitable integration in the agricultural engineering programmes of the ICAR as co-opted centres.

3. The group also deliberated upon the major developments in the field of mechanization, post harvest processing and energy. On the basis of the daylong deliberations, the following action points emerged. The 10th Plan achievements and eleventh plan targets communicated

by the institutes and AICRPS need to be made specific and focused. It was decided to request the information in a structured manner as per the format given in annexure-A

3.1. The revised information will be sought by Sept. 8, 2006, compiled and made available to the sub-group well in advance of the next meeting scheduled to be held during September 14-15, 2006. The Directors, Project Director and Project Coordinators will be requested to participate in the second meeting of the sub group in order to finalize the programmes of the Agricultural Engineering Division for the 11th Plan and to submit the report to the 11th plan Working Group on time i.e. by 30 September, 2006.

The meeting ended with a vote of thanks to the Chairman and the members of the sub-groups.

Prepared by	**Approved by**
Pitam Chandra	**B.S.Pathak**

Annexure – 1A

Proforma for Submission of Information by the Institutes & AICRPs for Review and consideration of the Sub-Working Group on Mechanisation, Post Harvest Processing and Energy Constituted by the Planning Commission, Government of India.

1. 9th Plan achievements:
    - 1.1 Technologies Developed
    - 1.2 Present status of TOT/Commercialization of the Technologies

2. Spillover of the 9th Plan R&D programmes to 10th Plan
    - 2.1 Projects completed and technologies developed
    - 2.2 Projects still continuing
    - 2.3 Likelyhood of spill over to 11th Plan

3. 10th Plan achievements
    - 3.1 Targets
    - 3.2 Achievements (Quantify and compare with the existing)
    - 3.3 Technology Spillover to 11th Plan
    - 3.4 Shortfalls if any
    - 3.5 Reasons for the shortfall
    - 3.6 Status of the technologies developed
    - 3.6.1 Technologies released for TOT/extension and their status with techno-economic analysis
    - 3.6.2 Ready for FLD
    - 3.6.3 Under testing
    - 3.7.4 Still under development

4. FLDs conducted and their impact
5. Outreach programmes conducted
6. Success stories of the TOT programmes during 10th Plan
7. Infrastructural facilities developed
    (Specialized equipment, pilot plant, laboratories)
8. Constraints in execution of programmes
    - 9.1 Scientific manpower
    - 9.2 Finance
    - 8.3 Any other
9. Interactions among the institutes and industry during 10th Plan and summary of joint programmes
10. Thrust areas for R&D during 11th Plan
    - 10.1 R&D Gaps Identified:
    - 10.2 Targets
    - 10.3 Anticipated results

11. Major TOT and FLD Programmes planned during 11th Plan

Annexure 3

Sub-Group on Mechanization, Post Harvest Processing and Energy
Eleventh Plan Working Group on Agricultural Research and Education.

Proceedings of the second meeting of the sub-group

The second meeting of the sub-group on Mechanization, Post Harvest Processing and Energy Management was held during September 14-15, 2006. The agenda for the meeting is given in Annexure 2A. The meeting was chaired by Dr. BS Pathak on both days and the attendance on both days is given in Annexure 2B.

On the first day of the second meeting of the sub-group, all the Directors, Project Director (SPU), and Project Coordinators were invited to participate and present their achievements during the Xth Plan in relation to the targets. They also presented the priorities for the XI Plan. The summary of Xth Plan achievements is included in Annexure 5. The sub-group expressed its general satisfaction over the Xth Plan progress. However, several suggestions emerged from the deliberations to expand and strengthen the programmes if the expectations from Agricultural Engineering Division in respect of quality and cost competitiveness of agricultural produce and value added products are to be realized. The following comments/ observations are in relation to the on-going programmes.

- Farm mechanization level needs to be increased considerably from the present level. Emulating zero till drill, other farm implements and machines with proven performance may be identified for large scale demonstrations.
- Soybean processing entrepreneurship in both rural and urban settings has found favour. This activity needs to be promoted extensively for human nutrition, income and employment. An all India network on soybean processing may be conceived.
- As the level of mechanization is increasing, there is greater need for effective management of the machinery and prime movers for maximizing the benefits.
- There is a need for constant attention on energy inputs and outputs in different agricultural production systems in order to maximize the returns.
- Machinery design should employ precision tools like computer aided design for competitive product development.
- Crop residues and other agricultural by-products need greater mechanization and processing inputs for deriving economic and environmental benefits.
- There is a need to develop core competence in machinery design, processing unit operations, production and processing system simulations, non-destructive and rapid quality assessment, biomanufacturing, food quality and safety assurance.

- Ergonomics and Safety in Agriculture programme should aim at the minimization of occupational hazards for the workers engaged in agricultural production as well as post harvest processing activities

- Utilization level of draught animals for farm and off-farm activities needs to be enhanced and necessary equipment needs to be made available. Even conjunctive use of animal power alongwith other power sources may need to be considered to obtain best results.

- Post harvest loss reduction, value addition and byproducts utilization for enhanced income and employment generation should be the basis for developing region and commodity specific packages of post harvest technology.

- Activity domain of Indian Lac Research Institute, Ranchi may be expanded to include natural resins and gums for increasing the relevance of the institute in the region where it is located and the output in relation to the commodities that have remained largely unattended so far.

- The programme on Application of Plastics in Agriculture needs to be reoriented to better meet the protected production technology needs of horticulture, livestock and fisheries sectors.

- Higher resource allocations are required for FLDs, multi-location trials, technology assessments in collaboration with industry and other outreach activities so that the ultimate users of technology are benefited without long gestation periods.

- The importance of information technology, decision support systems and statistical tools in agricultural R&D, production, processing and marketing is expected to increase for knowledge based activities. There is a need to strengthen the activities of information acquisition, analysis and communication for faster and informed decisions.

The sub-group, with the relevant inputs from the SMD functionaries, utilized the second day of the meeting to finalize the frame-work of the report. Member-secretary was advised to circulate the draft report to the Chairman and the Members through e-mail and to finalize it on the basis of the feedback. The modalities of submitting the report to the Working Group were also needed to be found out from the Member-secretary of the Working Group.

The meeting ended with a vote of thanks to the Chairman and the members of the sub-groups.

Prepared by	**Approved by**
Pitam Chandra	**B.S.Pathak**

Annexure 4

Some Promising Applications of Nano-technology in Agriculture

1.Buckyball Fertiliser

Researchers at Kyoto University (Japan) have discovered a method of producing ammonia using buckyballs. Ammonia is a key component of fertiliser, but it is not clear if the resulting product for use in the fields would contain buckyballs.

2. Seeding Iron

The Russian Academy of Sciences reports that they have been able to improve the germination of tomato seeds by spraying a solution of iron nanoparticles on the fields.

3. Soil Binder

A nanotech-based soil binder, called SoilSet developed by Sequoia Pacific Research of Utah (USA), is a quick-setting mulch which relies on chemical reactions on the nanoscale to bind the soil together.

4. Soil Clean-Up Using Iron Nanoparticles

A nano clean-up method of injecting nano-scale iron into a site contaminated by heavy metals and PCBs has been tested. The particles flow along with the groundwater and decontaminate en route, which is much less expensive than digging out the soil to treat it. The tests with nano-scale iron show significantly lower contaminant levels within a day or two. The tests also show that the nano-scale iron will remain active in the soil for six to eight weeks, after which time it dissolves in the groundwater and becomes indistinguishable from naturally occurring iron.

5. Electrospinning Nanofibres Can Turn Waste Into New Products

It may soon be possible to produce a low cost, high-value, high-strength fiber from a biodegradable and renewable waste product for air filtration, water filtration and agricultural nanotechnology using the recently perfected technique of electrospinning to spin nanofibers from cellulose. Whenever cotton is converted to fabric and garments, fiber (cellulose) is lost to scrap or waste. At present it is largely discarded or used for low-value products, such as cotton balls, yarns and cotton batting.

6.Clay Nanoparticles to Improve Plastic Packaging for Food Products

Chemical giant Bayer produces a transparent plastic film (called Durethan) containing nanoparticles of clay. The nanoparticles are dispersed throughout the plastic and are able to block oxygen, carbon dioxide and moisture from reaching fresh meats or other foods. The nanoclay also makes the plastic lighter, stronger and more heat-resistant.

7. Creating a Molecular Barrier by Embedding Nanocrystals in Plastics to Improve Packaging

Until recently, industry's quest to package beer in plastic bottles (for cheaper transport) was unsuccessful because of spoilage and flavour problems. Today, Nanocor, a subsidiary of Amcol International Corp., is producing nanocomposites for use in plastics beer bottles that give the brew a six-month shelf-life. By embedding nanocrystals in plastics, researchers have created a molecular barrier that helps prevent the escape of oxygen. Nanocor and Southern Clay Products are now working on a plastic beer bottle that may increase shelf-life to 18 months.

8. Embedded Sensors in Food Packaging and 'Electronic Tongue' Technology

Chemical giant Bayer produces a transparent plastic film (called Durethan) containing nanoparticles of clay. The nanoparticles are dispersed throughout the plastic and are able to block oxygen, carbon dioxide and moisture from reaching fresh meats or other foods. The nanoclay also makes the plastic lighter, stronger and more heat-resistant.

9. Using a Nanotech Bioswitch in 'Release on Command' Food Packaging

Researchers in the Netherlands are going one further to develop intelligent packaging that will release a preservative if the food within begins to spoil. This "release on command" preservative packaging is operated by means of a bioswitch developed through nanotechnology.

10. Nanoparticle Farming - Grow Nanoparticles in Genetically Engineered Crops?

In the future, industrial nanoparticles may not be produced in a laboratory, but grown in fields of genetically engineered crops - what might be called "particle farming." It's been known for some time that plants can use their roots to extract nutrients and minerals from the soil but research from the University of Texas-El Paso confirms that plants can also soak up nanoparticles that could be industrially harvested. In one particle farming experiment, alfalfa plants were grown on an artificially gold-rich soil on university grounds. When researchers examined the plants, they found gold nanoparticles in the roots and along the entire shoot of the plants that had physical properties like those produced using conventional chemistry techniques, which are expensive and harmful to the environment. The metals are extracted simply by dissolving the organic material.

11. Grow Particle Plants indoors in Gold-Rich Soil

Initial experiments showed that the gold particles formed in random shapes, but changing the acidity of the growing medium appears to result in more uniform shapes. The researchers are now working with other metals and with wheat and oats in addition to alfalfa to produce nanoparticles of silver, Europium, palladium, platinum and iron. For industrial-scale production, the researchers speculate that the particle plants can be grown indoors in gold-enriched soils, or they can be farmed nearby abandoned gold mines.

12. NanoParticle Farming in India

Nanobiotech researchers at the National Chemical Laboratory in Pune, India, have been carrying out similar work with geranium leaves immersed in a gold-rich solution. After 3-4 hours, the leaves produce 10 nm-sized particles shaped as rods, spheres and pyramids which, according to researcher Murali Sastry, appear to be shaped according to the aromatic compounds in the leaves. By altering those aromatic compounds, Sastry believes it will be possible to alter the shape of the nanoparticles (and their properties).

13. Nanosensor Networks to Track Livestock

Just as converging technologies in crop production will use nanosensor networks to continuously monitor the health of plants, so, too, will sensors monitor livestock. We may envision 'smart herds' - cows, sheep and pigs fitted with sensors and locators relaying data about their health and geographical location to a central computer. Implanting tracking devices in animals is nothing new - either in pets, valuable farm animals or for wildlife conservation. Injectable microchips are already used in a variety of ways with the aim of improving animal welfare and safety - to study animal behaviour in the wild, to track meat products back to their source or to reunite strays with their human guardians. In the nanotech era, however, retrofitting farm animals with sensors, drug chips and nanocapsules will further extend the vision of animals as industrial production units.

14. Linking Nanosensors to Drug Delivery Systems for Animals
This is a vision of precision agriculture where the long-term aim is not merely to monitor, but also to automatically and autonomously intervene with pharmaceuticals using small drug delivery devices that can be implanted into the animal in advance of illness. The notion of linking in-built sensors to in-built smart delivery systems has been called "the fuel injection principle" since it mimics the way modern cars use sensors to time fuel-delivery to the engine. One of the current barriers to implantable medical devices is that their composite materials (e.g., metal or plastics) are often incompatible with living tissue. New materials, engineered at the nano-scale to be biocompatible, seek to address this problem.

15. Nano-Aquaculture
The world's fastest growing area of animal production is the farming of fish, crustaceans and molluscs, particularly in Asia. With a strong history of adopting new technologies, the highly integrated fish farming industry may be among the first to incorporate and commercialise nanotech products.

16. Cleaning Fish Ponds with Nanotechnology Devices
Nevada-based Altair Nanotechnologies makes a water cleaning product for swimming pools and fishponds called 'NanoCheck.' It uses 40 nm particles of a lanthanum-based compound which absorbs phosphates from the water and prevents algae growth. There may be potentially large demand for NanoCheck for use in thousands of commercial fish farms worldwide where algae removal and prevention is costly at present.

17. DNA Nano-Vaccines Using Nanocapsules and Ultrasound Methods
The USDA is completing trials on a system for mass vaccination of fish using ultrasound. Nanocapsules containing short strands of DNA are added to a fishpond where they are absorbed into the cells of the fish. Ultrasound is then used to rupture the capsules, releasing the DNA and eliciting an immune response from the fish. This technology has so far been tested on rainbow trout by Clear Springs Foods (Idaho, US).

18. Using Iron Nanoparticles to Speed Up the Growth of Fish
Scientists from the Russian Academy of Sciences have reported that young carp and sturgeon exhibited a faster rate of growth (30% and 24% respectively) when they were fed nanoparticles of iron.

Annexure 5

Tenth Plan Achievements of the Schemes of Agricultural Engineering Division

Central Institute of Agricultural Engineering, Bhopal

Targets	Achievements
Agriculture Mechanization	• Light weight power tiller (140 kg) operated by 3.5 kW engine. • Animal drawn bed former and seed cum fertilizer drill for cultivation of vegetables on raised bed. Development of tractor operated Plastic Mulch laying machine. • Tractor operated Lugged Whieel Puddler (185 cm). • Self Propelled Rice Ridge seeder operated by 5 hp diesel engine. • Technology for Mechanized transplanting of rice including nursery raising. • Technology for minimum tillage dry seeded rice in wheat straw fields. • Technology for minimum tillage cultivation of wheat after combining harvested rice. • Tractor operated till plant machine. • Self propelled Biasi cultivator operated by 5.5 diesel engine. • Technology for direct seeding of wheat. • 4-row sprouted manual rice seeder. • Tractor operated inclined plate planter with bed forming attachment and bed former for sowing of inter crops on broad/raised beds. • Self propelled chopper type combine harvester for sugarcane. • Indigenous laser guided land leveler. • Tractor operated Orchard Sprayer. • Frontline demonstration of Improved Agricultural equipments for cereals, rice horticultural crops, oilseed and pulse crops. • Manufacturing package for serrated sickle has been developed. • Upgraded material for rotavator blades with production process and heat treatment finalized. Material for sickle blade and its heat treatment has been finalized and introduced. • Studies on duckfoot sweep and tine material is in progress. • Material testing laboratory has been partially established. • Abrasion test of material, micro structure and fatigue test facilities are already established.

Irrigation and Drainage Engineering	• Automation of surge flow irrigation system for vertisols • Optimized surge flow parameters in vertisols and automatic controlled surge irrigation system was designed and developed. • Design parameters and drainage requirement studies in vertisols • Package of practices/technology for surface and sub surface drainage system for soybean crop cultivation in vertisols developed. • Technology for artificial ground water recharge in hard rock areas has been developed. • Performance characteristics of drip Irrigation system in vertisol • Package of practices / technology for cultivation of mango and guava through drip irrigation in vertisols were developed. • Improving skills & instrumentation for water application in fields for enhanced water use efficiency • Developed package of practices for surface and sprinkler irrigation systems in vertisols.
Agriculture Energy & Power	• A solar tunnel dryer& PAU driers were tested for drying gooseberry. • Performance evaluation of step type solar cocoon stifler at 5 silk rearing centers. • Biogas slurry filtration unit was modified and installed for field evaluation. • Five modified Janta biogas plants of 2 m^3 capacity were constructed at users site and monitored. Briquettes were prepared from charred soybean stalk and cow dung for evaluating their effectiveness in gasification. • Five units of 10 kW CIAE natural draft gasifier were fabricated for multi-location trials at various centres of AICRP on RES. • A 20 kW producer gas cooling and cleaning system was designed, developed and tested for tar absorption by using different materials for filtering the tar • Studies were conducted to optimize parameters for production of ethyl ester from Karanj oil.
Agro-Processsing	• Power operated 350-400 kg/ h groundnut decorticator for seed and snacks industries developed. Osmotic-cum-heated air drying for cauliflower, green pea and mushroom developed. • A pilot plant for making oil free potato puffed product (20-25 kg/ day) has been developed. • An upgraded dal mill to enhance dal recovery and to increase the capacity of mill was developed along with a dust free type cleaner. • A fruit grader (3 t/ h) for round shaped fruits has been developed.

Soybean Processing	• Technologies developed to produce soy-shrikhand and amrakhand with mango as an ingredient. Sugar-free salted and sweet biscuits • Suitable processing approach developed for elimination of heat stable antinutritional constituents in soybean and sunflower,Soy milk based rasogulla and Producing phytate and galactoside free soy products • Equipment developed: Deep fat frier (using thermic fluid) and Integral Extrusion expelling unit for production of edible grade Medium fat Soy flour and soy oil (Laboratory unit). • Fifty-six training programmes were organized (26 for rural women groups and 34 for upcoming entrepreneurs). Through these courses a total of 479 women and 357 potential entrepreneurs were trained in soybean processing for food uses and soy products. Feed back survey of former trainees revealed establishment of 155 enterprises in different states and 10 micro enterprises by women in Bhopal district. Apart from these, twenty training programmes were organized for 300 women, under NATPs. Two winter schools in which 32 ICAR/SAUs scientists and faculty participated.
Technology Transfer	• Commercial prototype developed involving manufacturers for the following CIAE prototypes : Pneumatic planter, modular planter, inclined plate planters, wheel hoe weeder, semi axial flow thresher, high capacity thresher, multi crop thresher and vegetable transplanter, precision plot drill, dhall mill, cleaner-cum-grader, grain floor separator and manual rice transplanter. • 10,235 prototypes were produced in PPC and through local manufacturers and supplied throughout the country for mechanization promotion. • Participated in 42 National and Regional level exhibitions & trade fairs and displayed & demonstrated the CIAE technologies • Surveyed and compiled the directory of commercial agricultural machinery and the fast wearing components • 2539 persons including Extension Officers, Government Officials and Entrepreneurs were trained during the last four years. • The IEP Centre, Coimbatore organized 75 field demonstrations of mechanized rice cultivation, and organized 30 short training programmes. The centre fabricated and supplied 10 units of 6-row manual rice transplanter and 20 units of single row cono weeder.

Central Institute of Post Harvest Engineering & Technology, Ludhiana

Targets	Achievements
Assessment and minimization of post-harvest losses in food grains, oilseeds and horticultural crops during harvesting, handling, storage, transport and at rural homes.	Technology for processing of Wild Pomegranate for quality products. Post harvest management of peach. Post harvest management of ber.
Processes and processing equipment and pilot plants for value addition, income and employment generation from food crops, livestock and fishery.	Developed cycle rickshaw for fish transportation. Effect of pearling on recovery of high quality low fat degermed maize. Developed integrated paddy dryer. Developed technology for debittering of kinnow juice.
Development and commercialization of low cost fruit & vegetable packaging lines.	Designed and developed tomato grader. A non-destructive method to measure maturity and sweetness of mango. Efficacy of kinnow peels against Helicoverpa armigera (Hubner) and major grain storage pests.
Evaporative cooled, MAP and CA storage for fruit & vegetable for increased shelf life.	Studied post harvest behavior of selected vegetable crop influenced by pre-treatments. CIPHET low cost storage technology for fruits and vegetables.
Modernization of dal milling and oil expelling industries.	Effects of pre milling treatment on dhal recovery were optimized. Enhancement of oil recovery using mechanical extraction for mustard seed.
Processing utilization of crop residues, agro-processing by-products and wastes for food, feed, fuel and manure.	Developed indirect type biomass fired furnace.
Development of appropriate agricultural structures and environment control.	Developed porous bricks of evaporative cooling. Low cost green house for cold desert region. Evaporative cold room.
Development of agro-processing models for typical production catchments.	AICRP on PHT is looking after this aspect. CIPHET developed a APC model for demonstration to farmers.
Development of rural agro-processing for economic empowerment of rural women and assessing their techno-economic feasibility.	Promoted Shelf Help Groups in Abohar region and imparted trainings on processing of fruits & vegetables.
Multiplication of proven prototypes, establishment of pilot plants, Front Line Demonstrations, HRD and	Established pilot plant for handling & packaging of tomatoes. pilot plant for processing of kinnow. chilli processing plant.

entrepreneurship development in post harvest technology.	tomato puree making plant. pilot plant for pulses.
Performance evaluation of processing equipment.	Two stage evaporative cooler. Groundnut pod decorticator. Cleaner-cum-grader for karanj seed. Clipper for harvesting of strawberry and capsicum. Kinnow collector cum grader.
Quality testing of processed products.	Product of pomegranate, guava and ber. Sunflower decorticator and sunflower products. Technology for modernization of sattu processing industry.
Demonstration of technology on pilot scale.	Pilot Plant of whole tomato packaging was established. Low cost filter.
Transfer of post harvest technology with complete documentation.	Project Profiles on Post Harvest Technology for Rural / Micro Entrepreneurs. Bleaching earth for bleaching of oil. Mustard seed grinder for higher oil recovery. Mustard by-products.
Generation and maintenance of database on post harvest equipment and processes.	A database on post harvest equipment & process has been developed. It contains information about 500 equipment.

Central Institute for Research on Cotton Technology, Mumbai

Targets	Achievements
Handling and processing *Kapas* for producing contaminant-free cotton	Extractor Cleaner for trashy cotton High productive commercial type Variable Speed Double Roller (DR) Gin Heap Maker
Standardisation of processing machinery for production of value added textiles from desi cottons	Improved computer controlled miniature Spinning System Village level Sliver Producing Machine Commercial processing at export mill of improved arboreum cottons
Fibre, yarn and fabric production and finishing process for long and extra long cottons and their blends	Blended yarn, fabric and garment from cotton blends with Wool/Ramie in cotton spinning systems Biochemical scouring of cotton textiles Enzymatic wax removal from cotton textiles Flame retardant finishing for upholstries and apron
By-product processing and utilisatio	Utilisation of ginning waste to produce absorbent cotton Value added products from cotton stalk, seed hulls and proteins Cotton plant stalk compacting machine (Different models) Pilot Plant for particle board preparation from cotton stalks

Targets	Achievements
Technology dissemination and services	Commercial Testing/ Characterisation of Cotton samples Training in Ginning, Quality Evaluation, Dissemination of Technologies : Compost from Ginnery Waste Biogas from Willow Dust Consultancy on Technologies Developed at CIRCOT Preparation of Standard reference materials for Cotton testing Creation of a Referral Laboratory for Cotton Textiles

NATIONAL INSTITUTE OF RESEARCH ON JUTE AND ALLIED FIBRE TECHNOLOGY

Targets	Achievements
Standardization of accelerated retting of jute with low volume of water	Retting process has been standardized by chemi-microbial process and this has also be well demonstrated in different jute growing areas.
Creation and maintenance of culture bank for jute and allied fibre crops	This activity has been initiated during Xth plan period to develop a collection of microbial strains – bacterial or fungal which can be used subsequently for retting, bio-pulping, bio-finishing, degumming etc. A sum total of 12 no. of bacteria and 24 no. of fungal strains were collected, purified and identified. These are efficient microbial agents for fibre extraction, fibre softening and other microbial processes.
Studies on physico-chemical properties of non-conventional fibres.	Physico-chemical properties of non-conventional fibres like khimp, date-palm, palm seed and banana were studied and the extent of their blendeability with jute for different end uses was assessed.
Development of technical textiles such as flame retardant textiles,	Jute-cotton blended fire retardant fabrics were developed and hand-gloves could successfully be made from the fabrics with LOI value around 30.
Studies on properties and utilization of Date Palm Leaf	Studies on physico-chemical properties of Date Palm Leaf were made. It was found that blend of date palm leaf with jute stick in 50:50 proportion is suitable for making particle boards. These boards can subsequently be used for false ceiling, wall paneling, partition wall. Pilot plant trials for making the doors were also completed.
Utilization of sisal leaf fibre in blend with jute for making decoratives and upholsteries.	Sisal fibre can be blended with jute in the jute processing system with some modification to make a wide range of products with good consumer appeal. The blended goods were lustrous and stronger of all jute goods and were suitable for making decorative products.
Development of manually	Besides the power driven jute ribboner some low cost

operated jute ribboner machine for marginal farmers	manually operated ribboner machine have been developed, tried and demonstrated.
Compaction of jute waste/agro residue by briquetting and generation of energy through subsequent gasification for thermal application.	Field demonstration of jute caddies briquettes has been conducted at Bakers Unit for firing the oven with the briquettes in place of conventional fibre woods.
Value addition of coconut fibre by admixing with jute for making diversified products	The problem of rigidity of coconut fibre can be overcome to a great extent by admixing with jute in 50:50 proportion and by processing in the jute system. The process has been standardized and newer avenues in utilization of jute may emerge by taking advantage of abundance of both the fibres and similarity of their physico-chemical properties.
Development of flush door by using jute stick particle board in the core and jute felt on the surface.	In collaboration with Institute of Plywood Research and Training a process of making flush door type of panels has been standardized by which costly teak wood can be eliminated to a great extent.
Geo-textiles for road construction.	It has been established that jute geo-textiles are ideal reinforcing fabric for enhancing life of roads particularly low volume roads. Jute polypropylene tubular fabric can also be used for the purpose and some stretches of roads have been constructed with jute geo-textiles in Port Blair, Kumargaon, W.B., Mohammad Bazar, Birbhum during the plan period.
Promotion of jute in apparel sector	It has been established that in contradiction with common motion, jute can well be used for making over-garments with suitable thermal insulation value and consumer appeal. Such fashion garments were distributed among the distinguished participants of Annual General Meeting of ICAR in the year 2005.
Use of black liquor for making hand-made paper from jute	Black liquor from paper mills contains a significant quantity of caustic alkali and when discharged may cause environmental problems. This liquor can well be reused for making hand-made paper from jute waste at a low cost.
Development of natural adhesive from lignin	Lignin derivatives have been developed which can supplement part of synthetic resin in adhesive formulation for making particle boards.
Modernization of measuring equipment and development of thermal insulation value tester	Measuring equipment such as bundle strength tester has been made more user friendly than at present through elimination of personal error and computerization. An universal thermal insulation value tester for fabrics and boards have been designed and developed to measure the warmth of fabric/boards.

Indian Lac Research Institute

Targets	Achievement
Productivity and quality improvement	Methodology including DNA isolation, PCR protocol, etc. has been standardized for lac insect characterization through RAPD profiles for reliable characterization of lac insect germplasm. Descriptors have been developed for the three major lac hosts, *palas* (*Butea monosperma*), *kusum* (*Schleichera oleosa*) and *ber* (*Zizyphus mauritiana*) for characterization. Four productive breeds of *kusmi* lac insect have been identified, multiplied and sold 92q of brood lac under Revolving Fund Scheme. Modified *kusmi* lac production technology was transferred through regular training programmes of the Institute.
Production improvement and crop management	*F. semialata* has emerged as a promising host for intensive lac cultivation under bushy condition. The net return from the first crop is about Rs 1.0 lakh per ha, which would increase in subsequent crops. *Prosopis juliflora* (*Ganda babool*) has been identified as a potential new host for *kusmi* lac production in the coastal region of Gujarat. The yield ratio of up to 1:6 (broodlac input : output) was recorded. Ethofenprox (Nukil 10 EC) has been found effective in the management of lac insect predators *Chrysopa* sp. and *Eublemma amabilis*. This can be integrated with application of endosulfan (Thiodan) and carbendazim as per requirement. Effectiveness of four egg parasitoids, *Trichrogramma acheae, T. ostrinae, T. exiguum and T. poliae* in suppressing the lac predators has been demonstrated in the field. Application of biopesticide, *Bacillus thuringiensis* sub sp. *kurstaki* (Delfin, 0.05%) controls lac insect predators on *rangeeni* and *kusmi* crops. The effectiveness of this pesticide is under FLD.
Processing and value addition	Comparative studies on the different physico-chemical properties of seedlac and shellac of various origins viz., Thailand, Indonesia, Chinese, and Indian revealed that Indian lac is superior especially, in respect of flow, heat polymerization time, colour index, gloss and bleach index. For cultivation operations Broodlac Placement Tool, Used up Broodlac Removal Tool, Modified Tree Pruner, Lac Scraper (hand-operated, pedal-operated and power-

	operated) have been developed. Post-harvest processing: Pedal/power-operated seed lac washing machine, hand operated lac grader and lac winnower developed. The technologies of manufacture of lac scraper and modified tree pruner, have been transferred to M/s National Enterprise, Ancillary Industrial Area, Hatia, Ranchi. Melting profiles by DSC could be utilized to understand quality of aleuritic acid and lac dye; UV-visible spectrophotometer could also be used for quality judgment of lac dye. Technology for preparation of bleached lac with superior keeping quality (up to 18 months at room temperature), has been developed.
Product development and use diversification	Two compositions of shellac based spiritless wood varnishes were developed. The technology of manufacture has been transferred to many entrepreneurs. Water thinnable shellac based coating composition has been developed for cementitious surfaces. The paint film on wall remained unaffected upto two and half years of its application (No flaking, peeling off and discoloration was observed).
Technology assessment, refinement and transfer	A pilot plat has been developed that can produce 2kg (maximum) of technical/crude grade lac dye from the washing of 400kg of sticklac.
Human Resource Development	Over 20,000 beneficiaries have been trained under different training programmes at the Institute and also in more than 200 places in ten different states viz., Jharkhand, A.P., M.P., Chhattisgarh, Orissa, Maharashtra, West Bengal, Gujarat, U.P., NEH region and Bihar. These included, farmers (in major numbers) besides Govt. officials of different states, entrepreneurs etc. Institute also provided training on manufacture of 11 lac based value added products to 29 entrepreneurs. The institute organized one winter school on lac cultivation, 3 kisan melas and 10 Symposia/seminars/meets related to lac cultivation, processing and consumption during 2002-03 –2005-06

	ILRI has opened lac sale counter to popularize the lac products developed. Besides, Lac information center and help line have also been established. A database containing the basic information on lac and lac technologies has been developed. A directory containing information lac processing units in the country has been compiled.

AICRP on FIM

Targets	Achievements
Survey of manufacturers and preparation of Directory	Survey was completed and directory compiled.
Development of light weight power tiller	Development of unit was completed.
Development of tractor mounted furrower	Development was completed and testing is continuing
Development of inclined plate planter for intercropping on raised bed farming system	Development was completed.
Development of two row and three row vegetable transplanter	Development was completed. Three row unit is under testing
Development of tractor mounted two row vegetable transplanter (plug type)	Developed and tested. Further testing is continued
Development of tractor mounted check-row planter cotton	Development and testing was completed. Refinement and further testing is continued
Development of power tiller operated air assisted seed drill	Development and evaluation was completed. PFT trials are continued
Development of zero till drill matching to power tiller	Zero till was developed and evaluated
Development of twin auger digger sugarcane planter	Development and testing is continue
Adoption of manual 4 row pregerminated paddy seeder for hilly region.	Evaluated seeder. Adoption trials are continuing
Development of tractor mounted multicrop planter	Development of planter is continuing.
Development of three row tractor mounted rotary weeder	Development was completed. Feasibility test is continued
Development of attachment for power tiller for sugarcane planted with 1.2-1.5 m row	Development and evaluation was completed. FLD trials to be continued
Development of walk behind type self propelled sprayer	Development and testing was completed
Adaptation of sprayers for orchard crops of hill	Adaptation and testing is

Targets	Achievements
region	continue
Adaptation of vacuum nozzle on power tiller mounted boom sprayer	Tested the sprayer with vacuum nozzle.
Development of sprayer for orchard crops	Development and evaluation of sprayer was completed
Development of tractor mounted air sleeve boom sprayer	Development and initial testing was completed. Further testing is continued.
Development of self propelled harvester for fodder crops.	Two types cutting mechanism developed and evaluated. Testing for main fodder crop is continued
Development of tractor mounted turmeric digger	The development was completed. Testing of machine is continue
Development of mechanical harvester for mango and sapota	Adaptation and testing is continued
Development of tractor mounted onion harvester cum elevator	Development of machine is continued
Development of power tiller operated potato digger	Development and testing is continued.
Development of high capacity pigeon pea thresher	Completed
Development of power operated maize dehusker-cum-sheller	Development and testing was completed
Development of arecanut sheller	Adaptation and testing is continued
Adaptation of maize sheller on power tiller	Feasibility testing is continued
Development of whole crop maize thresher	Development was completed. Testing is continued
Development of flail type chopper-cum-spreader for rice.	Refinement of unit and its FLD is continuing
Development of power-operated sugarcane leaf stripper	Development and evaluation was completed
Development of tractor mounted banana sucker remover	Development and preliminary evaluation was completed.

Targets	**Achievements**
	Further testing is continued.
Development of tractor mounted shredder-cum-incorporator for banana stem	Developed and evaluated. Further testing is continued
Adaptation of chipper shredder on power tiller	Equipment evaluated. FLD to be continued.
Development of groundnut combine	Development was completed. Testing is continued
Development of power tiller operated slicer cum incorporator	Development and preliminary testing was completed. Further trials are continued
Development of power tiller operated farm yard manure spreader	Development and initial testing was completed. Further testing is continued.
Development of tractor mounted slasher	Development was completed. Test trials are continue
Development of tree climber for coconut and arecanut	Developed and tested equipment
Development of instrumentation system for measurement of draft and speed	Development was completed. Testing is continued
Development of package of power tiller operated implements for groundnut cultivation	Package was developed and evaluated at farmer's fields
Development of package of power tiller operated equipment for major pulses and oilseeds	Package was demonstrated after feasibility testing
Development of package of power tiller operated euipment for vegetable crops and seed production	Package was identified and will be tested for vegetable crops
Tractor mounted rotavator (GBPUAT, MPKV, UAS, Dr PDKV, MPUAT, JNKVV, NDUAT, PAU, IISR, RAU, CIAE, AAU, KAU, OUAT, TNAU)	2044 ha
Manually operated low land rice seeder (IIT, TNAU, UAS, ANGRAU, RAU, CIAE, AAI, BAU, KAU, OUAT, AAU)	909 ha

Targets	**Achievements**
Self propelled 8 row rice transplanter (TNAU, NDUAT, CIAE, KAU, CCS HAU, AAU, JNKVV, GBPUAT, AAI, RAU, PAU, ANGRAU, IIT)	878 ha
Tractor mounted zero till drill (GBPUAT, NDUAT, PAU, AAI, CIAE, Dr. PDKV, JNKVV, CCS HAU, RAU, OUAT, TNAU)	4888 ha
Tractor operated strip till drill (PAU, GBPUAT, CIAE, AAI)	1610 ha
Tractor mounted sugarcane sett cutter planter (TNAU, MPKV, PAU, IISR, NDUAT, CCS HAU, AAI, GBPUAT, CIAE)	322 ha
Tractor mounted aeroblast sprayer (PAU, CIAE)	251 ha
Self propelled high clearance sprayer (Dr PDKV, UAS)	39 ha
Manually operated cono weeder (MPKV, IIT, TNAU, UAS, BAU, ANGRAU, CIAE, AAI, KAU, AAU)	70 ha
Power weeder (ANGRAU, CIAE, UAS, JNKVV, PAU, CCS HAU, OUAT, AAI)	70 ha
Self propelled vertical conveyor reaper (AAI, MPUAT, AAU, KAU, JNKVV, BAU, Dr PDKV, CIAE, IGFRI, MPKV, OUAT, GBPUAT, IIT, UAS)	783 ha
Tractor mounted vertical conveyor reaper (NDUAT)	564 ha
High capacity multicrop thresher (AAI, UAS, CIAE, CCS HAU)	1641 h
Hold on type paddy thresher (KAU)	260 h
Flow through paddy thresher (UAS, KAU, BAU, AAI, IIT)	1305 h
Groundnut thresher (TNAU, MPKV)	67 h

Targets	Achievements
Sunflower thresher (UAS, MPKV)	69 h
Horticultural tools (TNAU, AAI, BAU, CIAE, KAU, MPKV, HPKV)	131 Nos
Animal drawn puddler (AAU, BAU)	49 ha
Power tiller mounted leveler (ANGRAU, OUAT, NDUAT)	24 ha
Power tiller operated rotavator (NDUAT, HPKV, CIAE, MPKV, TNAU, OUAT)	101 ha
Tractor mounted clod crusher (NDUAT)	34 ha
Tractor mounted rotary puddler (JNKVV)	78 ha
Manually operated wheel hoe (NDUAT, CIAE, AAI, JNKVV, MPKV, UAS)	118 ha
Animal drawn inclined plate planter (UAS, JNKVV, IIT, MPKV, IIT)	28 ha
Four row animal drawn walk behind type rice transplanter (RAU	24 ha
Tractor mounted multipurpose equipment for sugarcane (IISR, OUAT)	133 ha
Raised bed planter (CIAE, CCS HAU, AAI, GBPUAT, RAU)	136 ha
Tractor operated roto till drill (CIAE, NDUAT)	59 ha
Tractor operated semi-automatic potato planter (NDUAT, AAI)	2416 ha
Tractor operated automatic potato planter (CCS HAU, PAU)	1331
Tractor drawn multicrop planter (UAS, CIAE, Dr PDKV, MPKV, NDUAT, OUAT, JNKVV, PAU)	171 ha

Targets	Achievements
Self propelled boom sprayer (PAU, ANGRAU)	42 ha
Tractor operated potato digger cum elevator (NDUAT, AAI, CCSHAU)	463 ha
Tractor operated straw combine (CIAE, PAU, JNKVV)	277 ha
Tractor operated straw baler (CIAE, PAU, NDUAT)	233
Multicrop thresher (5 hp) (BAU	144 h
Tractor operated post hole digger (AAI, CCS HAU, JNKVV, TNAU, PAU, OUAT, KAU)	4486 pits
Power tiller operated post hole digger (OUAT)	1100 pits

Prototypes fabricated during X Plan period

Manually operated	Animal drawn	Power operated	Total
17,317	774	486	18,577

AICRP on PHT

TARGETS	ACHIEVEMENTS
Development of prototypes	A continuous type coconut dehusker has been designed and fabricated by Kasargod centre. The unit has installed capacity of 50 nuts per hour without any breakage to the kernel with an efficiency of 90%. A vegetable washer has been developed by PAU Ludhiana centre. Bangalore Centre developed a pulp extractor for custard apple. Mechanically extracted pulp could be stored with preservatives for 6 months under refrigerated conditions. Kharagpur Centre developed an improved cashew nut sheller of commercial capacity. Testing was conducted with roasted cashew nut supplied from cashew processing plant Development of improved 3-pan furnace by IISR, Lucknow centre.

Development of value added products	A pilot plant for the production of tomato concentrate has been established by Coimbatore centre. It consists of various units such as pulper, boiler, steam kettle, etc. Tomato paste made from hybrid tomatoes in the steam kettle was packed in cans for storage studies. Samples were tested up to 24 months of storage. Vinegar production from sugarcane juice is studied. Bhubaneswar Centre developed RTS products syrup, jam, jelly from cashew apple and pineapple. Pantnagar Centre developed jaggery chocolates. Bhubaneswar Centre developed squash, RTS, jam and jelly from custard apple pulp. The products were packed in pet bottle, glass bottle and poly-pouches. Economic analysis showed that one glass bottle RTS (200 ml) cost Rs 4.25/-. Studies of prevalent practices of jaggery and khandsari and process development for herbal jaggery.
Utilization of byproducts / wastes	Enzymatic hydrolysis of apple pomace was studied for acid and alcohol fermentation. Bhubaneswar Centre reported that 30 ml stevia leaf extract was equivalent to 3 kg of sucrose in sweetness. Different methods od dehydration were studied to retain maximum colour, favour and sweetness. The process for preparation of extract from stevia leaves is being standardized. Bhubaneswar Centre developed squash, RTS, jam and jelly from custard apple pulp. The products were packed in pet bottle, glass bottle and poly-pouches. Economic analysis showed that one glass bottle RTS (200 ml) cost Rs. 4.25/-.
Feasibility testing of equipment / technology developed	The arecanut dehuskers of UAS, Bangalore and CPCRI, Kasaragod were field evaluated. Bhubaneswar Centre conducted feasibility study of CRRI dryer. Coimbatore Centre conducted feasibility analysis of vegetable washing machine developed by Ludhiana Centre. Bhubanesar Centre evaluated the performance of a zero energy cool chamber with respect to storage of specific fruits and vegetables. Kolhapur centre tested feasibility of hammer mill for jaggery powder making. The jaggery dried at 45^{o}C temp. for 5 h showed slightly better colour, particle fineness and lower moisture content.
On-farm evaluation of prototypes Frontline demonstration of technologies, machines and products	The turmeric boiler developed at Coimbatore Centre was refined and 3 no. of turmeric boilers were used in farmers' field. Kharagpur Centre demonstrated technology and products in a training programme on "Food processing technologies and fabrication of related machineries" during 13-16 Sept. 2005. The participants were trained for grain puffing, paddy parboiling in a new drum parboiler, dehydration of vegetables, preparation of

	tomato and chilli sauce, jam and tomato chutney.
Technology transfer and Commercialization of prototypes developed	A total of 11 no. of manual arecanut dehusker were sold among farmers by Bangalore Centre. Insect traps from TNAU Coimbatore centre has been licenced to one entrepreneur. An improved cassava rasper was developed and one unit was sold to M/s Vineesh Industries, Trivandrum.
Establishing of new Agro Processing Centre (APC) and monitoring of the existing APCs	3 APCs were managed by Self Help Groups of women by Bangalore Centre. A new APC was established with Ponmalar Women SHG at Selvarajapuram near Coimbatore. Bhubaneswar centre established an APC in Pipili. Processing activities continued at APCs by Akola, Bhubaneswar, Coimbatore, Junagadh, Ludhiana, Pantnagar and Udaipur Centres, An Organic Agro Processing Centre was established by Akola Centre at Nimkhad Bazar village (Amravati district, Maharastra state).
Nation-wide assessment of Post Harvest Losses of Crops / Commodities	An assessment of Post harvest losses of major crops and commodities is in progress by 33 Centres under the AICRP on PHT and would be completed by the end of the Plan period

AICRP on Renewable Sources of Energy.

Targets	Achievements
Commercialization of PAU farm solar dryer	MLT and ORP trials carried out. Design refinement under progress
Commercialization of PAU solar dryer	Now available commercially.
Commercialization of walking type solar tunnel dryer	Systems for various applications under operation at selected locations.
Commercialization of high efficiency solar air heater	ORP trials under progress
SPV refrigerator.	Commercialized
Commercialization of Horizontal flow biogas plant	System operating at selected locations.
Demonstration of biphasic anaerobic systems for vegetable market waste at selected towns/locations.	3t/day plant under operation at Anand (Guj.) Two 10t/day plants are under installation.

Commercialization of family size solid state cattle dung based biogas plant.	Design finalized and submitted to MNES for approval.
Popularization of acid rich liquor on agro residues for biogas generation.	Demonstration plant installed at selected locations.
Demonstration of high rate digestion of agro industrial effluent.	Plants installed in a sago industry and a commercial dairy.
Refinement and field demonstration of solid state anaerobic fermentation of crop residues.	Field evaluation under progress.
Refinement and demonstration of technology for drying and enrichment of biogas plant digested slurry.	Technology has been developed.
Development of technology and pilot plant for conversion of crop residues to alcohol.	Technology has been developed.
Development of crop residues based gasifier system for engine operation.	Gas cleaning system has been developed and is under MLT.
Commercialization of agro residues based gasifier for thermal applications.	Technology development under progress.
Design refinements and field evaluation of bagasse based gasifier for thermal applications.	Field demonstration under progress.
Design refinements and demonstration of coir pith based gasifier for thermal applications.	Field demonstration carried out in a selected industry.
Refinement and demonstration of technology for pre-conversion and preparation of biomass for energy carrier.	System has been developed/ procured and trials are under progress.
Demonstration of stand alone renewable energy system for power supply in a village.	Installation of a system is under progress.

AICRP on Application of Plastics in Agriculture, CIPHET, Ludhiana

Targets	Achievements
Standardization of surface covered structures and environmental control measures under different agro-climatic conditions.	**Low cost bamboo greenhouse for crop production.** Raw materials required are whole split bamboos and normal carpentry tools for its construction. It is covered with UV stabilized film of 200 micron. The cost of the construction is about Rs. 80/sq m.
Development of environmental control measures and cost effective gadgets/equipments to enhance the production of aquaculture	**Portable FRP Carp Hatchery for commercial seed production** It is portable, easy in fabrication and requires less water. The capacity is 1.1.2 million eggs/operation and the cost is approximately Rs. 20,000/-. **FRP & HDPE floating cages for commercial fish culture.** Best suited for fish culture in large water bodies like reservoirs, lakes etc. It is easy to fabricate, higher fish production, eliminates predators and easy harvesting. The cost of one HDPE cage is Rs.550/sq.m while for FRP cage it is Rs.500/sq.m. **Pools of translucent FRP for fish rearing.** It is cheap and has got high employment potential. The cost of pool is Rs. 3/litre capacity. **FRP seed rearing tubs for catfish culture.** It is easy to fabricate, portable and easy in operation. The cost for 600-liter capacity is Rs. 4200/ **Closed loop water filtration unit for aquarium.** It is corrosion and abrasion resistant and the cost for 24-liter capacity is Rs. 5500/-. **Open enclosure breeding system for craps.** It is portable and cheap. The cost for 1800 litre is approximately Rs. 13,000/-.

Low cost equipment for water and nutrient management	**Low cost plastic lined tanks** The tanks of small capacity are very much useful in hilly regions for water harvesting. In Almora, several LDPE tanks were constructed at farmers field. The cooperative centre at Almora provided the technical support, supervision and LDPE film. Low tunnels were used successfully for growing of nurseries of vegetables like tomato, capsicum, cabbage, cauliflower. chilli etc and earliness of 13-15 days was observed as compared to open depending upon the crop which was helpful for off-season cultivation of vegetables. Covering the crop with low tunnels during extreme cold period (Dec-Feb) resulted in significant higher yield in the crops like chilly, strawberry, tomato. A low capacity screen filter was designed and developed for micro irrigation system in Greenhouse cultivation. A low cost equipment was developed for nutrient management through micro irrigation system.
Refinement of technologies for efficient post harvest management of fruits, vegetables and flowers	**Standardization of agro-techniques for strawberry cultivation**. A complete package of practice which include cultivars, mulch, planting date, fertigation and irrigation schedule, pest management etc have been worked out for Abohar region. Farmer after taking training are successfully growing strawberry in their fields, and earning Rs. 0.85-1.00 lakhs/ acre. Package and practices for the crops like tomato, capsicum, broccoli, red cabbage, chilli, cucumber, been worked out for different agro ecological zones which includes date of planting, irrigation and fertigation schedule, pest management, environmental control etc.
Controlled atmosphere storage structures and packaging for perishables	Studies on packaging of selected fruits and vegetables conducted at CIPHET, Abohar and revealed that Shrink wrapping of kinnow fruit drastically reduced the weight loss as compared to unwrapped fruits. *Acidity and ascorbic acid decreased while total soluble solids increased during storage.* *Changes in biochemical composition were almost inconsistent for different plastic films. However, plastic film (LDPE) with least thickness (20 and 25μ) was found to be worthwhile proposition for individual shrink wrapping of kinnow fruit due to their delaying effect on fruit deterioration.* The results indicated that shrink wrapped fruit stored at low temperature could be kept up to ten weeks as against four weeks at ambient condition.

Alternate plastic material for agricultural machines/equipment	**Plastic hopper for multi crop planters.** Plastic hoppers are three times lighter than the metallic hopper. The cost of hopper of a manual planter is Rs. 170/unit while for power tiller operated planter it is Rs. 208/unit. **Plastic thermocole beehives.** Wooden components were replaced by plastic sheet. Thermocole was used as an insulating material. Cost of beehives (56cmx41cmx24cm) is Rs. 2500/-.
Human resource development and transfer of technology.	Scientists and technical are getting training when they needed
Application of greenhouse to enhance the agriculture and aquaculture production	**Poly house for rearing of fish during low temperature periods.** It is suitable for maintaining food stock of fish procured during winter periods. The cost is Rs. 385/-sq.m. A study on Application of greenhouse for drying onion slices has been conducted at CIPHET, Abohar and it was found that the overall acceptability was found better in the samples pretreated with 0.3 % KMS followed by 0.5 % NaCl and control. The slices dried in forced ventilated polyhouse gave better acceptability with better rehydration ratio followed by slices dried in low cost polyhouse with chimney and open sun drying.
Development of techniques and devices for transportation and handling of fishes.	**FRP transportation tank for live fishes.** It is useful for transportation of large quantity of live fish seed and brood fish for long distances and simultaneously provides higher income to the farmer by selling live fish in the market. The cost for 1280 litre capacity FRP transportation tank is Rs. 4600

AICRP on Ergonomics and Safety in Agriculture

Targets	Achievement
Data on agricultural accidents in 4 states (Madhya Pradesh, Tamil Nadu, Orissa, Punjab)	Agricultural accident data from 3 states have been collected and survey for accidents in Punjab is in progress.
Development and evaluation of 6 safety gadgets and their evaluation	Four safety gadgets namely safe feeding chute for sugarcane crusher, greasing tools for gears of crusher, bagasse removal tool from rollers of crusher and turning indicator system for tractor trailer have been developed.
Information collection and report preparation from various states	Report prepared and submitted to DOAC for consideration.
Information collection and report preparation from various states	Report prepared and submitted to DOAC and State Govts. for consideration.
23 demonstration/ training programme	16 demonstration/ training programmes were conducted.

Fabrication and supply of 12 units	Eleven units got fabricated and supplied to organizations for use in data collection work.
Data on 7000 workers	Anthropometric data and strength data have been collected for 5250 workers (2980 male and 2270 female). Work is in progress.
12 equipment to be ergonomically evaluated/ refined.	Eight equipment were ergonomically evaluated and refined. These are Eight row paddy seeder, Cono weeder, Self-propelled reaper windrower, Diaphragm pedal pump, Six row paddy transplanter, Sugarcane stripper, Wheel hoe and Garlic planter.
16 equipment equipment to be ergonomically evaluated/ refined.	Thirteen equipment were ergonomically evaluated to assess their suitability for farm women and refined wherever necessary. These are Push-pull type weeder, Eight row and four row paddy seeders, Cono weeder, Groundnut stripper, Cotton stalk puller, Fruit harvester, Four row paddy transplanter, Two row paddy transplanter, Sugarcane stripper, Pedal pump for irrigation, Hanging type grain cleaner, Hand ridger.
Data on tractor and power tiller	Studies have been carried out on two makees of tractors and two makes of power tillers and base data on vibration and noise aspects have been generated. Vibration isolators for tractor seat as well as for power tiller have been developed and evaluated.
50 demonstrations of seven equipment	Work is in progress.

AICRP ON UAE

S. No.	Particulars(s)	Targets	Achievements upto 2005-06*
1.	Village Saturation Programme of Improved Animal Drawn Equipment	No. of Villages to be covered= 40 No. of Farmers to be covered = 500	35 454
2.	Front line Demonstrations of Improved Animal Drawn Equipment	a) No. of Demons-trations = 200 b) Area coverage = 200 ha c) No. of beneficiaries = 2000	154 170 1866
3.	Rotary Mode Operations of Draught Animal with Selected Gadgets	a) No. of rotary setups =12 b) No. of matching gadgets to be evaluated =08	10 08
4.	Mass Production and Commercialization of	a) Type of equipment = 15 b) No. of prototypes to be	12 3642

	Improved Animal Drawn Equipment	fabricated = 3500	
5.	Testing and Design Refinements	a) No. of equipment to be tested = 08 b) No. of test trials = 200	08 194
6.	Draftability Studies of Non Descriptive Breeds of Bullocks	No. of animals =16	12
7.	Feed Management of Draught Animals	No. of feed management studies = 14	12

* The targets fixed will be fully achieved as the approved activities are well in progress during 2006-07.

8. ANIMAL SCIENCE

STATUS REVIEW

Livestock plays a crucial role in the economy of the country. In spite of poor infrastructure, low investments and resource poor stakeholders in this sector, livestock has provided sustainability and stability to Agricultural Production as a whole. While the annual growth rate for agricultural crop sector has been even negative for some years in the last decade, the overall average of 2.5% growth in total agriculture is mainly because there has been a consistent annual growth of more than 4% in the livestock sector. The contributions of Agriculture to National GDP have substantially decreased over past decade, but the contributions of livestock remained consistent between 27 to 32% of agriculture GDP. The contribution from milk sector alone (90,358 crores) is higher than wheat (51,002 crores) and sugarcane (30,988 crores). Animal Husbandry provides self-employment to millions of household in rural areas. A large manpower is also involved in livestock related activities. The export earning from livestock sector has shown an annual growth of 12%.

Total Factor Productivity growth study shows that the highest economic returns have been seen in investments made in livestock sector with a significant contributions coming from impact of research. **Technologies supported and demand driven Livestock sector will be the future engine for growth to ensure nutritional security and livelihood of landless rural poor below the poverty line. This demands a paradigm change in agricultural production and research concepts.**

Considering the overwhelming evidence that sustainability in agriculture is through livestock and that the issues of poverty alleviation, nutritional security, rural employment, women empowerment, particularly among the resource poor farmer can best be addressed through livestock, there should be a policy shift to greater financial, infrastructure and program support to this sector. Therefore, future agriculture research priority should involve intensification of programs in this sector.

The allocation of funds for Animal Sciences research in ICAR has not been in conformity to what this sector demands/deserves. This sector contributes 29% to the total agriculture GDP, but in terms of allocation it has received 7-14% of the ICAR funds for research, which has decreased over years. Several of animal science programs have not taken off for want of adequate infrastructure and research fund support, a situation that needs to be changed with higher sectoral allocation.

CRITICAL RESEARCH REVIEW

To achieve the productivity targets, there is an urgent need for reorientation of research programs. Emphases need to shift on assessing the genetic potential of indigenous breeds, which of late have been found to be highly productive once given suitable management and environment. The classification of animals as dairy breeds will therefore have to be revised. Intensive research work needs to be undertaken for genetic identification of traits of excellence in Indian breeds, like Jaffarabadi buffalo, Black Bengal goat, Garole sheep etc. and identify the functional genomic associated with their trait of excellence. The biodiversity existing in the domestic livestock needs to be investigated using molecular tools which should involve the transfer of major genes associated with production excellence, tropical adaptability to diseases and stress resistance.

With large quantities of animal products now being produced, the research on process technologies, value addition, packaging, storage, transportation and marketing should receive high priority for intensive research. Quality assurance of animal products for domestic markets and for export, particularly in the changed international scenario, needs added emphasis. In the absence of any proper slaughter regime, there is considerable wastage in meat production and the losses up to 30% could be saved through organized rural slaughter house system for which necessary research back up in terms of slaughter- house design, hygienic meat production, quality control and marketing needs to receive added attention. Male buffalo and cattle calves suffer acute neglect and this results in great wastage. Effective package of practices for management to slaughter age need to be evolved. Prevention of animal losses due to disease should be the major area of focus with emphasis on development of diagnostic kits and vaccine. The health of the human population is intimately connected to the health of the animal with several fatal and debilitating diseases being common to man and animal. A serious attention to animal health care, disease diagnostic and prophylactic will go a long way in ensuring human health also.

With endemic shortage of animal feeds to the extent of about 40% annually in the livestock sector, research efforts should be to utilize greater amount of agricultural by- products and straws for animal feeding. Technologies to augment feed resources including the genetic modification of microorganism to utilize high lignin forage grasses are required to be developed. There should be research efforts to support intensive animal production.

Since the biotechnological research and its application in animal production and health has remained segmented, there is urgent need to have a comprehensive program on buffalo genome, genomic for high fecundity, transgenic for modification of milk, growth, fiber and hair, and manufacture of pharmaceuticals, vaccines and diagnostics.

Market opportunities for livestock sector following the policy of economic liberalization of the government of India, the value of livestock output has grown by over 5.5% per year since early 90s and there are expectations of even faster growth as the demand for livestock products is increased. The sector's ability to capitalize on new market opportunity is constrained by the availability of infrastructure and research support for quality genetic material production and animal health system.

In the concepts of development and sustainability, it is, therefore, essential that **livestock be considered the real estate around which the future agricultural development should be based**.

CRITICAL EVALUATION

There is extreme duplication in research agenda of the institutes specially in the areas of conservation, evaluation and identification of germplasm, Animal genetics & Breeding and Animal Nutrition which need to be thoroughly looked into and need to be avoided. Those programs, which are not close ended and have lost reference in light of modern techniques and technology and also stake holders expectations, need to be dropped. Also the formation of discipline-oriented institutions should take up any of the residual programs, which are essential. These species specific institutes therefore, have to do an exercise that such overlapping are avoided, particularly, if such programs do not come under such basic research and have limited applied research identity. Species improvement program should be in a holistic manner and not to be restricted to the genetic and breeding. All should be encompassing to nutrition, health, and production.

A large number of research advances and technologies have been claimed as achievements and some of them appear to be very promising particularly in the light of field problem and stakeholders demand, which need to commercialized on priority basis. Active research on these programs on advances made so far will remain more beneficial to the system than continuing and amending research efforts done. Such identified programs need to be discontinued further, kept in abeyance and the results obtained so far be implemented in certain research mode and on basis of action research the results, borne out of targeted improvements be reshaped and recommended wherever necessary and suitable for continuation.

RESEARCH THRUST

- Productivity Enhancement and Management of Animal Genetic Resources through development of methodologies and technologies for conservation and improvement of indigenous livestock and poultry breeds for high yielding strains for milk, meat and fiber through crossing and selection, fertility using newer embryo biotechnological tools, marker assisted selection to improve disease resistance (small ruminants – parasitic diseases) & fertility and buffalo genomics.

- Manipulation of rumen ecosystem for improving digestibility of low quality roughages, Isolation of cellulose gene; rumen fungi and fungi from wild animals, bio-availability of nutrients and micronutrients, improvement and utilization of local feed and fodder resources, cereal straws and other agro-by products, identification of newer feed resources and development of complete rations for different categories of livestock and poultry, elimination of anti-nutritional factors in feed resources to allow their high utilization, use of additives, supplements and probiotics for efficient utilization of straws.

- ❖ Animal disease modeling and forecasting to develop strategies for their control, development of diagnostics and immuno prophylactics using molecular techniques and strengthening prophylactic measures for livestock diseases, including emerging, exotic and zoonotic diseases, intervention of newer generation drugs and indigenous drug formulations for various diseases, environment pollutants, industrial toxicants, mycotoxins and mycotoxicosis, characterization and use of animal microbes for development of diagnostics& vaccines and improving quality and efficacy of products and repository of animal microbes.

- ❖ Development and improvement of processing technologies for value addition; quality assurance; shelf life and reducing cost of packaging and prevention of losses, livestock production for sustainable livelihood; social impact of livestock production and technologies on productivity and economic empowerment of livestock farmers, pricing, marketing, processing and trade strategies/policies; institutional credit and policy support for accelerated livestock development.

- ❖ Human Resource development through sstimation of manpower need for livestock research, education, research education and training, research and training priorities for animal husbandry extension and economics and clinical education as PG Research

NEW INITIATIVES

In order to maintain the growth rate and global situation and also to meet sanitary and phyto sanitary requirements, it is necessary to establish some the of National reference laboratories along with BSL-III level containment facilities. Certain research areas like genomic, vaccines, diagnostics & drugs, environmental pollutants, contaminants & toxicants zoonotic diseases, ethno-veterinary medicine, repository of micro-organisms, methane production etc. in network mode fare required to be undertaken. In addition, programmes of diversification of nutrient sources in animal feeding for intensive production, market intelligence, economic pricing and marketing of Livestock Products, dry land productivity and production augmentation in livestock, feed processing and feed Quality improvement and rural & backyard poultry production are important to be considered.

RECOMMENDATIONS

After critical analysis of the achievements and the requirements of this sector, the sub-group on animal science is proposing following recommendations.

A. RESEARCH

Recommendation No. 1:- Strengthening of the on-going activities/schemes/ programmes

In view to sustain the livestock production and productivity it is pertinent to strengthen the institutions and the activities already being carried out under various programs/schemes. In addition, new initiatives need to be undertaken to meet the international requirements in terms of the risk assessment and management, Sanitary and Phyto- sanitary and Codex Alimentarius requirements. Following allocations for different institutions/schemes have been recommended to implement the various activities during the XI plan.

S. No.	Institutions/schemes/programmes	XI Plan allocation (Rs. In Crores)
1.	National Bureau on Animal Genetic Resources	20.00
	Network project on Animal Genetic Resources	15.00
2.	National Dairy Research Institute, Karnal including R&D support and Pilot project on IRD	80.00
3.	Central Sheep & Wool Research Institute, Avikanagar`	25.00
	Network Program on Sheep Improvement	15.00
4.	Central Institute for Research on Goats, Makhdoom	25.00
	AICRP on Goat Improvement	15.00
5.	Central Institute for Research on Buffalos, Hisar	25.00
	Network Project on Buffaloes Improvement	25.00
6.	National Institute of Animal Nutrition & Physiology, Bangalore	30.00
	AICRP on Improvement of Feed Sources & Nutrient Utilization for raising Animal Production.	20.00
7.	NRC on Camel, Bikaner	20.00
8.	NRC on Equines, Hissar	25.00
	Veterinary Type Culture	25.00
9.	Project Directorate-Cattle, Meerut	15.00
	AICRP on Cattle Research	25.00
10.	PD on Foot & Mouth Diseases including AICRP	30.00
11.	Central Avian Research Institute, Izatnagar	25.00
	PD-Poultry, Hyderabad	15.00
	AICRP on Poultry	25.00
12.	Indian Veterinary Research Institute, Izatnagar	85.00
	Network on Gastro Intestinal Parasitism	20.00
	Network on Hemorrhagic Septicemia	
	Network program on Bluetongue Disease	

	PD on Animal Disease Monitoring & Surveillance including AICRP	25.00
13.	NRC on meet and meat products technology, Hyderabad	25.00
14.	NRC on Pig, Guwahati	25.00
	AICRP on Pig	20.00
15.	NRC on Mithun, Jharapani, Nagaland	20.00
16.	NRC on Yak, Dirang, Arunachal Pradesh	20.00
	Total	**740.00**

Recommendation No. 2:- New initiatives to be undertaken

I.	**Establishment of Infrastructure**	
a.	Establishment of National Referral laboratories • National reference laboratory for semen evaluation • National Reference Lab. for Feed & Feed Ingredients • National Reference Lab. for Quality Assurance in Livestock Products	60.00
b.	Establishment of Bio-safety level-III containment laboratories	150.00
c.	Establishment of International Reference Laboratory for FMD	20.00
d.	Establishment of new campus of Central Avian Research Institute	60.00
	Total (I)	**290.00**
II.	**Establishment of Institutes/Centres/ Network programmes**	
a.	Network on Animal Genomics	100.00
b.	Network on Livestock related Environmental pollutants, contaminants & toxicants	70.00
c.	Network on Zoonotic diseases of public health significance	10.00
d.	Network on Ethno-Veterinary Medicine	10.00
e.	Network on development of newer generation diagnostics, vaccines and drugs	80.00
f	Centre for Animal Disease Research & Diagnosis (CADRAD), IVRI to Institute on Animal Disease Research & Diagnosis.	45.00
g.	Network on Methane production & Nutrient Utilization	20.00
h.	Establishment of Institute on Animal Virology	55.00
i.	Network on Repository for livestock microorganism	25.00
j.	Network on Epidemiology and surveillance for diseases in Wild life	10.00
k	Institute on Health and management of Pet animals	15.00
	Total (II)	**440.00**
III.	**Programmes**	
a	Diversification of nutrient sources in animal feeding for intensive production	10.00
b	Market intelligence, economic pricing and marketing of Livestock Products	25.00
c.	Dryland productivity and production augmentation in livestock	75.00

d.	Feed processing and feed Quality improvement	10.00
e.	Rural & Backyard poultry production programme	15.00
	Total (III)	**135.00**
	(Total – I+II+III)	**865.00**

Recommendation No.3: Upgradation/modification of the Project Directorates/ National Research Centres

In view of the significant contributions made by different institutions and based on QRT recommendations duly approved by GB, ICAR, is recommended for upgradation/modification.

a. National Research Centre on Equines (NRCE) to Equine Research Institute (ERI)
b. Veterinary Type Culture (VTC) –an integral part of NRCE, Hissar to independent Institute on Veterinary Type Culture (IVTC)
c. Project Directorate on Cattle (PDC) to Central Cattle Research Institute (CCRI)
d. Project Directorate on Animal Disease Monitoring and Surveillance (PD-ADMAS) to Institute on Animal Disease Monitoring and Surveillance (IADMAS)
e. Project Directorate on Foot and Mouth Disease (PD-FMD) to Institute on Foot & Mouth Disease (IFMD).
f. Project Directorate on Poultry to Rural Poultry Research Institute (.RPRI)
g. High Security Animal Disease Laboratory (HSADL) to independent institute on High Security Animal Disease (IHAD).
h. Centre for Animal Disease Research & Diagnosis (CADRAD), IVRI to Institute on Animal Disease Research & Diagnosis.

Recommendation No. 4:- Consolidation of Foot & Mouth activities.

In view of the disease situation it would be pertinent to consolidate all the activities being carried out by IVRI & PD-FMD at one place by transfer of the H/Q of PD-FMD from Mukteswar to Bangalore as per the recommendation of the QRT and approved by GB,ICAR. This would also meet the requirement for the International Referral laboratory for SAARC Region designated by Govt. of India and would be helpful in better utilization of financial and human resources. This new organized infrastructure would undertake in addition to the epidemiology including molecular epidemiology the activities of vaccine research and quality assurance.

Recommendation No. 5:- Competitive Grant Research Schemes

In recent past AP Cess fund schemes were being implemented which were being implemented through different institutions, veterinary and agriculture Universities in the important areas of research in order to bridge the critical gaps. But due to the discontinuation of such schemes it is now difficult to support such proposals. This activity has made significant achievement in the recent past. Therefore, in order to promote and stream line similar activities during this plan, it is recommended that the scheme may be implemented on the lines of AP Cess fund with a total outlay of **Rs. 150 Cr.**

B. ANIMAL SCIENCE EDUCATION

Education through internet has become a part of modern knowledge delivery and technique acquisition. Alternate use of animal demands to have virtual labs. in the pre and Para-clinical fields. For this purpose, such virtual classrooms need to be set up in each veterinary and animal science institution.(40x1 **= 40 cr)**

Recommendation No. 6:- Revitalizing the infrastructure for Veterinary and Animal Science and critical allied disciplines:

Over the years, Indian Council of Agricultural Research has considerably strengthened agricultural education by financial support to the constituent universities. While in some of the universities, the funds have been adequate, but in most of the veterinary colleges, the flow of funds within the university had not been in accordance with the priorities and needs of the veterinary and animal science faculty.

To ensure excellent human resource development that would meet the demands of global competitiveness and meet highly competent professional requirements for modern livestock production as well as trading the knowledge of our graduates in international standards, a higher investment is proposed as follows:

a. Building Repair and re-constructions:**(40x5 cr each=** 200 Cr).
b. "State of Art" Demonstration/Instruction including instructional livestock farms and livestock product processing Units: **(40 x 2 = 80 cr.) for development and 40x.0.5 cr x for 5 years annual maintenance =100 cr**. total -180 cr.)
c. Super specialty veterinary clinical institution: . (2x60 cr = **120 cr.)**

Recommendation No. 7:- Clinical Complexes in Veterinary Institutions:

The performance of the veterinary institutions is reflected through the type of clinical facilities and expertise developed among the professionals undergoing training. The present state of clinical facilities in most of the colleges is apologetic and needs a complete change both in terms of infrastructure as well as the quality equipments and services available. (30x4 = 120 cr.)

Recommendation No. 8:- Strengthening teaching faculty:

Though providing the faculty is primarily through the State Govts., but over the years it has been observed that the State funding is not available for providing faculty positions in the new frontier areas of science which essentially need to be part of the educational curriculum. Under these circumstances, strengthening of teaching faculty is paramount for new areas which are being included in the student curriculum.(40x1 = 40 cr.)

Recommendation No. 9:- Capacity Building in Veterinary Science Teaching:

In the absence of specialized Veterinary and Animal Science training/teaching Institutions in the country and considering the fact that considerable advancement in science and technology has occurred world over in the clinical and production sciences, the present faculty need re-training in advanced specialized training institutions outside and inside the country. For this purpose, a special faculty improvement program with short and long-term training outside the country in collaboration with advanced institutions in the developed world need to be initiated. At least 15 teaching faculty members from the institutions need to be deputed during the next five years (40 cr.)

Recommendation No. 10:- Teaching Assistance Program for Capacity Buildings in Veterinary Colleges.

The acute shortage of manpower in Veterinary Institutions need to be met immediately through liberalized entry into the veterinary teaching. Outstanding Graduates from each college be offered positions of teaching assistance at emoluments at part with the first entry level for the scientists and they be allowed to pursue their Masters program in service (to be completed within five years). This is to ensure that academic brilliance is ploughed back into teaching /research- an area which is a major concern for modern education.(40 cr.)

Recommendation No.11:- Centre of Excellence in Animal science Education :-

In order to meet the training needs of Veterinary teachers in various veterinary colleges it is recommended to create Centre of Excellence should be established. (40 Cr.)

Recommendation No. 12:- Attract trained personnel for teaching and research as testing/Research Associate:

In order to attract trained manpower also to avoid brain drain who have obtained Doctoral/Research experience within the country and outside back to our teaching institutions, it is essential that we should have certain positions ear-marked in each institution so that such manpower which is eager to return back to the country or ready to serve the education/research areas, have a window to enter the NARS. These officers be offered pay-scales equivalent to S-2 with an entry basic salary of basic 12,000/-with an initial tenure of five years. It is proposed that five such positions in different disciplines be available for each of the colleges/institutions.(20 cr.)

Recommendation No. 13:- Fellowships/Scholarships:

To attract students for professional career in veterinary science education as well as post-graduate teaching and research, it is essential that we should provide additional fellowships/scholarships both at under-graduate and post-graduate level for all the veterinary institutions.. **(60 cr.)**

C. ANIMAL SCIENCE EXTENSION

Recommendation No. 14:-Veterinary Extension Education:

At present the extension activities are not so developed to transfer the technologies to the farmers sufficiently and at the same time KVK's already existing are also not meeting the demands, therefore, at initial stage 100 such Pashu Vigyan Kendras including livestock demonstration farms for hands on training need to be set up in districts under the livelihood programme with an overall proposed allocation of **Rs.1000 cr .**

D. PROGRAMMES TO BE MODIFIED/PHASED OUT/RE-ORGANIZED

There is extreme duplication in research agenda of the institutes, which need to be thoroughly looked into and need to be avoided. Following areas have been recommended to be critically evaluated and rectified.

Recommendation No. 15:- Conservation, evaluation and identification of germplasm is mentioned as an objective of all the institutes and also the main mandate of NBAGR which is also targeting all the species particularly those, for which there are species specific institutes. The programs under this area therefore need review for the clear delineation of the institute activity vis-a-vis NBAGR.

Recommendation No. 16:- In the discipline of Animal genetics & Breeding, Animal Nutrition programs have been undertaken at certain applied aspects which have had long innings and associated with the large components and scientific personnel. These programs, which are not close ended, and have lost reference in light of modern techniques and technology and also stake holders expectations, need to be dropped. Also the formation of discipline-oriented institutions should take up any of the residual programs, which are essential. These species specific institutes therefore, have to do an exercise that such overlapping are avoided, particularly, if such programs do not come under such basic research and have limited applied research identity.

Recommendation No. 17:- A large number of research advances and technologies have been claimed as achievements in the institute reports. Some of them appear to be very promising particularly in the light of field problem and stakeholders demand. Active research on these programs on advances made so far will remain more beneficial to the system than continuing and amending research efforts done. Such identified programs need to be discontinued further, kept in abeyance and the results obtained so far be implemented in certain research mode and on basis of action research the results, borne out of targeted improvements be reshaped and recommended wherever necessary and suitable for continuation.

Recommendation No. 18:- Species improvement program should be in a holistic manner and not to be restricted to the genetic and breeding. All should be encompassing to nutrition, health, and production.

SUMMARY OF FINANCIAL REQUIREMENTS DURING XI PLAN FOR ANIMAL SCIENCE RESEARCH

S. No.	Programmes/Schemes/activities	XI Plan Requirement (Rs. In Crores)
A.	**RESEARCH**	
1	On-going programmes/ schemes- Strengthening of the infrastructure development including upgrading the proposed institutions	740.00
2	New initiatives	
	Establishment of infrastructures	290.00
	Establishment of Institute/Centre/Network programmes	440.00
	Programmes	135.00
3	Competitive Grant Schemes	150.00
	Total for Research (A)	**1755.00**
B.	**EDUCATION**	
3	Veterinary Education	950.00
	Total for Education (B)	**950.00**
C.	**EXTENSION**	
4	Veterinary Extension Education	1000.00
	Total for Extension(C)	**1000.00**
	Grand Total (A+B+C)	**3705.00**

CHAPTER- I

INTRODUCTION

- Livestock plays a crucial role in the economy of the country. In spite of poor infrastructure, low investments and resource poor stakeholders in this sector, livestock has provided sustainability and stability to Agricultural Production as a whole.

- While the annual growth rate for agricultural crop sector has been even negative for some years in the last decade, the overall average of 2.5% growth in total agriculture is mainly because there has been a consistent annual growth of more than 4% in the livestock sector.

- The contributions of Agriculture to National GDP have substantially decreased over past decade, but the contributions of livestock remained consistent between 27 to 32% of agriculture GDP. The contribution from milk sector alone (90,358 crores) is higher than wheat (51,002 crores) and sugarcane (30,988 crores).

- Animal Husbandry provides self-employment to millions of household in rural areas. A large manpower is also involved in livestock related activities.

- The export earning from livestock sector has shown an annual growth of 12%.

- Total Factor Productivity growth study shows that the highest economic returns have been seen in investments made in livestock sector with a significant contributions coming from impact of research. **Technologies supported and demand driven Livestock sector will be the future engine for growth to ensure nutritional security and livelihood of landless rural poor below the poverty line. This demands a paradigm change in agricultural production and research concepts.**

- Considering the overwhelming evidence that sustainability in agriculture is through livestock and that the issues of poverty alleviation, nutritional security, rural employment, women empowerment, particularly among the resource poor farmer can best be addressed through livestock, there should be a policy shift to greater financial, infrastructure and program support to this sector. Therefore, future agriculture research priority should involve intensification of programs in this sector.

- The allocation of funds for Animal Sciences research in ICAR has not been in conformity to what this sector demands/deserves. This sector contributes 29% to the total agriculture GDP, but in terms of allocation it has received 7-14% of the ICAR funds for research which has decreased over years. Several of animal science programs have not taken off for want of adequate infrastructure and research fund support, a situation that needs to be changed with higher sectoral allocation.

- To achieve the productivity targets, there is an urgent need for reorientation of research programs. Emphases need to shift on assessing the genetic potential of indigenous breeds, which of late have been found to be highly productive once given suitable management and environment. The classification of animals as dairy breeds will therefore have to be revised. Intensive research work needs to be undertaken for genetic identification of traits of excellence in Indian breeds, like Jaffarabadi buffalo, Black Bengal goat, Garole sheep etc. and identify the functional genomic associated with their trait of excellence. The biodiversity existing in the domestic livestock needs to be investigated using molecular tools which should involve the transfer of major genes associated with production excellence, tropical adaptability to diseases and stress resistance.

- With large quantities of animal products now being produced, the research on process technologies, value addition, packaging, storage, transportation and marketing should receive high priority for intensive research. Quality assurance of animal products for domestic markets and for export, particularly in the changed international scenario, needs added emphasis. In the absence of any proper slaughter regime, there is considerable wastage in meat production and the losses up to 30% could be saved through organized rural slaughter house system for which necessary research back up in terms of slaughter- house design, hygienic meat production, quality control and marketing needs to receive added attention. Male buffalo and cattle calves suffer acute neglect and this results in great wastage. Effective package of practices for management to slaughter age need to be evolved. Prevention of animal losses due to disease should be the major area of focus with emphasis on development of diagnostic kits and vaccine. The health of the human population is intimately connected to the health of the animal with several fatal and debilitating diseases being common to man and animal. A serious attention to animal health care, disease diagnostic and prophylactic will go a long way in ensuring human health also.

- With endemic shortage of animal feeds to the extent of about 40% annually in the livestock sector, research efforts should be to utilize greater amount of agricultural by- products and straws for animal feeding. Technologies to augment feed resources including the genetic modification of microorganism to utilize high lignin forage grasses are required to be developed. There should be research efforts to support intensive animal production.

- Since the biotechnological research and its application in animal production has remained segmented, there is urgent need to have a comprehensive program on buffalo genome, genomics for high fecundity, transgenic for modification of milk, growth, fiber and hair, and manufacture of pharmaceutical.

- Market opportunities for livestock sector following the policy of economic liberalization of the government of India, the value of livestock output has grown by over 5.5% per year since early 90s and there are expectations of even faster growth as the demand for livestock products is increased. The sector's ability to capitalize on new market opportunity is constrained by the availability of infrastructure and research support for quality genetic material production and animal health system.

- In the concepts of development and sustainability, it is, therefore, essential that **livestock be considered the real estate around which the future agricultural development should be based**.

CHAPTER-II
LIVESTOCK SECTOR PROFILE

1. GENERAL

During the past five decades independent India has been growing through its resurgent struggle and emerging as a vibrant dynamic nation largely because it has done tremendously well in the area of agriculture-transforming a hungry country to a food surplus nation. The contributions of livestock sector through a series of revolutions (White, Feather, Yellow, Blue and Red) have been tremendous in this transformation of national economy. It may not be forgotten, however, that we still have millions of famished populations, acute malnutrition, endemic poverty, poorly fed livestock, low productivity, inadequate disease monitoring, and a huge animal population to be looked after.

The total export earnings from livestock sector increased to Rs. 3476 crores in 2000-01 as compared to 782 crores in 1988-89 showing an annual growth of 12 per cent. Against this, the investment of central government including the share of state governments in animal husbandry and dairying sector was extremely low valued between only 0.04 to 1.0 per cent. The investment in animal husbandry and dairying as a percentage of total investment of the government in the ninth plan was 0.4 per cent only.

Considering the overall food and nutrition scenario of the country particularly its expanding populations (human and animal), the changing food habits, growth rates in per capita consumption of food commodities (1.95 per cent for rice, 2.41 per cent for wheat, 1.08 per cent for cereals compared to 6.66 per cent for milk and 4.66 per cent for meat fish and eggs), demand for nutritious and animal based foods (milk, meat and eggs), the demand for livestock products is steeply going to rise. Targeting a 5.0 per cent annual growth, India would be requiring 142.7 million tons of milk, 7.1 million tons of meat and eggs and 11.8 million tons of marine products by 2020 compared to 64.8, 3.3 and 4.7 million tons during 1991 respectively (ICAR Vision 2020). Unless and until the new technologies, which can ensure a higher growth, are not made an essential feature of our developmental growth process for increased production and productivity from animals, the transition to self-sufficiency will not be a reality. Therefore it is imperative that procedures, practices and policies should be taken up in implementation mode. The present trends indicate that animal protein requirement would rise faster than cereals in the consumption pattern both in India and the world during the millennium mainly due to increase in income and need for quality food. This could be achieved using sustainable production systems while maintaining environment and addressing concerns of animal bio-diversity, quality of products, human and animal health and welfare.

2. EMPLOYMENT

Animal husbandry provides self-employment to millions of households in the rural areas. Women constitute 71 per cent of the labour force in livestock farming. Rural women play a significant role in animal husbandry and are involved in operations like feeding, breeding, management and health care. A large manpower is also involved in livestock-related activities like manufacture of animal food products and beverages, manufacture of textiles, tanning and dressing of leather, farming of animals, production, processing and preserving meat and meat products, manufacture of dairy products and retail and wholesale trade of livestock products.

3. GROWTH RATE

Over the last decade, the overall growth rate in Gross Domestic Product at 93-94 price varies between 10.10 and –2.19. This shows great influence which agro-climatic and other external factors exercise on the agricultural production. Over the same year, animal growth rate in GDP for livestock sector varied between 6.75 and 3.98. This steady and sustainable growth in livestock sector, in fact, stems the total agricultural growth thereby ensuring an annual average of 2.5%. Despite comparatively limited investment, the sustained growth in the livestock sector is illustrative of the fact that livestock gives sustainability to the total growth output. Increased investment in the livestock sector to increase its annual growth rate on an average of 4.5% to 5.5% is highly implied to ensure the required agricultural growth.

Average production per lactating and per milch animal during a year proved beyond doubt that high rate of acceleration in milk production in the country was achieved basically due to enhancement in productivity of cow and buffalo and was not merely due to increase in number of these animals.

CHAPTER – III

ISSUES CONCERNING TO LIVESTOCK PRODUCTION

Livestock Density:

Demographic data on cattle and human population indicates density of animals is highest where there is endemic poverty. It is in these areas that holding size of land is very low, people belong mostly to marginal, landless or labor class and are the owners of the majority of low producing livestock. Crop development strategies and rural development program that do not directly address the livestock are, therefore, able to produce low impact and poverty continues.

Livestock Global Advantage

India is a host to a large number of livestock species/ breeds which rank high world over in production excellence (fat in milk, protein composition in milk, body weight, growth, fecundity and wool quality etc.). The digestive capacity of the livestock also comes as a global advantage since Indian breeds can more effectively utilize high lignin feed and forages for growth and production. This also gives an added advantage in terms of production of lean meat from sheep, goat and buffaloes.

Biodiversity

India plays home to one of the mega diversities of livestock in the world, but faces a challenge between plenty and poverty with respect to livestock. Though the vast livestock genetic resources has been an integral component of Indian agriculture, during recent years due to commercialization of agriculture, more emphasis has been given to cash crops which contribute little to quality animal food. As a result, livestock breeds sustainable on agriculture by-products have become relatively uneconomical and are being replaced by more productive indigenous or exotic breeds from a different environment. From the concepts of sustainable animal, emphasis is shifting on to economic animal and such shift is bringing in great pressure on livestock breeding which cannot stand the competitive output ratio. In spite of about 130 breeds, cattle (30), buffalo (10), sheep (42), goats (20), camel (8), horses (6) and poultry (18), are documented in literature, there are hardly any institutions or organizations which are responsible for systematic, sustained, breed improvement in natural tract or their conservation. Advantage of excellence is, therefore, under risk of being lost, if not animal itself.

Low Input Production System

Animal protein produced from livestock is a low input production system since majority of cattle; buffaloes, sheep and goat are fed around the year on straws or agricultural byproducts. The model in developed world is to use feed grains to be converted to animal protein. However, in India, 91 million tones of milk, 5.1 million tones of meat and over 45 billion eggs are produced in an efficient model of low cost feed. Productivity of milk, meat and eggs can easily be geared up if inputs in production model are suitably increased through diversification of un-utilizable/surplus grain to livestock. Low unit cost of production can be maintained if the total productivity and efficiency of production are associatively used in the development model.

Productivity targets

Targeting a sectoral growth of 6-8 percent, an indigenous cow should have an increase of production from 750 to 850 kg annually. Cattle crossbred produce an average of 2051 to 2150 kg/animal and buffaloes on an average 1263 kg/animal to 1360 kg/animal. Through small increment in production, it will be possible to create discernible change in total production, due to large population size of the production units. The basic reason to attain such a significant growth in milk production was due to acceleration in productivity of both cattle and buffaloes. The average annual milk production of cow in milk has increased from 626.3 Kg in 1987 to 771.6 kg in 1992. The compound growth in productivity of a cow was 4.26 and the simple growth rate was 4.64%. Buffalo average milk production enhanced from 1094.6 kg in 1987 to 1200 kg during the year 1992. The compounded growth rate of the same was 1.85 and the simple growth rate was 1.92% respectively (Rajender Singh et al., 2000)

The Last Decades:

Our planning process over the past decades in the agricultural sector has been focused on increasing food grains. All strategies have been addressed to the crop sector and rightly so, because the focus was providing the good grains. But incidental to such planning process, as per "the law of un-intended consequences" the livestock sector got neglected and in its wake the landless and the marginal farmers, which constitute 58% of the rural population, never received the due attention. Incidentally this population sustains itself through 472 million livestock and 410 million poultry birds who serve as the most critical components of our rural production system. Over these years there was lack of support for the inherent capacity of livestock sector, which is now being recognized. The programs for farmers both in the central and state governments, particularly the subsidiaries were meant for people with land. There being much greater equity in livestock holdings any attempt to directly reach the animals and animal owners would have brought about faster rural transformation.

Besides the above, nascent or non-existence animal industry and absence of subsidiary, absence of big players in the livestock sector, contributions from the livestock sector not getting its due recognition, absence of technology interventions, no support for marketing and commodity pricing structure for livestock and livestock products, the livestock operations remained least remunerative. The overall effect of this apathy resulted in the sector not being able to express itself to its potential resulting in the economy of the animal owners and the economic standing of the sector remaining low. Through a limited support, dairy sector has amply proved as how rural transformation through nutritional support, health care and disease protection of animals and marketing system can bring in more income to resource poor farmers and bring about rural development with its true social implications

CHAPTER-IV

POLICY ISSUES

- Considering the overwhelming evidence that sustainability to agriculture is through livestock and that the issues of poverty alleviation, nutritional security, rural employment, women empowerment, particularly among the resource poor farmers can be best addressed through livestock.
- Technology supported and demand driven livestock production will be the future engine for growth that ensures nutritional security and livelihood of land less rural poor below the poverty line. Therefore, research priorities should involve intensification of programs in this sector with provisions for services and goods.
- Population growth, urbanization, changing food habits and increasing income are fueling an increase in demand for non grain based food of animal origin. Significant portion of total energy and protein intake, of late, comes from animal products and the increasing trend over the years is bound to change the production strategies of cereal crops and national land use policy.
- Transition from subsistent livestock farming to sustainable and financially viable livestock and poultry farming will imply creating an enabling environment in which the farmers will have a better access to cheap, assured and easily available input resources. There is no such program focused for such transition.
- Animal productivity is connected with nutritional input to the animal. About 50-78% of the cost of production is attributed to feed alone among different species. While calculating the national demands on food grains, animal requirements need to be taken into consideration particularly for improved livestock whose productivity is linked to the feed input (high yielding cows, buffaloes, sheep, goat and poultry). For the past decade, animal nutritional augmentation has been based on utilization of straws and agricultural by-products, which should now change and priorities be fixed for grain production for animal use. Low yielding sub-fertile soil can, especially, be utilized for such coarse grain production where the nutrient input and management demands are low. Similarly, in irrigated land, a mandatory appropriation of certain area for fodder production can be linked to agricultural production incentives.
- A livestock production system is considered robust since there are hardly any mentionable incentives or subsidiary systems. This has created a highly uneven playing ground for livestock and crop husbandry farmer. Incentives/subsidiaries of crop production are connected to land, but, marginal/landless farmer subsistence on low income generating livestock remains unsupported. There is a great need for a new approach policy for credit to livestock sector.
- The organized financial sector is unwilling to finance livestock program and the livestock farmers are mainly dependent on financial intermediaries and thus the farmers have to pay very high interest rate. With economic return from livestock being low, higher investments are prohibitive for the farmers. Suitable input models need to be researched to reform the situation.

- To have any systematic Disease Risk Analysis in place, there should be a strong research back up. At present, the research institutions work in absolute isolations with state Disease Investigation Laboratory which often do not have a strong technical back up. All State Agricultural Universities and designated ICAR laboratories should have a mandated disease investigatory role to set up a research data base and to provide a research backup for risk analysis of animal diseases.
- To ensure biodiversity conservation, a national livestock genomic policy envisaging improvement and conservation of breeds should be framed and an Implementing Agency set up which will work in close collaboration with Private Breed Societies /organizations/NGOs.
- To reduce economic losses from morbidity and mortality in livestock, quality diagnostics and vaccines are made available to the farmers at cheap rates is a pre-requisite. In spite of the fact that several technologies are available through ICAR system, there are no takers in the industry due to poor economic viability of such ventures. The discipline of Animal Health is, therefore, at cross roads. On one hand, the developed biologicals (diagnostics and vaccines) are available and at the same time, the stakeholders cannot use them. As a policy issue, the Council should take the scaling up and commercial manufacturing, since any investment is going to have a large pay off through reduction in disease losses, increase in productivity and better health of animals and human being.
- The Animal Science and Veterinary Institutions, particularly those in the SAUs are acutely under staffed to the tune of over 50 percent, which is a serious situation. A graduate after over five years study finds academic pursuit less remunerative and our poorly equiped colleges offer no challenge to these graduates. There needs to be a policy change in a) recruitment qualification, b) salary structure c) infrastructure facilities and d) a massive HRD support.
- Livestock extension is presently a part of and modeled on agriculture extension. But livestock extension, which is primarily based on providing services and goods, needs to be treated differently from crop related extension activities based on transferable knowledge. Services and goods involve costs, which are of much higher magnitude than transfer of knowledge alone. Important domestic animal (dogs and cat) and wild animals are not at present covered under the purview of the Council and there is no programme on their health and management. These animals are in fact vital links in animal and human disease and therefore should come under the research and education agenda of ICAR.

CHAPTER - V

INFRASTRUCTURE

Animal science division at present is having 2 National Institutes with the status of Deemed to be University, 5 Central institutes, 7 National research centers, 1 Bureau and 4 Project Directorates. In addition, species specific All India Coordinated Projects (AICRP's)/ Network programmes are also being implemented through respective species-specific institutions. Anml Science Division is operating their programmes through these institutions under the following broad-based programmes.

1. Animal Genetic Resource
2. Livestock improvement
3. Animal Health
4. Livestock Products Technology
5. Socio-economic research

A. RESEARCH INSTITUTES AND ACTIVITIES

1 Indian Veterinary Research Institute (IVRI)

- Development of quick and precise methodologies including kits for diagnosis of diseases/conditions, package of practices for optimum animal health.
- Improvement of immuno-prophylactics, use of biotechnological tools in evolving vaccines for important diseases of livestock and poultry.
- Pharmacological evaluation of herbs/plant products and promotion of etheno-veterinary medicines.
- Genetic studies on disease resistance in domestic species of livestock.
- Development of techniques for multiple ovulations, embryo transfer, in vitro fertilization and cloning of embryos.
- Development of reasonably economic diets and feeding schedules for SPF, Pets, sick farm animals and captive wild life.
- Processing and preservation of meat, using cutting edge technologies.
- Human Resource development in Veterinary and Animal science for education and research.

2. National Dairy Research Institute NDRI)

- Improved evaluation of cows and progeny testing through various traits and field records.
- Improvement of cattle breeding through optimization using biotechnological tools to increase production and productivity.
- Optimization of feed utilization by rumen manipulation, anti- metabolite removal, mineral and vitamin availability and better techniques for fodder production.
- Safety, Quality assurance of Milk products and improvement of dairy plant efficiency.
- Economic evaluation of dairy farming systems and constraint analysis.
- Fertility improvement and shelter management.

- Dairy processing equipment design and development.

3. Central Institute for Research on Buffalo (CIRB)

- Genetic resource improvement of buffaloes through production and maintenance of superior germplasm and embryo transfer Technology.
- Optimization of reproductive efficiency by rearing selected bull calves under intensive rearing system, improving protocol for freezing buffalo semen and embryo transfer technology.
- Feed utilization and improvement and optimization of management practices.
- Development and transfer of technology to end user through transfer of progeny tested bulls, urea molasses mineral mixture etc.

4. Central Sheep and Wool Research Institute (CSWRI)

- Developing technologies for enhanced mutton and carpet wool production.
- Genetic improvement and testing of Bharat Merino for fine wool production using biotechnological interventions
- Optimization of sheep production through nutritional and physiological manipulation.
- Processing and product development utilizing indigenous wool and specialty hair.
- Transfer of technology to end-users.

5. Central Institute for Research on Goats (CIRG)

- Production of superior germplasm of Indian goats and crossbreeding for economic traits meat and milk production under on station and on farm condition.
- Augmentation in meat and milk production using physiological approaches and reproduction bio-technology.
- Development of economic feeding system and feed processing technology for small holders and commercial goat farming.
- Integrated small ruminant management and production system for commercial farming.
- Development of preventive and control measures for economically important diseases of goats.
- Farming system research on integrated rural development programme with special reference to goat improvement.
- Development of processing technology for value added meat and milk products from goat.
- Organization of training programmes and goat production technology for national and international farmers and entrepreneurs.

6. Central Avian Research Institute (CARI)

- Development of specialized poultry genetic stocks with evaluation, improvement and conservation of indigenous poultry.
- Basic research on poultry (molecular genetics, cyto-genetics and immuno-genetics).

- Development of package of nutritional, health care and managemental practices for optimizing poultry production.
- Identification of alternate feed resources for poultry and studies on mycotoxins and pesticide residues in poultry feeds .
- Development of poultry housing system and management equipment (cages automation system, feeders, waters) suited for different breeds, age groups and species under varied geo-climatic conditions.
- Studies on general physiology, reproduction under stress and varied conditions for different breeds, species and age groups.
- Rural/backyard poultry production.
- Post harvest technology for storage of egg, and their developed products.
- Recycling of poultry waste by biodegradation methods.
- Technology transfer to rural and urban areas by various audio-visual means and practical training.

7. National Bureau of Animal Genetic Resources (NBAGR)

- Creation of information data repository on livestock and poultry genetic resources.
- Field surveys of genetic resources vis a vis conservation and management
- Creation of in situ and ex situ germplasm banks.
- Molecular characterization of genetic resources.
- Policy planning, manpower development, documentation and methodologies for sustainable use of animal resources.
- Training of manpower.

8. National Institute on Animal Nutrition and Physiology (NIANP)

- Biotechnological approach for augmenting productive efficiency.
- Bio-energetics in productive processes through improved shelter physiology.
- Improvement of quality and utilization of feed and assessment of feed and animal resources availability for formulation of data base for different agro climatic zones in the country.
- Institute-village linked programmes and human resource development through advanced trainings of scientific and technical personnel in India and abroad.

9. National Research Centre on Equines (NRCE) including Veterinary Type Culture (VTC)

- Development of diagnostics and vaccines along with epidemiology of important equine diseases.
- Physiological and biochemical studies on equine work performance including draft ability.
- Optimization of reproductive efficiency.
- Equine breed evaluation, improvement and management practices.
- Nutritional requirements, resource utilization, and improvement.
- Assessment and development of technologies for equine products and transfer of technology.
- Repository of Veterinary Microbes.

10. National Research Centre on Camel (NRCC)

- To study work standards in camel and to study quantitative and qualitative genetic parameters in Indian camel.
- To develop suitable managemental practices for camel rearing.
- Research on feed and fodder resources and their utilization in camel.
- Studies on camel reproduction.
- Research on blood group and biochemical polymorphism in Indian Camel.

11. National Research Centre on Yak (NRCY)

- Yak breeds evaluation improvement, and management practices.
- Physiological aspects of yak production, work potential and adaptation.
- Yak nutrition and feed resource development.
- Yak health surveillance and monitoring.
- Improvement of reproduction efficiency of yak.
- Evaluation and management of technologies for yak products and by-products.
- Extension, training and research on Socio -economic aspects.

12. National Research Centre on Mithun (NRCM)

- Research on improvement of mithun for meat and milk through selection and crossbreeding with Brown Swiss for meat and Jersey cattle for milk.
- Comparative studies on different mithun strains on production, reproduction and disease aspects and creation of database on mithun.
- Research on development of package of practices for optimization of mithun production.
- Survey and nutritional evaluation of mithun feeds.
- Research on basic physiological aspects of mithun.

13. National Research Centre on Meat (NRCMt)

- Nationwide survey on meat production pattern, indigenous and exotic meat products manufacture, consumption and marketing.
- Improvement of quality and tenderness of fresh meats using new techniques and technologies.
- Process optimization and scale up production designs for indigenous and exotic meat products.
- Evolving least cost formulations using plant and animal proteins.
- Evolving protocols for total quality and safety assurances with emphasis on total quality management (TQM) and hazard analysis for critical control points (HACCP) and shelf life dating and predictive microbiology.

14. National Research Centre on pigs (NRCP)

- Genetic improvement & conservation of different breeds of pigs.
- Shelf life enhancement, Quality control & assurance, storage, packaging and marketing of pork.
- Development of cheaper feeding system.
- Study of hormonal profile and improving reproductive efficiency.

15. National Centre for Agricultural Economics and Policy Research (NCAEP):

- Technological change in agriculture:
- Sustainable agricultural systems:
- Supply and demand market
- Institutional change
- Agricultural growth

16. Project Directorate on Cattle (PDC)

- To evolve a national milch breed "Frieswal' capable of producing 4000 kg milk in a mature lactation of 300 days utilizing Friesian x Sahiwal crossbred available with military dairy farms.
- Conservation and genetic improvement of some of the important indigenous breeds of cattle in their native tracts through establishing germplasm units and associated herds.
- To undertake progeny testing of crossbred bulls on large scale in the field.

17. Project Directorate on Poultry (PDP)

- Pure line improvement of layer populations for specific objectives and improvement of colored broiler populations to optimize production efficiency at parent and broiler level.
- Genetic selection and breeding for feed utilization efficiency and immune-competence to improve economic efficiency of pure line layer and broiler populations.
- Development of gene lines with single genes such as sex-linked recessive dwarf(dw) gene and their utilization in tropical broiler production.
- Development of germplasm for backyard/free range farming for rural and tribal areas.
- Biotechnological approaches for improving traits of importance in broiler and layer populations.

18. Project Directorate on Animal Disease Monitoring and Surveillance PD-ADMAS)

- National Disease Monitoring and Surveillance programmes through regular series of population sero-eqidemiological surveys
- Updating of national livestock disease and related data bases to develop disease forecasting models and Animal Disease Referral and Expert System (ADRES)
- Field validation of livestock disease forecasting models

19. Project Directorate on Foot and Mouth Disease (PD-FMD)

- Disease zoning along with vaccination with polyvalent or monovalent vaccine depending upon prevalence of serotype(s).
- Harmonization of FMD vaccine and diagnostics along with quality assurance.
- Sero-monitoring and sero-surveillance of the disease including molecular epidemiology.
-

20. All India coordinated Research Projects (AICRP) & Network Programmes

- National Project on Animal Genetic Resources, Karnal
- NP on R & D support for process upgradation of indigenous milk products for industrial application
- Pilot Project on IRD
- Network Program on Sheep Improvement
- AICRP on Goat Improvement
- National project on Buffaloes improvement.
- AICRP on Improvement of Feed Sources & Nutrient Utilization for raising Animal Production
- AICRP on Cattle Research AICRP in Foot & Mouth Diseases
- AICRP on Poultry
- Network Project on Gestro-intestinal Parasitism
- Network on Haemorrahigic Septicaemia
- Network Program on Bluetongue Disease
- AICRP on Animal Disease Monitoring & Surveillance
- AICRP on Pig

CHAPTER- VI

MAJOR ACHIEVEMENTS DURING X PLAN

Animal Genetic Resources Evaluation, Conservation and Improvement

- Established National Informatics Centre on indigenous farm animal genetic resources and programme on characterization, evaluation and conservation of animal genetic resources through surveys.
- In-situ conservation of animal genetic resources on organized farms and under sustainable production systems in the field conditions and Ex-situ conservation of farm animal genetic resources using genetic markers.
- Technologies developed for improvement of the indigenous sheep breeds through selection using both natural breeding and artificial insemination.
- Developed technologies to preserve ram semen (liquid/frozen) and fertility trials conducted by use of preserved liquid and frozen semen.
- Technology has also been perfected for collection and transfer of embryos for quick multiplication of superior sheep germplasm.
- Quality of wools available from different indigenous and crossbred sheep evaluated with regard to their physical attributes and their physio-mechanical properties. Suitable blend formulations recommended for manufacture of different products.
- Carpets made from different types of indigenous and imported wools and from their blends and blended with wollenized jute evaluated for different quality characteristics.
- Developed superior genetic stocks of layers, broilers, quails and guinea fowls and development of package of practices relating to nutrition, management and health care to optimize growth, production and reproduction of the above avian species in tropical environment.
- Improvement of existing layers and broilers populations to achieve performance comparable to commercials through revised selection methodology on large population size with high selection pressure undertaken. In broilers the traits of economic importance such as feed efficiency, number of settable eggs, fertility, hatchability, less abdominal fat, better immunocompetence, livability etc., given importance in selection programmes. Similarly, in layers, in addition to egg weight and egg number the traits such as feed efficiency, heat tolerance, shall strength, shell thickness, livability etc will be given importance while formulating selection programmes
- Exotic and indigenous pigs and their crosses evaluated genetically and phenotypically for various economic traits. Package of practices developed for raising the exotic, indigenous and crossbred pigs under optimal managemental conditions.
- Developed synthetic broiler male line with white colour plumage was undertaken. Commercial test cross (KRISHIBRO) from coloured pure line attained body weight of 1339g without any finisher ration with a feed conversion ratio of 1.96 and mortality of 2.62 percent at six weeks of age.
- A new synthetic coloured control broiler population developed to measure the environmental trend for the selected lines.

- Parents of VANARAJA chicks selected with special emphasis on colour combination besides other traits of economic importance. Seven strains of poultry especially suitable for backyard farming released to institutional farms for performance testing.
- Genetic polymorphism was absent in Indian Yak
- 4,10,989 fertile eggs, day old chicks and grown up birds of Vanaraja and Gramapriya supplied to the farming community of rural and tribal areas.

Livestock Improvement

- Developed a data base information system on feed and animal resources available in the country The programme developed enables working out the nutrient requirement (DM, DCP and TDN) for different categories of livestock and give information on surplus / deficit of feed resources in different states for different years.
- Protected these fat supplements for incorporation in higher levels (5% and above) for achieving higher energy density in the ruminant rations developed. Protein supplements like silk worm pupae meal (de-oiled), chilli seed cake (expeller), chilli seed cake (solvent extracted), soybean extraction, sunflower extraction and maize gluten meal are good sources of bypass protein.
- Supplementing the ruminant diet with bentonite or activated charcoal reduces aflatoxin secretion in milk. Feeding of small quantity (1% DM) of either sodium bentonite or activated charcoal was able to reduce the secretion of aflatoxin in milk.
- For laying quails, a dietary provision of 75 mg Zn per kg and 3.0% calcium was found optimum and that no interaction between the two nutrients was evident.
- Supplementation of diet with fungal phytase improved remarkably the dietary phosphorous utilization with a concomitant decrease in phosphorous excretion. In another study, it was found that growing quails performed optimally on diets containing upto 8% crude fibre.
- Detoxification of linseed meal (autoclaving + Vit. B6 10 ppm) and use of activated charcoal in insecticide based diets had a beneficial effect in enhancing the growth and reducing the severity of lesions in different organs of broilers.
- Poultry wastes biodegradation and its recycling are important to contain growing pollution menace. Anaerobic biodegradation of poultry droppings in presence of high cellulosic material like the dry grass and or tree leaves, left a bio-mass of high manureal value for increasing crop yield.
- Supplementation of Zn to practical diets from 0-320 ppm did not influence any change in growth, feed intake, feed conversion efficiency. Zn available from the basal diet (29 ppm) was adequate to support the performance of broilers during initial growth period of 5 weeks.
- Feeding of spineless prickly pear cactus alongwith roughage *Cenchrus* can serve as the sustenance ration for short term scarcity feeding of sheep. The soybean cake and cotton seed cake had higher amount of undegraded dietary protein (UDP) than those of mustard, groundnut, rapeseed and til cake.
- Sperm cells were found to synthesize steroid hormones during their maturation, under the influence of gonadotrophins. This synthesis is probably necessary for

sperm maturation, besides the hormone dependent protein synthesis of testis and epididymis to support sperm maturation.

- For the assessment of incidence of infertility in goats under farm as well as under field conditions major causes of reproductive constraints have been identified and their appropriate lines of treatment suggested automization of semen freezing protocol for higher post thaw motility and fertility in goats is in progress. A field technique of semen preservation has been developed and perfected for adoption under field conditions and is ready for commercial exploitation.
- Modulation of peripheral catechnolamines to control stressed moulting, loss in body weight and metabolic processes in white leghorn hens provided a strong basis of modulating certain physiological aspect favorably.
- Studies on haematological and biochemical parameters of Mithun, thermo-adaptability, immunoglobulin pattern, different mineral and enzymes studies, reproductive behaviour and induction of lactation using 17 ß estradiol and progesterone in yak were initiated.
- More than 40 non-conventional feeds identified and technology for their use in complete feeds developed. More than 100 complete feeds using locally available ingredients developed and recommended for growing and milch animals.
- The technology for cryopreservation of camel semen perfected
- A serum based sandwich ELISA test developed for early pregnancy diagnosis in equines.
- A highly sensitive enzyme immunoassay (EIA) for GH determination in mithun blood plasma developed and validated.
- Gene for Lysozyme, an antimicrobial protein, has been cloned and sequenced from the mammary gland and stomach tissues of buffalo and sheep, and native protein purified from buffalo colostrum.
- A sensitive ELISA procedure developed to estimate prostaglandin metabolites (PGFM) in mithun plasma and PGFM concentration has been estimated in mithun during different stages.
- National Research Centre on Pigs established at Rani, Guwahati, Assam.

Livestock Products Technology

- Development of milk based probiotic spray dried food formulation.
- Manufacture of probiotic Edam cheese containing *B. bifidum*.
- Development of low fat cheddar type cheese.
- Production of milk protein concentrates using ultra-filtration technology and their utilization.
- Development of platform test for detection of adulteration directly in milk with foreign fats & oils.
- Development of technology for dried carrot milk food.
- Technology of manufacturing delipidized whey protein concentrate employing membrane processing.
- Technology for Mozzarella cheese from skim milk microfiltration. Low cost processed cheese preparations developed.

- Microfilteration of milk for extended shelf life. Technology of long life soft drink from butter milk.
- Process for continuous hydrolysis of whey lactose.
- Dehydration of Paneer for enhancement of shelf life.
- Development of prototype equipment for continuous manufacture of paneer.
- Pesticide residues: Package of practice has been standardized / developed for the analysis of OCPR in milk.
- Meat production potential & carcass quality evaluation of Sirohi weaner kids, Marwari kids, Malpura, Garole, Malpura & Garole crosses evaluated.
- Appraisal of broiler rabbit potential as an alternate source of meat (Soviet Chinchilla, New Zealand White, White Giant, Grey Giant and Black Brown breeds).
- Technologies for convenience & value added meat products such as nuggets, patties, sausages, meat balls, restructured rolls, kebabs & tandoori developed from buffalo meat, mutton, chevon, chicken meat, broiler rabbit meat.
- Egg- crust pizza formulation developed.
- National Research Centre on meat established for development of meat sector at Hyderabad (A.P.).
- Indian wool suitable for blending with angora rabbit hair and mohair specially fibers has been identified on the basis of their fiber.
- Harshil wool of Uttaranchal was found promising to replace imported Merino wool for blending with Angora rabbit hair.
- A process based on osmotic dehydration developed for production of ready-to-reconstitute Ras Malai.
- An eco-friendly earthen pot using special clay and shellac coating developed for packaging of dahi to prevent shrinkage and increased shelf life.
- Blended yarns of Mohair with Chokla and 50% Gaddi Synthetic have been made in the blend ratios of 20 / 80, 30 / 70, 40 / 60 and 50 / 50 using woven system.
- Blended yarns of Angora rabbit hair with 50% Bharat Merino and 50 % Merino have been made in the blend ratios 20 / 80, 30 / 70 and 40 / 60 on a woolen system.
- New German Angora rabbit have been introduced, which produces about 1 Kg. of wool per annum with 2% guard hair. The wool is of good quality and shawls could be produced locally by blending with Gaddi synthetic wool.
- A process for Herbal Ghee with functionalities like resistance against heart diseases and blood pressure regulating properties developed.
- Mozzarella type cheese developed using buffalo skim milk and vegetable fats employing direct acid method.
- Method for making cottage cheese from Yak milk standardised.
- The leather produced from mithun hides was found to be of excellent quality with huge export potential.

Animal Health

- Rinderpest and other important diseases of livestock & poultry diagnosed and controlled by precise and timely diagnosis. Freedom from Rinderpest achieved.
- Molecular epidemiology of various serotypes of FMD along with nucleotide sequence have been determined and compared by the partial/ full sequence of the 1D gene of FMD virus field isolates of serotypes O, Asia 1 and A.
- The ***Non-structural (NS) proteins*** of FMD viruses are conserved across the

serotypes. Antibodies to the NS antigens persist in the animals for long periods (up to 3 years) following infection. The protective antibody status following vaccination in ***Liquid Phase Blocking ELISA (LPBE)*** was further evaluated and standardized for screening large number of serum samples.

- A disease simulating forecasting model based on computer application has been developed and a national data base based on eco pathological zoning have been developed. Disease simulation models have been developed for the critical epidemiology, which are the tools, that relate/simulate the pathogenic performance of the disease in relation to the conditions that change either deterministically or randomly.
- Pharmacodynamics and pharmacokinetics of the drugs have been analysed and efforts have been made for utilization of indigenous medicines for the treatment of livestock and poultry disease.
- The presence of heat stable antiviral and immunopotentiating activity in the extracts of *Ocimum sanctum* (Tulsi) leaves and seeds were demonstrated.
- It was also shown for the first time in the country that dogs could be used as effective bio-monitors of lead and cadmium pollution in the urban and industrial areas.
- The antigenic variation and characterization of antigenic profile of purified antigens have been developed in terms of dot ELISA for the diagnosis of Johne's disease. For protozoal infections diagnostic tests involving molecular biological techniques have been developed and chemotherapy for the treatment of theileriosis have been investigated.
- An exclusive hybridoma laboratory for the production of N and H protein based monoclonal antibodies to RPV and PPRV have been developed for use in the ELISA kits for national sero monitoring and sero surveillance programmes.
- Polymerase chain reaction (PCR) assay was standardised for the diagnosis of trypanosomosis, a dreaded protozoan disease caused by *Trypanosoma evansi* in domestic and wild animals.

- A mapping of tick population responsible for transmitting diseases was undertaken.
- A newly designed linear skeletal fixator provided better and stable fixation of fractures in large animals than conventional fixator.

Diagnostics/Vaccines/Technologies developed

- Various diagnostics and vaccines developed and technologies transferred for commercialization.
- The immuno diagnostic kits for FMD, Blue tongue, brucella, IBR and IBT were prepared and released for the field application.
- Equine influenza vaccine was produced and made it available for commercial utilization.
- ELISA kit in form of strip/ immuno dipstick for equine influenza was developed. Inactivated oil emulsified Inclusion Body Hepatitis-Hydro pericardium Syndrome (IBH-HPS) vaccine, prepared from the virus propagated in SPF-chicken embryos, which afforded complete protection to the chicks from one week to 6 weeks against the disease.

- Monoclonal based highly sensitive and specific Avidin- Biotin ELISA test was developed for comparative sero epidemiological monitoring of livestock diseases.
- An indigenously developed cheaper monoclonal antibody (Mab) based competitive-ELISA kit was for sero-surveillance against rinderpest.
- Complement fixation test based diagnostic kit COMPLEMENT FIXATION FOR EQUINE BABESIOSIS (COFEB) has been developed which would be helpful in saving foreign exchange and detection of infection within 4 hours against about 10-12 hours by conventional methods.
- A milk based bovine brucellosis ELISA kit has been indigenously developed for screening the milk samples collected from the village milk producer's cooperative societies to identify infected village and to develop strategies for its control/eradication.
- Powerful veterinary epidemiology software **India.admas Epitrak** has been developed for the first time, which is exclusive to the livestock disease scenario in India.
- Two new isolates of bluetongue virus, which was characterized as Type 23, were added the inventory of Centre for Animal Disease Research and Diagnosis. Rose Bengal colored antigen was developed for Serum Agglutination Test (SAT) for diagnosis of Caprine pleuropneumonia for field application.
- A dot ELISA based on soluble antigen of *Brucella mellitensis* biovar –1 isolated from goat was developed which was found to be very sensitive.
- A test to diagnose Bovine Immuno-deficiency virus in cattle and buffaloes, a condition similar to AIDS in human beings developed.
- Ingress of highly pathogenic animal influenza in the country checked by timely disease diagnosis and preventive measures.
- Molecular epidemiology of FMD has been carried out to assess the extent of infection and prevalence of virus in the country. The full-length cDNA of the second most common serotype of FMD virus Asia 1 has been constructed and nucleotide data deduced by sequencing.
- Avian influenza (Bird flu) virus detected in the samples from Maharashtra and more than 45,000 samples tested for Avian Influenza after outbreak of Bird Flu.
- Monoclonal antibody developed against six equine rota virus strains used for detection of foal rota virus in stool of more than 50 diarrhoeic foals.
- Surface antigen used for sensitive and specific detection of *Theileria annulata* infection.
- A novel multifunctional protein identified from *Haemonchus contortus* and gene coding for this protein cloned, expressed and the recombinant protein analysed. The cloned protein shows great potential for futuristic vaccine for control of gastro-intestinal parasites.
- Truncated fragment of EMA-2 gene of *Babesia equi* was expressed in pGEX T-1_ expression vector. ELISA was standardized using the GST –tagged purified recombinant protein for detection of *B. equi* antibodies. No cross reactivity was observed with reference to *B.cabbali* or *T. evansi* positive serum samples.
- An inactivated vaccine against Avian Influenza developed.

CHAPTER-VII

TECHNOLOGIES GENERATED

A. Technologies

Diagnostic Kits

- ELISA based & compatible AB-ELISA Kit for Infectious Bovine Rhinino-tracheitis (IBR)
- ELISA based & software compatible AB-ELISA Kit for Brucellosis in Serum & Milk.
- Monoclonal based ELISA kit for Foot & Mouth Disease (FMD).
- ELISA kit for Peste des Petitis Ruminants (PPR)
- ELISA based kit for Infectious Bursal Disease (IBD)
- Agar Gel Precipitation Test & ELISA based kit for Blue Tongue
- Ic ELISA kit for Rinder Pest (RP) & PPR.
- ELISA kit for Herpes infection in equines
- COFEB for diagnosis of Babesiosis in equines.
- COFAL for the diagnosis of Avian Leucosis Complex (ALC)
- ELISA based kit for pregnancy diagnosis in equines
- PCR based diagnostics for Bovine viral diahhorea, Avian flu etc.

Vaccines

- Oil Adjuvant Foot & Mouth Disease (FMD).
- Peste des Petitis Ruminants (PPR).
- Infectious Bursal Disease (IBD).
- Oil Adjuvant Haemorrhagic Septicaemia.
- HS& FMD Combined Vaccine

Software based disease models

- India-admas Epitrax..
- National Animal Disease Referral Expert System (NADRES)
- Disease Simulating Model
- Desease Information model
- Weather forecast model

Technology

- Cystoscope technology as a field tool for determining optimum time for insemination.
- Technology for cost effective production of indigenous vaccine against PPR
- Attenuated homologous vaccine for PPR.
- Foot & Mouth Virus vaccine strains
- Area specific Mineral Mixture for increasing reproductive efficiency and productivity
- Indigenous substitution of Cedar wood oil with turpentine oil and benzene as clearing agent for histo-pathological work
- Diagnostic techniques for determination of environmental pollutants and toxicants including fungal toxins.

- Bovine horn plate as supporting aid in long bone fracture management
- Udder management technologies in mastitis

Drugs

- Technologies for ring worm cure
- "Mange Cure" against mites

B. Patents granted

Diagnostics

- Method for preparation of a diagnostic kit useful for forecasting EHV-1.
- COFEB-test kit for the diagnosis of *B.equ*i infection in equines.

Vaccine

- An Asian origin live attenuated homologous vaccine for Peste des Petitis Ruminants (PPR)
- Development of technology for preparation of inactivated oil emulsified egg drop syndrome-76 vaccine using indigenous strain.
- Development of methodology for production of a thermostable immuno-prophylactic agent against IBD in chicken.
- Indigenously developed cost effective and potent aluminum hydroxide gel concentrated & adjuvant vaccine for FMD

Drugs

- Indigenous drug formulation against skin diseases of animals.
- A process for preparing a herbal formulation for the treatment of mange.
- Development of technology for Area specific mineral mixture to increase productivity of bovines

Milk Products

- Processing of whey for the preparation of Acidophilus whey drink 'acido-whey'
- Continuous ghee making machine
- Mechanized conical process Vat.
- Development of Whey Mango Beverage.
- A simple and efficient micro dialysis assembly dialysis of samples in micro liter volumes.

Meat Products

- Methodologies for tenderization and process for preparation of enrobed products through tough goat meat.
- Processing of buffalo meat crackles-a crisp snack.
- Utilization of buffalo liver for preparation of loaves using carrot and potato.

CHAPTER – VIII

RESEARCH THRUST AND PRIORITIES

I. Research Thrust

A. Research Priorities

i. Productivity Enhancement and Management of Animal Genetic Resources

- Development of methodologies and technologies for conservation and improvement of indigenous livestock and poultry breeds.
- Development of high yielding strains for milk, meat and fiber through crossing and selection
- Augmentation of fertility using newer embryo biotechnological tools.
- Marker assisted selection to improve disease resistance (small ruminants – parasitic diseases) & fertility.
- Buffalo genomics.

***ii.* Feed & Feeding System and Environment**

- Manipulation of rumen ecosystem for improving digestibility of low quality roughages.
- Identification of best fiber digesting rumen bacteria and dominant rumen microbes.
- Isolation of cellulose gene; rumen fungi and fungi from wild animals.
- Bio-availability of nutrients and micronutrients.
- Improvement and utilization of local feed and fodder resources, cereal straws and other agro-by products.
- Identification of newer feed resources and development of complete rations for different categories of livestock and poultry.
- Elimination of anti-nutritional factors in feed resources to allow their high utilization.
- Use of additives, supplements and probiotics for efficient utilization of straws.
- Improving feed quality for reduction in green house gases.

iii. Disease diagnosis and control

- Animal disease modeling and forecasting to develop strategies for their control.
- Development of diagnostics and immuno prophylactics using molecular techniques and strengthening prophylactic measures for livestock diseases, including emerging, exotic and zoonotic diseases.
- Intervention of newer generation drugs and indigenous drug formulations for various diseases.
- Environment pollutants, industrial toxicants, mycotoxins and mycotoxicosis.
- Characterization and use of animal microbes for development of diagnostics& vaccines and improving quality and efficacy of products.
- Repository of animal microbes.

iv. Value Addition, Food Safety and Economics

- Development and improvement of processing technologies for value addition; quality assurance; shelf life and reducing cost of packaging and prevention of losses.
- Optimization of by-products technologies.
- Livestock production for sustainable livelihood; social impact of livestock production and technologies on productivity and economic empowerment of livestock farmers.
- Pricing, marketing, processing and trade strategies/policies; institutional credit and policy support for accelerated livestock development.

v. Human Resource

- Estimation of manpower need for livestock research, education, research education and training.
- Research and training priorities for animal husbandry extension and economics.
- Clinical education as PG Research

B. Species Specific Research Priorities

i. Cattle

- Genetic resource identification, conservation and improvement of some of the important indigenous breeds of cattle in their native tracts through establishing germplasm units and associated herds.
- To undertake progeny testing of crossbred bulls on large scale in the field.
- Improvement of breeding through optimization using biotechnological tools to increase production and productivity.
- Optimization of feed utilization by rumen manipulation, anti- metabolite removal, mineral and vitamin availability and better techniques for fodder production.
- Safety, Quality assurance of Milk products and improvement of dairy plant efficiency.
- Economic evaluation of dairy farming systems and constraint analysis.

ii. Buffalo

- Genetic resource improvement of buffaloes through production and maintenance of superior germplasm and embryo transfer Technology.
- Optimization of reproductive efficiency by rearing selected bull calves under intensive rearing system, improving protocol for freezing buffalo semen and embryo transfer technology.
- Feed utilization and improvement and optimization of management practices.
- Development and transfer of technology to end user through transfer of progeny tested bulls, urea molasses mineral mixture etc.
- Safety, Quality assurance of Milk products and improvement of dairy plant efficiency

iii. Equines

- Conservation & improvement of equid population.
- Epidemiological studies on various existing and emerging disease of equines.

- Development of drugs, diagnostics & vaccines against equine diseases.
- Development of Health Technology/package for migratory flocks
- Generation of base line data for various physiological and biochemical parameters for Indian breeds..
- Studies on the equine draughtability and the methods for the improvement of this power.

iv. Camel

- Breed characterization by DNA finger printing techniques & ex-situ conservation.
- Studies semen extenders & characteristics
- Disease diagnosis & control including monitoring & surveillance.
- Studies on reproductive physiology, endocrinology AI and ETT
- Evaluation and development of technologies for camel products milk, and hair, hides other by products utilization.
- Selection of camel for improved draught and racing capacity
- Sustainable camel husbandry and socio-economic transformation & socio economic research on future of camel rearing system and alternatives.

v. Yak

- Genetic divergence of yak germplasm through application of biochemical polymorphism (a) genetic market) & DNA finger printing technologies
- Studies on biochemical profile in yak during growth, production and reproduction including immunogens.
- Studies on thermo adaptability of yak inn different seasons.
- Disease monitoring & surveillance with diagnosis & control.
- Survey of socio-economic conditions of yak herdsmen in relation to their yak husbandry practices.

vi. Mithun

- Cytogentics and Molecular Genetic studies & ex-situ conservation of Mithun.
- Development of economic housing system for Mithun
- Screening and recording of major disease of Mithun (both specific and non specific) and development of preventive and control measures against such disease..
- Studies on Mithun milk and meat with the possibility of its utilization in various product along with its both under farm and free range conditions.

vii, Goats

- Studies on Genetics variants of polymorphic traits and gene markers studies in Indian goat breeds.
- Genetic improvement through the use of artificial insemination either with freshly diluted semen or with frozen semen with cryo-preservation of embryos
- Studies on hormonal and metabolic profiles in different physiological stages of goats, synchronization of oestrus with environmental and behavioural stimulation, etc.
- Development of cheaper complete feed.

- Surveillance and monitoring of goat disease for forecasting and control.
- Shelf life enhancement, Quality control & assurance, storage, packaging and marketing of goat meat and milk and other products.

viii. Sheep

- Genetic improvement of fine & carpet wool and mutton breeds& their characterization.
- Biotechnological approach for cryo-preservation of embryos & semen
- Development of economic sheep ration for migratory sheep, using mineral trace elements and biomodulaters for improving growth and wool quality
- Pasture development for arid & cold arid areas for sheep production system.
- Surveillance and monitoring of sheep disease for forecasting and control.
- Development of complete feed and supplementation of feeding system for optimizing meat and wool production.
- Utilization of different types of wool as pure or in blends with other animal and plant fiber.

ix. Rabbits

- Enhancement of productivity in terms of wool and meat through genetic, nutritional disease control and improved housing and management practices.
- Development of improved technologies for wool and meat processing.

x. Pigs

- Genetic improvement & conservation of different breeds of pigs.
- Surveillance and monitoring of pig diseases for forecasting and control.
- Shelf life enhancement, Quality control & assurance, storage, packaging and marketing of pork.
- Development of cheaper feeding system.
- Study of hormonal profile and improving reproductive efficiency.

xi. Poultry

- Studies on identification of DNA markers linked with disease resistance and development of divergent lines for immuno-competence in important avian species of economic importance.
- Updating nutrition research and assessing the bio availability of nutrients & reducing incriminating factors in poultry diets.
- Induction of early maturation of oviduct to improve egg size during the initial laying phase and extension of peak egg production period.
- Disease diagnosis & prevention through development of diagnostics & vaccines
- Development of improved zone specific poultry for rural poultry practice.

C. Programme Specific Research Priorities

i. Animal Production including breeding

The greatest problemin the area of Animal breeding has been that we have not been able to establish a field performance recording system for progeny testing of cattle and buffalo bulls nor has been possible to develop a multiple ovulation and embryo transfer driven programme for sire evaluation on basics of progeny testing. It is therefore necessary that a (MOET) programme for selection of sires be developed for crossbred herds in order to produce proven crossbred bulls of an index greater than 5,000 kg of milk in 305 days

Indian livestock in million of years of evolutionary development have resulted into one of biggest biodiversity hot spots in the World. Some of them have characters of high fecundity, disease resistance, heat tolerance and give moderate production under low-input regime. These animals have been neglected so much that many of them are under the threat of extinction. The major thrust therefore need be taken up the following research priorities.

- Characterization of breeds using DNA finger printing technologies for all species of livestock
- A multi–centre ex-situ conservation using deep freezing of sperm, occyte, embryos and storage of DNA fragments.
- Studies on identification of genes associated with disease resistance and high producing identification of markers associated with different economic trait.
- Socio–economic study on assessing the problems related to in-situ conservation.

ii. Dairy development

The research should be two pronged for small farmers and large scale dairy farmers. The small unit dairy farmers are handicapped with the availability of non-descript dairy cattle and buffalo. Problems associated with these are poor breeding services, non availability of graded animal semen and also high cost of feed and un-organized market. Therefore, the thrust should be given on the strategy on the following areas:

- Development of elite animals using Embryo Transfer Technology.
- Standardization of multi ovulation technologies in buffaloes.
- Selection in Yak and mithun population for trait such as milk, fat percentage, carcass yield, fibre yield & draught capacity.
- Genetic improvement through cloning and bypassing the traditional genetic improvement pathway using progeny testing as a base.

iii. Animal Nutrition

An effort was made to create an institution for this specific purpose to use biotechnology in breaking lingo-cellulosic bond in the plant cell wall to break lignin and cellulose through a solid state fermentation process. Some partial success has been obtained in this direction but more efforts are needed. Therefore, in addition, emphasis need be given to following research issues on priority.

- Research on development of quality standards conforming to the basic parameters, to identify adulterants, anti-oxidizing agents, toxicants, anti-nutritional factors for producing safer feed mixtures
- Development of National level data bank on feed, fodder, supplements, biomodulators, taste enhancer etc

- Rumen microbiology research with special emphasis to identify and characterize microbial population and enzyme profile in relation to nutrient utilization..
- Molecular marker and gene transfer research in rumen microbes for enhancing capability of breaking lingo-cellulose bonds
- Use of transgenic feeds and their effect on livestock health.
- Research on process technology for improving efficiency of feed mixing.
- Studies on clinical nutrition , nutrition of pet animals , game & wild animals & supplement research
- Temperate and alpine pasture research for sheep and yak production system

iv. Animal Health

For the control of any disease, specific diagnostics, vaccine, biological and drugs are essential to meet the Sanitary & phyto-sanitary, risk assessment & risk analysis regulations. Therefore, it is necessary to develop expertise in the field of Animal Health For this it is absolutely necessary that the emphasis be given to strengthen Animal health program to meet the challenges through the following research programmes

Data base on health & disease be generated by monitoring and surveillance of Isit A & B diseases of OIE

- Strengthening of Surveillance & monitoring system for exotic and emerging diseases
- Development & improvement of diagnostic technologies, immuno-prophylactics through biotechnological intervention for evolving new generation diagnostics & vaccines.
- Establishment of National Centre on the repository of micro organisms for developing sound disease diagnostics & vaccine development
- Pharmaco-kinetics of drugs including indigenous medicines and drug resistance studies.
- Environmental contaminants, toxicants & mycosis.
- Zoonotic diseases of public health significance.
- Immuno-modulators and host-parasite interactions.

v. Livestock Products

In view of the global liberalization, efforts are needed to be given for quality assurance and SPS requirements. Therefore, the research needs to be augmented in the following areas.

- Enhancement of shelf life through biotechnological interventions.
- Quality control and assurance of livestock products.
- Research on reducing post-harvest losses.
- Packaging & storage of livestock products.

vi. Socio-Economic Research

It would be necessary that a major research effort be made to estimate the economic value of livestock, their products and their interactions within the system. Following areas of socio economic research need to be undertaken.

- Economics of livestock production for sustainable livelihood of rural people

- Livestock productivity in mixed crop livestock systems in low input and intensive production system.
- Cost-benefit analysis on social impact of livestock production, acceptability of technologies; etc.
- Constraints and conflict analysis of technologies in livestock sector.
- Pricing, marketing, processing and trade strategies/policies
- Institutional credit and policy support for accelerated livestock development

Recommendations:

In view to sustain the livestock production and productivity it is pertinent to strengthen these institutions and the activities already being carried out under various programs. In addition, new initiatives need to be undertaken to meet the international requirements in terms of the risk assessment and management, Sanitary and Phyto-sanitary and Codex Alimentarius requirements.

Following recommendations are being made to implement the programs during the XI plan.

A. Strengthening of the on-going activities

S.No	Institute/Programmes/Schemes	Proposed XI Plan Outlay (Rs in Crores)
1.	National Bureau of Animal Genetic Resources, Karnal	20.00
	Network project on Animal Genetic Resources	15.00
2.	National Dairy Research Institute, Karnal including R&D support and Pilot project on IRD	80.00
3.	Central Sheep & Wool Research Institute, Avikanagar`	25.00
	Network Program on Sheep Improvement	15.00
4.	Central Institute for Research on Goats, Makhdoom	25.00
	AICRP on Goat Improvement	15.00
5.	Central Institute for Research on Buffalos, Hisar	25.00
	Network Project on Buffaloes Improvement	25.00
6.	National Institute of Animal Nutrition & Physiology, Bangalore	30.00
	AICRP on Improvement of Feed Sources & Nutrient Utilization for raising Animal Production.	20.00
7.	NRC on Camel, Bikaner	20.00
8.	NRC on Equines, Hissar	25.00
	Veterinary Type Culture	25.00
9.	Project Directorate-Cattle, Meerut	15.00
	AICRP on Cattle Research	25.00
10.	PD on Foot & Mouth Diseases including AICRP	30.00
11.	Central Avian Research Institute, Izatnagar	25.00
	PD-Poultry, Hyderabad	15.00
	AICRP on Poultry	25.00
12.	Indian Veterinary Research Institute, Izatnagar	85.00
	Network on Gastro Intestinal Parasitism	20.00
	Network on Hemorrhagic Septicemia	
	Network program on Bluetongue Disease	
	PD on Animal Disease Monitoring & Surveillance including AICRP	25.00
13.	NRC on meet and meat products technology, Hyderabad	25.00
14.	NRC on Pig, Guwahati	25.00
	AICRP on Pig	20.00
15.	NRC on Mithun, Jharapani, Nagaland	20.00
16.	NRC on Yak, Dirang, Arunachal Pradesh	20.00
	Total (A)	**740.00**

B. New initiatives:

I. Establishment of Infrasructure:-

a. Establishment of National Referral laboratories **(Rs. 60 cr)**
b.. Establishment of Bio-safety level-III containment laboratories **(Rs. 120 cr)**
c. Establishment of new campus of Central Avian Research Institute **(60 cr)**
d. Establishment of International Laboratory for FMD **(20 cr.)**

II. Establishment of Institutes/Centres/ Network programmes

a. Network on Animal Genomic **(Rs.100 cr.)**
b. Network on livestock related Environmental pollutants, contaminants & toxicants **(Rs. 70 Cr)**.
c. Network on Zoonotic diseases of public health significance **(Rs.10 cr).**
d. Network on Ethno-Veterinary Medicine **(10 cr)**.
e. Network on development of newer generation diagnostics, vaccines and drugs (Rs. 80 cr.)
f. Network on Methane production and nutrient utilization **(Rs. 30 cr)**
g. Establishment of Institute on Animal Virology **(Rs. 60 cr.)**
h. Network on Repository for livestock microorganism **(Rs. 25 cr)**
i. Network on Epidemiology and surveillance for diseases among Wild life animals **(Rs.10 cr)**
j. Institute on Health and management of Pet animals**(Rs.25 cr)**
k. Centre for Animal Disease Research & Diagnosis of IVRI to independent institute on Institute on Animal Disease Research & Diagnosis **(Rs. 45 cr.)**

III. Programmes:-

a. Diversification of nutrient base in animal feeding for intensive production **(Rs.10 cr.)**
b. Market intelligence, economic pricing and marketing (**Rs. 25 cr.)**
c. Dryland productivity and production augmentation in livestock **(Rs. 90 cr.)**
d. Feed processing and feed improvement **(Rs. 10 cr.)**
e. Rural & Backyard poultry production programme **(15 cr)**

C. Up gradation of the Project Directorates/National Research Centres to Institutes.

a. National Research Centre on Equines (NRCE) to Central Equine Research Institute

In view the significant achievements made by the institute the QRT of the institute recommended for the up gradation, which has already been approved by GB, ICAR.

b. Veterinary Type Culture (VTC) –an integral part of NRCE, Hissar to independent Institute on Veterinary Type Culture.

The activity was approved during X plan and for its initiation this was attached with NRC on Equines but keeping in view the importance of Microbes in animal science as a repository for the development of various diagnostics and vaccines it is stongly recommended that this may be taken up as an independent activity during this plan

C. Project Directorate on Cattle (PDC) to Centrall Cattle Research Institute

In view the significant achievements made by the institute the QRT of the institute recommended for the up gradation, which has already been approved by GB, ICAR.

d. Project Directorate on Animal Disease Monitoring and Surveillance (PD-ADMAS) to Institute on Animal Disease Monitoring and Surveillance In view the significant achievements made by the institute the QRT of the institute recommended for the up gradation, which has already been approved by GB, ICAR.

e. Project Directorate on Foot and Mouth Disease (PD-FMD) to Institute on Foot & Mouth Disease (NIFMD).

In view the significant achievements made by the institute the QRT of the institute recommended for the up gradation, which has already been approved by GB, ICAR.

f. Project Directorate on Poultry to Central Institute on Rural Poultry Research.

In view the significant achievements made by the institute the QRT of the institute recommended for the up gradation, which has already been approved by GB, ICAR.

g. High Security Animal Disease Laboratory (HSADL) to independent institute.
In order to develop research strategies specific for Trans-boundary diseases it is essential that HSADL, Bhopal-a campus of IVRI, Izatnagar should be separated and an independent status be given as per international norms.

h. Centre for Animal Disease Research & Diagnosis of IVRI to independent institute on Institute on Animal Disease Research & Diagnosis

The Centre is meeting the demand of the country for disease diagnosis and coordinating with Regional Referral Diagnostic Laboratories of Deptt. of Animal Husbandry & Dairying as a Central Unit designated by the deptt. But the objectives are not being fulfilled completely. Therefore, keeping in view the national perspectives and QRT recommendations approved by GB, ICAR, this center need to be made independent to an institute.

D. Consolidation of Foot & Mouth activities.

In view of the disease situation it would be pertinent to consolidate all the activities being carried out by IVRI & PD-FMD at one place by transfer of the H/Q of PD-FMD from Mukteswar to Bangalore as per the recommendation of the QRT and approved by GB,ICAR. This would be helpful in better utilization of financial and human resources.

E. Competitive Grant Research Schemes

In recent past AP Cess fund schemes were being implemented which were being approved to different institutions in the important areas of research in order to bridge the critical gaps but due to the discontinuation it is now difficult to support such proposals. This activity has made significant achievement in recent past. Therefore, in order to stream line the similar activities during this plan it is proposed that the scheme may be implemented on the lines of AP Cess fund in the selected important areas with an total outlay of **Rs. 150 Cr.**

F. PROGRAMMES TO BE MODIFIED/PHASED OUT/RE-ORGANIZED

There is extreme duplication in research agenda of the institutes, which need to be thoroughly looked into and need to be avoided. Following areas have been recommended to be critically evaluated and rectified.

a. Conservation, evaluation and identification of germplasm is mentioned as an objective of all the institutes and also the main mandate of NBAGR which is also targeting all the species particularly those, for which there are species specific institutes. The programs under this area therefore need review for the clear delineation of the institute activity vis-a-vis NBAGR.

b. In the discipline of Animal genetics & Breeding, Animal Nutrition programs have been undertaken at certain applied aspects which have had long innings and associated with the large components and scientific personnel. These programs, which are not close ended, and have lost reference in light of modern techniques and technology and also stake holders expectations, need to be dropped. Also the formation of discipline-oriented institutions should take up any of the residual programs, which are essential. These species specific institutes therefore, have to do an exercise that such overlapping are avoided, particularly, if such programs do not come under such basic research and have limited applied research identity.

c. A large number of research advances and technologies have been claimed as achievements in the institute reports. Some of them appear to be very promising particularly in the light of field problem and stakeholders demand. Active research on these programs on advances made so far will remain more beneficial to the system than continuing and amending research efforts done. Such identified programs need to be discontinued further, kept in abeyance and the results obtained so far be implemented in certain research mode and on basis of action research the results, borne out of targeted improvements be reshaped and recommended wherever necessary and suitable for continuation.

d. Species improvement program should be in a holistic manner and not to be restricted to the genetic and breeding. All should be encompassing to nutrition, health, and production.

CHAPTER - IX

ANIMAL SCIENCE EDUCATION

IVRI has been granted the status of deemed to be university in November, 1983. The university has been offering Master's and Ph.D. degrees in 23 and 18 disciplines, respectively n various disciplines of Veterinary and Animal science. This institution is fore-runner in providing such education at national and international level. In addition P.G. diplomas for sponsored candidates of state governments and defence organization are also offered. Besides, foreign students from SAARC and other developing countries are deputed for various programmes. Staff courses and summer institutes have been organized by the institute to continuously acquaint the professionals with latest developments in veterinary and animal sciences from time to time.

NDRI being the deemed to be university status is developing human resource in the field of Dairy Technology and besides providing research support to the Nation's Dairy Industry has also gained prominence as the front ranking Human Resource developmental Organization in the world dedicated to the cause of dairy development. A full-fledged and comprehensive three-year course leading to Bachelor's Degree in programme in order to cater to the demands of high tech dairy processing industry was started in 1957. Since 1989, the Institute has acquired Deemed University Status, NDRI has been the main fountainhead of trained manpower for the country's expanding dairy industry. The institute, over years, has been conducting not only regular degree/diploma training programme but has also been involved in giving specialized short courses. As an academic institution the university conducts programmes leading to award of B.Tech, M.Sc. and Ph.D. degrees in fourteen disciplines. Besides these degree programmes thousands of short courses/orientation trainings have been held through which the expertise has been provided in various aspects of dairying. NDRI has also provided PG training to students from Afghanistan, Iran, Ethopia, Egypt, Bangladesh, China, Iran, Nepal and Vietnam. Advanced trainig has also been provided to scientists from Ghana, Nepal, Syria, Nigeria and Sri Lanka

In addition to these deemed universities the animal science education is being imparted through veterinary colleges under different agricultural & veterinary universities. The financial support is being provided by the council to these institutions but the condition of veterinary colleges are so pathetic which needs a consideration and sufficient financial allocation is necessary to be provided. For meeting the demands of education ; human resource is necessary, therefore, attempts be made for continuous programme for developing their technical know-how in order to meet the challenges of the changing scenario.

i. Reorientation of educations system

In the past since independence the country has witnessed a significant progress in the field of Animal Science Education. These colleges are imparting education for direct employment in private and public sector institutions. Limited number of jobs is available in government institutions. Veterinary & A.H. and dairy activities are becoming commercialized and fragmented. At one side large & commercialized animal holdings are emerging in dairy, meat egg & wool sector & at the other small livestock unit are also increasing in number in far flung and under developed areas. There is strong need for reorienting our educations system in order to generate knowledge to meet the skill needs of the commercial farmers and small unit farmers, communicate the knowledge and skills effectively and utilize the knowledge for meeting the need of the two different types of livestock systems.

ii. Strengthening of infrastructures

Following Veterinary Council of India (VCI) notification on regulation of veterinary education which came in force in 1994, the veterinary colleges under the National Agricultural System (NAS) were supposed to strictly follow the "minimum standards of veterinary education- Degree Course-BVSc and AH – Regulation 1993". At present all the Universities in the country are bound to follow these regulations but due to financial constraints these are not being followed properly resulting into the de-recognition of the colleges which is one of the major crises in the country in the near future. Therefore, there is an urgent need to support these institutions to upgrade the facilities to meet the requirements.

The present agricultural education system comprises of 40 State Universities including 5 Veterinary Universities and one Central Agricultural University. In addition, 4 National Institute having the status of deemed universities are imparting UG/PG level education in Agricultural Sciences, Veterinary Sciences, Dairy Science and Fishery Sciences. Besides this Central Universities under UGC systems and many private colleges attached to several universities also impart UG/PG levels education in subjects of Agriculture, Animals Husbandry & Dairy Sciences. The UG programme is presently covering the disciplines of Agriculture, Veterinary, Fishery, Forestry, Sericulture, Dairy Technology, Food Technology, Horticulture, Home Science, Agricultural Engineering & Agricultural Marketing. Therefore, these institutions need development of infrastructures to meet the demads.

iii. Knowledge Initiative

The current scenario demands that the present educational system should be able to meet the needs of the farmers. It is necessary that the future veterinarians should be knowledge intensive and practical oriented in order to provide effective services to livestock sector and should be able to utilize the knowledge for meeting the needs of the two livestock production systems those of (i) commercially viable and wealth and employment generating entrepreneurships and also (ii) the low input small units systems which should be converted into an entrepreneurial system through intensive knowledge and technology driven system.

iv. The Post Graduate Educational programmes

It also need a complete revamping to meet the demand of the country for research and teaching; clinical and para-clinical based on hospital/clinic/diagnostic center focused programme leading to a professional masters and Ph.D. degree.

v. Professional upgradation

At the same time there is constant need for professional upgradation to meet the demands in private and public sector employment essentially managing clinical, para-clinical and prophylactic aspects of livestock sector, therefore, it is necessary that such programmes in veterinary colleges be initiated to upgrade the skills of these professionals through PG diploma courses.

vi. Continuing Education programme

In last 50 years Medical Sciences had made tremendous progress through continuing education programme but most of the veterinary colleges do not have facilities of using the latest diagnostic facilities and the teachers are not acquainted. Therefore, it is essential that this should be made mandatory & compulsory especially in the fields of Dairy Management, Dairy Technology, Food Processing & Health Management and Diagnosis.

The veterinary and dairy curriculum has no relationship with the graduates who have passed out of their institutions while the technology platform has undergone tremendous changes and no efforts has been made to up[grade the skills of veterinarians in the field and dairy, poultry and other specialists involved in livestock sector. A continuing education programme in different universities would be helpful in upgrading the skills.

vii. Holistic Veterinary Education:

Veterinary education did not develop in holistic manner and a veterinarian in addition to providing health care to animals are supposed to provide advanced knowledge in nutritional, physiological, reproductive and other requirement of livestock.

viii. Livestock Products based business management:

After independence livestock enterprises took the shape of medium & large scale industry e.g. poultry, dairy piggery, goatry, wool, hides & skin, animal germ-plasm, pet animal rearing, veterinary surgery & pharmaceuticals, livestock feed industry etc. All these need strong business management base but hardly any veterinary/dairy institution is having the ability to provide basic & applied knowledge in this area of animal science management. Therefore, there is urgent need to develop expertise in this direction to meet the challenges of fast growing livestock sector.

ix. Dairy Science

Related programmes on milk procurement, storage, handling, transport, semen handling, artificial insemination, fodder production, nutrition, disease control marketing, credit & insurance needs are organized by various institutions. These training programmes are offered to in-service candidates, staff of primary milk producers cooperatives, dairy technicians & teachers. NDDB organizes these programmes in their regional demonstration & Dairy Centers. CFTRI (Mysore) also conducts training in processing & preservation of dairy products. BAIF a voluntary organization is providing excellent support to dairy profession by organizing training and demonstration programmes in the country. Similarly AFPRO, KVKs & TTCs are also engaged in such demonstrations which are the basic need of the dairy industry.

A wide gap between the dairy science education imparted and the requirements of organized dairy industry of national/international standard was observed by dairy education A joint NDDB/ICAR panel was established to identify the inadequacies of the dairy education. This panel suggested establishment of four centers of excellence on the pattern of IITs to cater the region specific need in dairy education system. Third year of this course would be devoted on practical training in modern dairy plant. A model syllabus was devised in consultation with persons of industry & trade. They have given weight-age to engineering, management, & computerization.

x. Management Sciences:

Management Sciences are important tool for successful dairy industry which has involvement of socio-cultures & environmental base of dairy farmer, complexities of dairy plants and fluctuating nature of market and trade. Graduates should have the ability to cope & adjust under the above changed environment. Dairy education scholars should have the knowledge base to face these complexities.

Recommendations:-

Education through internet has become a part of modern knowledge delivery and technique acquisition. Alternate use of animal demands to have virtual labs. In the pre and Para-clinical fields. For this purpose, such virtual classrooms need to be set up in each veterinary and animal science institution.(40x1 = **40 cr)**

i. Revitalizing the infrastructure for Veterinary and Animal Science and critical allied disciplines:

Over the years, Indian Council of Agricultural Research has considerably strengthened agricultural education for financial support to the constituent universities. While in some of the universities, the funds have fluid adequately, but in most of the veterinary colleges, the flow of funds within the university had not been in accordance with the priorities and needs of the veterinary and animal science faculty.

To ensure excellent human resource development that would meet the demands of global competitiveness and meet highly professional competent requirements for modern livestock production as well as trading the knowledge of our graduates' international standards, a higher investment is proposed as follows:

a. Building Repair and re-constructions:

The college structures, buildings and laboratories are old some dating back as 113 years with most more than 40-50 years which are in a very depilated condition. An amount of 5 crores each is proposed as one time infrastructure grant to the colleges (40x5 cr each= 200 crores).

b. "State of Art" Demonstration/Instruction including instructional livestock farms and livestock product processing Units:

Each College needs a Demonstration and Instructional Unit where different breeds/species of livestock are kept and managed. Additionally, there are technological advances in management infrastructure which need to be demonstrated for student learning as well as for bringing awareness among the farmers. In fact modern livestock production units require such mechanized and "state of art" units which are necessary for production of quality animal products. Since setting up livestock demonstration/instructional farm needs heavy investments in terms of animals/sheds, equipments, gazetteer, manpower and feeding, a special grant needs to go for each college for, a)Construction and development of demonstration/instruction units and b) Maintenance of these units.((40 x 2 = 80 cr.) for development and 40x.0.5 cr x for 5 years annual maintenance =100 cr. total -180 cr.)

c. Super specialty veterinary clinical institution:

There is no super specialty veterinary clinical research institution in the country as of today. Such super specialty clinical research institutions are needs in the country on original basis. It is proposed that four such institutions need to be set up on regional basis. To begin with, two such institutions are being proposed, one for the north and one for the southern region. (2x60 cr **= 120 cr.)**

ii. Clinical Complexes in Veterinary Institutions:

The performance of the veterinary institutions is reflected through the type of clinical facilities and expertise developed among the professionals undergoing training. The present state of clinical facilities in most of the colleges is apologetic and needs a complete change both in terms of infrastructure as well as the quality equipments and services available. (30x4 = 120 cr.)

iii. Strengthening teaching faculty:

Though providing the faculty is primarily through the State Govts., but over the years it has been observed that the State funding is not available for providing faculty positions in the new frontier areas of science which need essentially to be part of the educational curriculum. Under these circumstances, strengthening of teaching faculty is paramount for new areas which are being included in the student curriculum.(40x1 = 40 cr.)

iv. Capacity Building in Veterinary Science Teaching:

In the absence of specialized Veterinary and Animal Science training/teaching Institutions in the country and considering the fact that considerable advancement in science and technology has occurred world over in the clinical and production sciences, the present faculty need re-training in advanced specialized training institutions outside and inside the country. For this purpose, a special faculty improvement program with short and long-term training outside the country in collaboration with advanced institutions in the developed world need to be initiated. At least 15 teaching faculty members from the institutions need to be deputed during the next five years **(**40 cr.)

v. Teaching Assistance Program for Capacity Buildings in Veterinary Colleges.

The acute shortage of manpower in Veterinary Institutions need to be met immediately through liberalized entry into the veterinary teaching. Outstanding Graduates from each college be offered positions of teaching assistance at emoluments at part with the first entry level for the scientists and they be allowed to pursue their Masters program in service (to be completed within five years). This is to ensure that academic brilliance is ploughed back into teaching /research- an area which is a major concern for modern education.(40 cr.)

vi. Centre of Excellence in Animal science Education :-

In order to meet the training needs of Veterinary teachers in various veterinary colleges it is recommended to create Centre of Excellence should be established. (40 Cr.)

vii. Attract trained personnel to teaching, Pool Officers:

In order to attract trained manpower also to avoid brain drain who have obtained Doctoral/Research experience within the country and outside back to our teaching institutions, it is essential that we should have certain positions ear-marked in each institution so that such manpower which is eager to return back to the country or ready to serve the education/research areas, have a window to enter the NARS. These officers be offered pay-scales equivalent to S-2 with an entry basic salary of basic 12,000/-with an initial tenure of five years. It is proposed that five such positions in different disciplines be available for each of the colleges/institutions.(20 cr.)

viii. Fellowships/Scholarships:

To attract students for professional career in veterinary science education as well as post-graduate teaching and research, it is essential that we should provide additional fellowships/scholarships both at under-graduate and post-graduate level for all the veterinary institutions.. (60 cr.).

ANIMAL SCIENCE EXTENSION

Extension programmes are being implemented through KVKs and Operation Research Projects and the technologies developed by institutions are being transferred for adoption. Urea molasses blocks provides nitrogen and minerals to the micro organism in the rumen and thus improve the digestion of the straw. The technology is being used routinely by the farmers to increase the milk production.

Newer bio technology relating to manipulating rumen microbes are being used which can improve the efficiency of utilization of feed resources. Various non conventional protein feeds are identified which are not palatable when fed alone but appropriate technologies have helped in utilization of these feed resources on large scale.

Embryo transfer and frozen semen technology along with artificial inseminations are being used for upgrading indigenous breeds for better production. Many of the disease problems amongst livestock and poultry have been controlled and are being regularly monitored. A regular vaccination, deworming and drenching is being done to control various diseases.

Recommendations:-

At present the extension activities are not so developed to transfer the technologies to the farmers sufficiently and at the same time KVK's already existing are also not meeting the demands, therefore, at initial stage 100 such Pashu Vigyan Kendras including livestock demonstration farms for hands on training need to be set up in districts under the livelihood programme with an overall proposed allocation of **Rs.1000 cr .**

9. FISHERIES AND AQUACULTURE

Proceedings of the Minutes of the First Meeting of Sub-Group (Fisheries) constituted by XI Five Year Plan Working Group on Agricultural Research and Education held on 27.07.2006 at KAB II, Pusa, New Delhi

A Meeting of the Sub-Group on Fisheries constituted by XI Five Year Plan (2007-2012) Working Group on Agricultural Research and Education was held on 27.07.2006 under the Chairmanship of Dr. T.J. Pandian, Former National Professor, Indian Council of Agricultural Research, New Delhi. The following Members were present.

1.	Dr. S.D. Tripathi, Former Director, CIFE, Mumbai	-	Member
2.	Dr. M.V. Gupta, Former ADG, World Fish Centre, Malaysia	-	Member
3.	Shri Haridas, Dy. Adviser (Fisheries) Planning Commission, New Delhi]	-	Member
4.	Dr. A.D. Diwan, ADG(M.Fy.), ICAR, New Delhi	-	Member Secretary

At the outset Member Secretary presented a formal welcome to the Chairman and Members of the Committee and briefed the terms of reference of the meeting.

The Chairman expressed his thanks to the Department of Agricultural Research and Education (DARE) for giving him an opportunity to act as the Chairman of the Sub-Group on Fisheries. Further he also briefed the Members about the objectives of the meeting and asked for the comments and suggestions from the members on the items (i) to (vi) of the Terms of Reference. These were discussed in detail.

- Capture Fisheries

➢ Sustainable management of marine fish resources
➢ Conservation of marine mammals and sharks
➢ Protection of livelihood of artisanal costal fishermen
➢ Fisheries Statistics of major riverine system and estuary
➢ Location of sanctuaries and strengthening of stocks by spawning the local stock at site
➢ Protection of natural spawning grounds and restoration of habitats
➢ Investigations on brackishwater lakes, lagoons and coldwater lakes

- Culture-based Capture Fisheries

➢ Enhancement of the production and productivity of different categories of reservoirs through various management practices and technological utilization

- Culture Fisheries

- ➢ Production System
- ➢ Fish breeding and seed production
- ➢ Soil and Water Environment
- ➢ Fish Nutrition
- ➢ Fish Genetics and Biotechnology
- ➢ Fish and shellfish Diseases and management
- ➢ Social Sciences, Economic and Extension
- ➢ Ornamental fish breeding and culture programmes
- ➢ Diversification of aquaculture practices and high value species
- ➢ Commercial scale operation of technologies in collaboration with private partnership
- ➢ Promotion of mariculture activities
- ➢ Genetic enhancement and improvement of selected species
- ➢ Socio-economic impact studies
- ➢ Survey of fish markets to identify demand and supply issues
- ➢ GIS studies to identify aquaculture sites

- Brackishwater Aquaculture
- Harvest and Post-Harvest Technologies
- Human Resource Development and Educational Activities

After deliberating the researchable issues the committee also discussed on-going programmes on women and other small and marginal farmers involved in fisheries. The institutional mechanism for strengthening, monitoring and evaluation system in fisheries research was also deliberated upon. It was decided that the interim report of the committee of the Sub-Group on Fisheries will be submitted by mid August.

The Meeting came to an end with Votes of Thanks to the Chair and Members from the Member Secretary.

(A.D. Diwan)

Member Secretary

ACHIEVEMENTS OF X FIVE YEAR PLAN (2002-2007)

FISHERIES

Development in Marine Fisheries

Developed a Mass Balance Trophic Model of the Arabian Sea ecosystem which can forecast the impact of change in effort on marine resources. Analysis based on trophic level of 707 species revealed that Fishing Down Marine Food Web occurs along southeast coast of India at the rate of 0.04 trophic level per decade. The National Marine Fisheries Census – 2005 was carried out in all the maritime states covering 7.56 lakh fishermen households, 3202 fishing villages. The historical time series data on biological aspects and landings of selected species analysed and published as "Marine fish Landings in India 1985-2005-Estimates and Trends".

Brackishwater Aquaculture

Captive brood stock development and domestication of kuruma shrimp *Marsupenaeus japonicus*, a candidate species for diversification was achieved. Culture of *M. japonicus* was successfully carried out in brackishwater pond with a survival of 83% and a production of 1018 kg /ha/4 months.

Developed captive land-based brood stock of Seabass, L*ates calcarifer* and produced F_4 generation. Standardised technology package for hatchery seed production or seabass and established a model marine finfish hatchery.

Freshwater Aquaculture

Giant Freshwater Prawn, *Macrobrachium rosenbergii* was bred in captivity using inland saline water and post-larvae raised with suitable ionic amendments without the use of sea water. Successful breeding of yellow catfish, *Horabagrus brachysoma* and freshwater eel *Mastacembelus aculeatus.* Through selective breeding technique, growth enhancement to the tune of 17% per generation in rohu *Labeo rohita* was demonstrated and **Jayanti** rohu given to farmers. Location and altitude-specific composite carp farming technology has been developed for hilly areas.

Management of Small Reservoirs

High fish production levels of 220 kg/ha/year have been achieved from small reservoirs as against the national average of 20 kg/ha/year.

Mariculture Technologies

Larval rearing protocols were developed for honey comb grouper *Epinephelus merra* and one seed production trial was successfully completed.

In vitro marine pearl production through tissue culture technique was successfully carried out in Indian Pearl Oyster *Pinctada fucata* and abalone, *Haliotis varia.* Make-up pearl production where *Pinctada fucata* pearls were colour - modified to mercurial blue and mercurial pink using heavy metals like iron and manganese.

Two species of sand lobster (*Thenus orientalis, Scyllarus rugosus*) were successfully bred in captivity and larval cycle completed in three to four weeks time.

Captive spawning of three varieties of damsel fishes namely *Dascyllus trimacultus, Pomacentrus coelestis* and *Dascyllus aruanus* was achieved.

Twelve hundred juveniles of sea cucumber, *Holothuria scabra* (mean size 25 mm) bred in captivity were sea ranched.

Duplex PCR Kit for the detection of white Spot Syndrome Virus commercialized.

Fish Harvest and Post-Harvest Technology

Developed designs of eco-friendly and resource - specific demersal trawls, V form otter boards, Turtle Excluder device (TED), square mesh cod ends, FRP sheathed, untreated rubber wood canoes, prototype of a 5.22 m LOA aluminum alloy boat for inland sector, Monoline fishing (long lining) for reservoir fisheries. Designed and constructed fuel-efficient 15.5m steel trawler, "Sagar Kripa', consuming 20% less fuel compared to conventional trawlers of the same size.

Standardised production of several value-added products from cuttlefish, squids, threadfin breams, Tilapia and Catla and carps. Developed a method of packaging system for cooked products in retortable flexible pouches, providing seal integrity, toughness and puncture resistance to maintain and preserve quality of cooked products for more than a year.Developed a method for detection of White Spot Disease in shrimp as also RT-PCR technique for detection of Yellow Head Virus.

Fish Genetics and Biotechnology

Sperm cryopreservation technique for endangered red tailed barb, *Gonoproktopterus curmuca* was standardized. Cryopreservation of eggs of rohu, *Labeo rohita* at the stage of blastomere achieved.

A probiotic preparation for the control of luminescent bacteria in the hatchery has been developed.

Polymorphic microsatellite and allozyme markers developed for fifteen fish species and *Macrobrachium rosenbergii.* Microsatellite enriched genomic libraries for *Chitala chitala* and *Pangasius pangasius* constructed.

Developed a database 'Fish Chromosome World', containing karyomorphological information on 126 finfish species from 34 families and 9 orders. Stock structure analysis of *Labeo rohita, Catla catla, Cirrhinus mrigala, Labeo dero* and *L.*

dycheilus from different riverine system in Indo-Gangetic plains using allozyme and microsatellite completed.

Fish Conservation and Management

Diagnostic capability for exotic OIE listed pathogens by PCR was developed. Guidelines for introduction of Aquatic Exotic and Quarantine in support of national strategic plan were developed and published.

Fisheries Education

The CIFE continued to offer doctoral, masters and post-graduate diploma and certificate courses in fisheries through its headquarters and research/education/training centers. The CMFRI,CIFT and CIFA continued their M.F.Sc. and Ph.D. programmes in Mariculture, Post-harvest Technology and Aquaculture in collaboration with CIFE. During the period, the CIFE produced 190 M.F.Sc. students, 49 Ph.D. students and 93 P.G. Diplomas.

Specific programmes pertaining to Fisheries Research to address the problems of less privileged regions

Fisheries Division under the ICAR has no research centers in the states of Sikkim, Mizoram, Arunanchal Pradesh, Nagaland, Tripura, Meghalaya and Manipur. However specific programme for development of fishery and aquaculture in the aforesaid states under the North east component has been initiated by the Central Inland Fisheries Research Institute (CIFRI), Barrackpore: Central Institute of Freshwater Aquaculture (CIFA) Bhubaneswar; Central Institute of Fisheries Education (CIFE); Central Institute of Fisheries Technology (CIFT), Cochin; National Bureau of Fish Genetic Resources (NBFGR), Lucknow and National Research Centre for Coldwater Fisheries , Bhimtal.

The research programmes implemented were –

- Preparing the inventory of ornamental fishes of NEH States
- Preparing the inventory of indigenous crafts and gears of NEH States
- *In situ* conservation programmes for threatened fishes in the identified water bodies involving local communities
- Demonstration and training programmes on integrated fish farming and composite carp culture
- Training in fabrication, FRP and rubber-wood canoes for inland fishing activity
- Demonstration on preparation of various fish products and maintenance and repair of ice plants and cold storages
- Training in cage rearing for raising fish stocking material in floodplains wetlands

- Different threatened / endemic fish species namely *Ompok pabda, Puntius sarana, Channa aurantimaculata, Channa stewarti, Channa blehere, Chitala chitala., Labeo pangusia,* and *Rita rita* were collected from natural habitats and added to the NE regional Live Fish Gene Bank at Guwahati.
- To manage fish & fisheries in NEH region on scientific lines, a collaborative programme on "Rapid survey of fishery resources in Arunachal Pradesh" covering 14 districts is in progress. The data pertaining to morphology and bioecology of all the water bodies and their fish biodiversity is being recorded. In addition, this survey work will be validated through application of GIS.
- Pen culture technology demonstrated earlier in the north east states has become popular and is now being practised by farmers in Lali beel (Morigaon), Deochora beel (Badarpur, Karimganj), Hauder beel, Samaguri beel (Nagaon), Haribhanga beel (Nagaon), Morakolong beel (Morigaon).Further, this technology now has been included as bankable technology by NABARD, in the region for financing from commercial banks. The Assam Fisheries Development Corporation has made pen culture a mandatory activity for the lease holders of beels in the the state.
- Pig-cum-fish culture demonstration involving 25 beneficiaries covering 25 ponds in 16 districts of Arunachal Pradesh was conducted.
- Composite fish culture demonstration programme was done in Meghalaya involving 40 beneficiaries covering 40 ponds in 7 districts.
- Demonstrations in fish handling, processing and product development
- Use of ice box for preservation and transportation of fresh fish

On-going Programmes for Women in Agriculture

- Demonstration of freshwater aquaculture technologies involving large number of farm women
- Training programmes on freshwater pearl culture and ornamental fish farming
- Special training workshops for women self groups on selected technologies of CIBA
- Special summer camps on (action research on community based coastal zone management with specific involvement of women).
  Topics covered included responsible fishing methods, net making, rain water harvesting, mushroom cultivation, preparation of vermicompost, fish ensilage and fish cutlet
- Training programme in production of value added fish products to women community of gram panchyat and SHGs in Kerala
- For sustainable development of fisheries, empowering the women folk to take decision on different fisheries activities are the most important inputs. With a view to improving the socio-economic status of women and weaker sections of society, a number of programmes were implemented by the Fisheries Research Institutes.

On-going Programmes for SC/ST/ OBC

- In Bihar and Jharkhand, a package of practices for freshwater prawn culture and composite carp culture was given to the SC/ST/OBC in consultation with the Director of Fisheries of the states.
- During the period, a total 580 numbers of fish farmer/fishermen belonging to SC, ST and OBC were trained in various programmes of implementation of fishery development interventions in beels which are located in West Bengal and Bihar.
- Training- cum-demonstration of mud crab fattening technology and cage culture of seabass for tsunami affected fisherfolk at Pulicat was conducted. One day seminar on seaweed and mud crab technology for Self Help Groups of Marakanam was undertaken. Farmers Meet on Brackishwater Aquaculture technologies at Kakdwip Research Centre of CIBA was held. CIBASTIM, the immunostimulant developed by CIBA was demonstrated in the farmers meet at Kakinada.
- Mass awareness programmes with regard to conservation and development of fisheries were organized for fishing communities including SC/ST /OBC population in the NE region.
- Demonstration of composite fish culture was undertaken in Kalahandi of Orissa and Bastar of Chhattisgarh. While in Kalahandi district of Orissa 26 ponds covering a total water area of 20.86 hactares are covered for demonstration purposes, in Bastar district 16 ponds of 12 ha. water area have been adopted. A total number of 325 beneficiaries were involved in the programme.

PRESENT STATUS AND CRITICAL GAPS OF RESEARCHABLE ISSUES IN FISHERIES

The fisheries sector in India is immensely contributing to the countries economy providing valuable foreign exchange and employment to millions of people. At the same time it is an instrument of livelihood for a large section of economically backward population of the country. More than 7 million fishers in the country depend on fisheries and aquaculture for their livelihood. Indian fisheries is an important component of the global fisheries, with India being the fourth largest producer of fish in the world and second in Inland fish production. India's share in the world's fish production has increased from 3.2% in 1981 to 4.5% at present. Fishery sector occupies an important place in the socio-economic development of the country. Fish production in the country has been showing an increasing trend and has reached a record level of 6.4 million tones.

Research and Development Support

Inland Fisheries

The inland fishery resources comprise rivers, canals, estuaries, floodplains wetlands, lagoons and reservoirs and this sector holds enormous production potential to meet the inland fish requirement of the country. The river system of the country comprises 14 major rivers (catchments >20,000 km^2), 44 medium rivers (catchments 2000 to 20,000 km^2) and innumerable small rivers and desert streams. Different river systems of the country, having a combined length of 29,000 km, provide one of the richest fish genetic resources in the world. The floodplain lakes are primarily continuum of rivers Ganga and Brahmputra. These are in the form of oxbow-lakes (*Mauns, Chaurs, Jheels, Beels* as they are called locally), especially in the states of Assam, Manipur, West Bengal, Bihar and eastern Uttar Pradesh. Reservoirs constitute the single largest inland fishery resource, both in terms of resource size and productive potential. A detailed study made by FAO in 1995 has estimated a total of 19, 370 reservoirs in the country with a total area of 3.15 million ha.

Indian floodplain lakes (0.24 million ha) are primarily continuum of rivers Ganga and Brahmputra. These are mainly located in states of Assam, West Bengal, Bihar and Uttar Pradesh. They occupy important position in inland fisheries of India, because of their magnitude, their production potential and serving as breeding and nursing ground for riverine fish stock. These water bodies are extremely rich in nutrients. The floodplain wetlands are lying uncared for and are in the process of swampification. These are capable of yielding one tonne of fish per ha on an average, if subjected to scientific management. Therefore, a vast untapped production potential is yet to be harnessed in floodplain wetlands.

The estuarine systems (2.7 million ha) are identified as important source of fish and prawn seed. These are vital for fisheries of both rivers and marine sector. The fisheries of estuaries in India are above 'subsistence level with average yield swaying between 45 to 75 kg/ha/year.

The post-independence period has witnessed commissioning of a number of small medium and large river valley projects leading to creation of a chain of impoundments in form of reservoirs. With present day magnitude of 3.15 million ha, reservoirs form the most important inland open water fishery resource of our country. The area under reservoirs is expected to reach 6.0 million ha in another two decades. The present fish production from reservoirs is estimated at 0.94 lakh tonnes, with over 79% contribution of small reservoirs, followed by large (14%) and medium (7%). At present level of management and utilization, they yield an average of 20 kg/ha/year, which is far below the potential. Though much higher per ha fish productions are possible, even a moderate increase of 100 kg/ha for small and 50 kg/ha for medium and large reservoirs can provide an additional increment of 1.65 lakh tonnes of fish (Valued at Rs. 49.50 lakh @ Rs. 30/- per kg). Therefore, reservoirs are one of the most potential fisheries resource for future fisheries development in our country. Scientific management of these waters through stocking, selection of right species, stock manipulation, fishery regulations, harvesting schedules, adoption of pen and cage culture technologies, development of package of practices for different categories of reservoirs would help in increasing the fish production from these water bodies.

Indian upland fishery waters include rivers (8,253 km), natural lakes (21900 ha) and reservoirs (29,700 ha). The capture fisheries of these waters is poorly developed. It is characterized by low primary productivity of resources, slow growth rate of fish, inefficient fishing practices and inaccessibility of fishing sites.

Marine Fisheries

The marine fisheries resources of the country are in terms of 8,129 kms long coast line, 0.5 million sq. km of continental shelf and 2.02 million sq. km of exclusive economic zone. Contributed by major fish species like oil sardine, mackerel, Bombay duck, pomfrets, shrimp, the catches have gone up from 0.53 million metric tones in 1951 to 2.99 million metric tones in 2004. The fish production from the open seas has been stagnating since the last decade and marine fisheries is still restricted to the near shore areas. Against the estimated potential of 3.9 million tones, the sector has already reached the 2.99 million tones mark, thus leaving a balance resource of around one million tones, in the pelagics of the Indian Southwest coast as well as deeper waters and oceanic zone.

Marine capture fisheries play a vital role in India's economy. The sector provides employment and income to nearly two million people. The growth in marine fish production during 1950s and 1970s has been faster as compared to the inland fisheries. However, 1980s and 1990s, the trend has been reversed, as the marine fish production has been slow as compared to the inland fisheries. During the last decade (1990s) the marine fish production have reached a plateau. The present scenario suggests that the current level of marine fish production from the exploited zone has to be sustained by closely monitoring the landings and the fishing effort and by strictly implementing the scientific management measures.

To fish those resources for increasing fish production from the marine sector, the industry needs ocean-going vessels and sophisticated on-board facilities which are capital-intensive. The strategies proposed for marine fisheries management are regulated and diversified fishing, targeting the under-exploited and non-conventional resources of the EEZ, identification of potential fishing zones, stock enhancement through sea ranching, installation of fish aggregating devices and artificial reefs, community based resource management, responsible fishing including reservation of identified coastal area exclusively for fishing by fisherman using traditional catamaran etc. closed seasons and mesh regulations, assessment and exploitation of resources available around islands and infrastructural support in terms of deep sea vessels, on-board and on-shore facilities.

The marine environment provides an immense biodiversity that is being catalogued for commercial uses. These include several microorganisms, algal forms, invertebrates, that could serve as potential sources of bioactive substances including antimicrobials, anaesthetics, anticarcinogens, etc. as well a wealth of valuable genetic material for transgenics and thus presents a huge opportunity for both Food and Drugs from the seas. Identification of suitable sites along the Indian coastline of over 8000 km, hatcheries and grow-out systems for finfish, shellfish and other organisms, possibilities of cage culture in island eco-systems are the strategies for realizing these potentials.

Research thrusts in the next five years pertain to studies in the shelf, slope and oceanic realms of the EEZ to assess and map the resource potential, upgradation and species diversification of mariculture technologies, socio-techno-economic aspects of marine fisheries and brackishwater aquaculture, design and fabrication of modern fuel-efficient fishing vessels, development of cost-effective and responsible fish harvesting systems, diversification and value addition for utilization of low value fish, quality assurance and management systems.

Culture Fisheries

Freshwater Aquaculture

The share of inland fishery sector, which was 29% in 1951, has gone up to more than 50% in 2003-04 indicating increasing contribution of inland sector to the total fish production. Further, it is significant that aquaculture production has increased tremendously during the last decade. Consequently, the percentage share of aquaculture in total inland fish production is estimated to be about 75-80%. Two specific aqua-producers, carps and prawns in freshwater aquaculture and shrimps in brackishwater aquaculture, have contributed to the bulk as well as value of the inland aquaculture sector.

Freshwater Aquaculture resources of the country have been estimated of the order of 6.23 million ha, of which 2.25 million ha are in the form of ponds/tanks, 0.827 million ha beels/jheels/derelict water bodies and 3.15 million ha reservoirs. The present contribution of 3.5 million tonnes from these resources hardly commensurate with their vastness and offer the scope for more production with the available technologies in the country.

There is a wide scope for increasing fish production through aquaculture and by utilizing the available reservoir area. With only 40% of available cultivable water area under aquaculture, the average fish production of tanks and ponds is only 2.2 tonnes/ha/year in FFDA ponds which is low and could be doubled through proper management. Further, by increasing the coverage of water area the fish production of existing waters could be enhanced significantly. Thus, the thrust has to be on bringing more and more water bodies under aquaculture practices and also to increase the productivity of water bodies through scientific management and inputs. Indian aquaculture is mainly dominated by major carps that account for around 80% of the total inland fish production. There are a number of potential finfish and shellfish species, catfishes, prawns, ornamental fishes etc. suitable for different agro-climatic conditions and can be brought under the aquaculture practices. There is scope for achieving production levels of 6 to 8 tonnes/ha/year in several parts of the country. Such potentials need to be harnessed in order to increase the overall production from the aquaculture sector through intensification of cultural practices.

Coldwater fishery resources encompass high and mid altitude lakes, rivers, streams and man-made reservoirs. According to conservative estimates, the riverine stream length holding coldwater fisheries in the two mountainous zones trained by the Indus and its tributaries, Jhelum, Chenab, Ravi, Veas, Satluj, Bhagirathi and Alaknanda are about 7,000 kms. The approximate fishable stream length of hill stream on North West and eastern Himalayas has been estimated as 3,200 kms. Further, there are large number of natural lakes located in the uplands of Jammu & Kashmir, Himachal Pradesh, Uttranchal, Arunachal Pradesh and Sikkim. These natural eco-tops are virtually dotted all over the hilly terrain of these states and hold rich ichthyofauna of both commercial and sport fishes.

While there exists vast scope for development of coldwater fisheries both on grounds of logistics and economics, these resources have largely remain untapped. The current fishing activities in the hills are limited to fishing/angling by individual fisherman in the rivers and streams, hardly of any commercial importance.

The successful evolvement of technology on commercial Rainbow Trout Farming in Jammu & Kashmir and Himachal Pradesh has opened tremendous potential in exploiting various hilly rivers and streams flowing in foothills of Himalayas. Similarly, successful Running water Fish Culture Programme being carried out by monoculture of mirror carp in the hill States has given a new impetus to the aquaculture promotion programme in the uplands. The expansion of both these programme could go a long way not only in boosting fish production in the Himalayan states but also generation of large scale employment for hill inhabitants.

Coastal Aquaculture

Coastal Aquaculture production in the country largely on account of shrimp farming is estimated that out of about 1.23 million ha identified as potential areas for brackishwater fish farming in the country, of the total area, about 10% area is being farmed at present. Of this area, about 80% is under traditional farming systems and the remaining is under extensive and semi-extensive shrimp farming. At present, about 300 shrimp hatcheries are operational with a total production capacity of 12 billion post-larvae (PL 20)/year, mostly in the private sector. The farmed shrimp production has increased from 40,000 tonnes in 1991 to 1,15,000 tonnes in 2003. This contributes to the bulk of the Indian shrimp exports. The major constraints in the development of coastal aquaculture are diversification of candidate species suitable for different saline conditions, development of disease free broodstock of finfish and shellfish, development of hatcheries for seed production, health and hygiene in the hatcheries and culture system and development of quality feed which need to be addressed by undertaking research and development activities.

The country has around eight million hectares of inland saline soils which are not very suitable for other enterprises and can be a potential resource for aquaculture activities. The technologies for utilizing such sub-soil ground waters for culture practices have already been demonstrated. Utilisation of these water bodies for fish culture would help the country in moving forward to achieve the fish production targets in the next decade.

Mariculture

Mariculture is expected to be a major activity in the coastal areas in the years to come. Given the wide spectrum of cultivable species and technologies available, the long coastline and the favourable climate, mariculture is likely to generate considerable interest amongst the coastal population. At a time when we speak of over-exploitation in the near-shore waters, limited access to capture fisheries and the need for diversification, mariculture can be one of the most appropriate alternatives. Technologies for a couple of species are presently available in the country and there is an urgent need for developing package of practices for many more commercially important species.

Growth of the Fisheries Sector

The Fisheries Sector contributes around 1.1% to the total GDP, around 4.7% to the GDP from the agriculture sector and over Rs. 7,000/- crores to the export earnings. India ranks fourth in the total fish production in the world and second to China in the inland fish production with a total fish production of 6.4 million metric tonnes. Around ten million people are engaged in fisheries and ancillary activities. The per capita consumption of fish is around 9 kg. The projections by the end of X Plan for total fish production are based on the assumption of 8% growth rate in the inland sector and 2.5% growth rate in the marine sector with an average growth rate of 5.5% with a total production potential of 8.0 million metric tonnes .

To manage the available vast resources and achieve the envisaged targets of bridging the gap between production and the potential, Fisheries Division of the ICAR has undertaken number of R & D programmes. The aquaculture in our country, is mainly dominated by the Indian major carps which account for 80% of the total inland fish production. There are a number of potential high value finfish and shellfish species, catfishes, prawns, ornamental fishes, etc. which are suitable for different agro climatic conditions and can be brought under aquaculture practices. The technology for seed production and culture of such high value species have been developed by the fisheries research institutes and efforts are being made to propagate these technologies among the farming community so that the average income of the farmer will be enhanced. In marine sector for augmenting fish production from seas, a series of programmes such as managing the exploited stock to realize sustainable yield through regulation, responsible fishing and fisheries management, exploiting and monitoring the deep sea fishery resources, diversification of fishing activities, installation of Artificial Reefs (AR) and Fish Aggregating Devices (FAD), stock enhancement through sea-ranching, increasing production through sea farming and coastal mariculture have been taken up. To achieve targeted growth of 5.5 % and increasing the returns with fish farming and fisher community, the following issues are being addressed through various R& D programmes.

- Increase in the coverage of areas of ponds and tanks for aquaculture practices
- Increasing productivity of existing water bodies
- Diversification of aquaculture species, culture systems and intensification of culture practices
- Increase production in reservoirs and floodplains areas through stock enhancement
- Popularisation of mariculture / sea ranching activities
- Extending area of fishing operations
- Develop technologies for utilization of unconventional fish species and by-catch discard
- Sustainable management of marine fisheries through involvement of stakeholders – the fishers in developing and implementing management practices

Seafood Exports

Fishery sector has been one of the major contributors foreign exchange earnings through seafood export. There has been phenomenal increase in the export of marine products both in quantity and in value terms during the last decade. The phase of marine products in the total export earnings of India is around 3.4%. The quantity of marine products from the level of 139419 tonnes in 1990-91 has increased over four lakhs tonnes in 2003-04. While the value of the export quantity has increased from Rs. 893.37 crores to Rs. 7,000 crores during this period. In the nineties, the export has increased with an annual growth rate of 10.41% and 20.23% in quantity and value respectively.

Among the export of marine products, cultured shrimps contributed 52% in terms of quantity and 75% in terms of value of the total export earning from shrimps.

In recent years, there has been a diversification in export of items like frozen squid, cuttle-fish and variety of other fishes. Japan continued to be our major market, importing around 45% of the seafood from India followed by European Union in the recent past. Other major markets are USA, Belgium, Italy, Thailand, Republic of Korea, China, Taiwan, Hong Kong, Singapore, and Malaysia. Export of the Middle-East has shown an increasing trend in the recent past. A notable feature currently seen in the entry of low-value finfish as major export commodity.

Prospects of export lie in diversified fishing, products and markets. Tuna and Cephalopods have been identified as potential export candidates. The trade in frozen fish, fish fillets and Surimi is promising and the industry is to be adequately geared and equipped to handle and export them in value added packages. Freshwater species, such as major carps too have a potential market, especially in West Asia. Modernization of the processing facilities to meet international standards is of primary importance for the industry in the coming years.

Fisheries Potential/Production

The country has a long coastline of 8129 km and equally area under estuaries, backwaters, lagoons etc. Highly amenable for developing capture as well as culture fisheries. After declaration of the Exclusive Economic Zone (EEZ) in 1977, the area available to India is estimated to 2.02 million sq. km. comprising 0.86 million sq. km on the west coast, 0.56 million sq. km on the east coast and 0.60 million sq. km around the Andaman and Nicobar islands. With the absolute right on the EEZ, India has also acquired the responsibility to conserve, develop and optimally exploit the marine living resources within this area.

The harvestable potential of marine fishery resources in the EEZ has been revalidated by a Group of Experts constituted by the Government of India, Ministry of Agriculture at about 3.93 million tonnes (October, 2000) consisting of 2.02 million tonnes of demersal, 1.67 million tonnes of pelagic and 0.24 million tonnes of oceanic resources. In the Inland sector, the resources potential has been estimated at 4.5 million tonnes which takes into account the production from both capture and culture fisheries.

While the inshore waters have been almost exploited to the MSY levels, the contribution from the deep sea has been insignificant. The thrust of the deep sea fishing industry has hitherto been directed at shrimps only, notwithstanding the other resources. As of today, the deep sea fishing industry is almost a 100% shrimp oriented enterprise, faced with over-exploitation of the available shrimp resources as well as the fierce competition from the smaller class of vessels.

The development of deep sea fishery industry is of concern to the entire marine fishery sector because it would have considerable impact on the management of near-shore fisheries, shore-based infrastructure utilization and post-harvest activities, both for domestic marketing and export. Similarly, while the upgradation of the small mechanized sector to support the entrepreneurial response in the sector will be given high priority.

Issues and critical gaps for Enhancing Fish Production and Productivity

- Over fishing in Coastal demersal waters
- Bycatches and discards in the seas
- Habitat degradation
- Low productivity levels in reservoirs (3.1 million hectares)
- Non-Availability of seed of different species for diversification in aquaculture
- Paucity for techniques for the mass production of live feed organisms
- Paucity of information on sharks and marine mammals
- Input availability and utilization (water and feed)
- Health management of farmed fish and shrimp
- Keeping quality and marketing of fish and shellfish
- Quality management in fish handling and processing
- Residues in processed fishery products

Approaches to Achieve Targeted Goals

- Sustainable marine fish stock management models
- Fish Aggregating Devices (FADs) and Artificial Reefs (Ars)
- Diversified fishing and sea ranching
- Fuel-efficient fishing crafts for marine and inland waters
- Open sea cage farming and mariculture
- GIS studies for aquaculture sites, both marine and inland
- Culture-based capture fisheries for reservoirs development
- Fishery enhancement of floodplains wetlands
- Seed production technologies for more fish and shellfish species for diversification of freshwater and coastal aquaculture
- Breed improvement in carps, shrimp and ornamental fishes
- Transgenics in ornamental fishes
- Feeds for broodstock, larval and grow-out stages of fish and shellfish
- Disease diagnostics and vaccines
- Integrated fish farming and inland saline aquaculture
- Hill aquaculture for aqua-tourism
- High value compounds from aquatic systems
- Value addition and diversified fishery products
- Shelf life enhancement and Quality assurance
- HRD in emerging areas of fisheries and aquaculture

Report of the Sub-Group of Fisheries for the XI Five Year Plan

Fisheries and Aquaculture

Fisheries research under ICAR is being carried out under five major programmes, namely (i) Capture fisheries, (ii) Culture fisheries, (iii) Fish genetic resources, (iv) Harvest and Post-harvest technology and (v) Fisheries education. The major thrust of research programmes proposed to be undertaken during the XI Plan are given below :

Capture Fisheries

- Species-wise biological database of commercially exploited marine fish
- stock and prediction of potential sources and yield
- Computer based management for simulation of fishery yields
- Marine biodiversity, database, conservation and management,
- especially sharks and marine mammals
- National marine and estuarine fisheries database on GIS platform.
- Standardizing fish yield enhancement tools for small and medium open bodies including wetlands and lakes
- Fisheries resource assessment of inland open waters on GIS format and biodiversity evaluation including catches and species trends
- Impact of river linking on fish stocks and aquatic biodiversity
- Ecological information and fishery potential of open water ecosystems to develop time series and forecasting capability
- Estimates of environmental flow in river system to sustain production function and study fish behaviour (ethology)
- Environmental impact assessment, fish health monitoring and bioremediation of stressed aquatic ecosystems
- Hill fishery resources assessment and management
- Improved management of reservoirs and floodplain fisheries through stock enhancement

Culture Fisheries

- Diversification of candidate species and aquaculture systems for culture in fresh and marine waters
- Develop and demonstrate mariculture technologies
- Develop simple technology for sea weed culture to support women entrepreneurs.
- Up scaling pen and cage culture technology in larger water bodies and floodplain wetlands.
- Up scaling of breeding and culture technologies for coldwater fishes
- Breeding and culture of cultivable high value finfishes and shellfishes
- Finfish and shellfish health management, immunoprophylaxis and therapeutic against common diseases.

Organic aquafarming

- Fish nutrition, feed development and technology for live feed organisms
- Genetic improvement of aquaculture species (finfish and shellfish)
- Development of fish and shellfish Cell lines
- Ornamental fish breeding and culture
- Water and waste water management including water budgeting for different aquaculture activities
- Production models for sustainable sewage fed aquaculture system
- Culture technologies for finfish and shellfish for utilization of inland saline water resources
- Develop technology to contain unwanted weeds in freshwater systems
- Techniques for mass rearing carp fry to fingerlings
- Integrated coastal zone management

Fish Genetic Resources

- Cataloguing of germplasm resources and development of database
- Biodiversity repository
- Developing simple technologies like post-mortem sperm preservation and genome conservation by interspecific androgenesis
- Genetic improvement and Biotechnology
- Exotics and quarantine, import risk analysis and disease diagnositcs
- Genotyping of fish and shellfish and allied taxonomy group across different ecosystems at inter and intraspecific levels
- Genetic cataloguing of marine microbes
- Cytogenetics and genotoxicity studies in fish and shellfish
- Conservation and management of germplasm resources of fresh water and marine fishes

Harvest and Post-Harvest Technology

Harvest

- Design of new generation (fuel efficient) combination fishing vessels and gears for sustainable exploitation of capture fisheries resources both marine (pelagic fisheries of the Southwest coast as well as off-shore and deep sea fishing) and inland sector
- Eco-friendly and responsible fishing technique for EEZ
- Energy conservation in fish harvesting, processing and transportation
- Support for utilization of by-catch
- Develop techniques for fishing to exploit fish stocks in the rivers and reservoirs

Post-Harvest

- Development of techniques for processing, value addition, packaging and marketing for fishery products to cater to the domestics and international market
- Development of technologies for minimization of post-harvest loss and effective utilization of fishing waste from fish
- Bioactive substances of pharmacological importance
- Sanitation, hygiene and quality control
- Quality management and food security
- Support for establishing more carp feed industries

Engineering

- Development of on board and on shore equipment for fishing and fish processing
- Bioinformatics and IT in harvest and post harvest fisheries sector
- Development of techniques to control seepage and evaporation in ponds
- Develop techniques for fish farm construction in porous and loose soils

Fishery Education

- Upgradation of syllabus of courses once in three years
- Interaction with experts from conventional universities and colleges
- Education and training programmes in specialized areas of fisheries
- Fishery informatics and data base
- Vocational and distance education
- Socio economics and evaluation of culture systems
- Information Technology and production of educational materials
- Human Resource Development in emerging areas.
- Upgradation of standards in teaching

New Initiatives

Network Programmes

- Responsible fisheries to achieve sustainability and optimum utilization of the resources in marine and coastal fisheries and aquaculture
- Marine Biodiversity and Conservation of the resources
- Strengthening mariculture and coastal aquaculture activities
- Developing resources specific fishing techniques
- Post-harvest and product development using unconventional fish species
- Reduce post-harvest losses and by-catch reduction
- Developing technologies for mass culturing fish feed organisms as compliment of aquaculture to generate additional income for women.

Indo-US Knowledge Initiative on Agriculture

A project on Indo-US Knowledge Initiative on Agriculture has been initiated by ICAR in joint collaboration with US on November 12 , 2005 to promote knowledge initiative on agricultural, education, research, service and commercial linkages. The priority areas of focus identified in agriculture are (i) Human Resources and Institutional Capacity Building (ii) Agri-processing and Marketing (iii) Emergent Technologies and (iv) Natural Resources Management. So far as Fisheries Division is concerned, almost all Fisheries Research Institutes will be actively participating in the above key areas identified under joint venture.

National Seed Project in Fisheries

A project on national seed production in agricultural crops and fisheries with particular reference to seed production in fisheries has been initiated in 2005. For fish seed programme 36 nodal points have been selected involving ICAR Institutes, SAUs and conventional Universities with a budgetary provision of Rs. 1611.00 lakhs. The main objective of the project is to produce quality seed of carps, catfishes, freshwater prawn, shrimp, seabass and ornamental fishes. The infrastructure involves hatchery establishment and other operational facilities for seed production. The first meeting of the project was held on 27-28th June, 2006 to assess the progress work of the project under the Chairmanship of Secretary, DARE and DG, ICAR. Each nodal point has been given the target for seed production of earmarked species annually.

Suggestion for Increased Infrastructure Development during XI Plan

The infrastructure of the following items to be developed during XI Plan:

- Automatic climate / environment control wet laboratory with flow through system for conducting stimulation experiments on fish and other aquatic organism
- Development of nursery ponds and sea farms for onsite testing of Mariculture technologies
- Setting up of tissue culture laboratory
- Procurement of research vessel for making onsite studies in the sea
- Hatchery for seed production and farm facility for culture of coldwater fishes
- Hatchery for seed production of tiger shrimp and infrastructural facilities for domestication – specific pathogen free broodstock (SPF) and genetic improvement
- Model farm with modern facilities and gadgets for freshwater aquaculture
- National facility for research on fish cell lines along with repository for cell, tissue and DNA material
- Quarantine facility for research purpose
- Facilities and infrastructure for development of live fish gene bank

- Infrastructure for Biotechnology / Nanotechnology / Bioinformatics / High pressure technology applications in fisheries
- Residential accommodation for scientific and other staff
- Farm laboratory and training centre with hostel facility
- A National Sate of Art Museum for Aquatic Animals
- Develop a flow-through model laboratory for testing fish-pass /ladder designs for the migratory fish species
- Create research facilities for sharks and marine mammals
- A National state of art museum and aquarium for aquatic animals and plants.

The Appropriate Budgetary requirement for the suggested Thrust Areas and Programmes

In view of the suggested thrust areas and programme for XI Plan in fisheries the budgetary requirements will be as follows

A.	**Non-Plan Budgetary Requirement**	**Rs. 500.00 Crores**
B.	**Plan Budgetary Requirement**	**Rs. 300.00 Crores**
C.	**Total Budgetary Requirement**	**Rs. 800.00 Crores**

The actual plan expenditure during the X Plan is approximately to the tune of Rs. 155.00 crores including budgetary allocation for 2006-07. In view of the additional requirement for development of modern equipment and laboratory facilities for research, education and extension and infrastructure for hatchery, demonstration farm and aquafarm and marine research vessels and processing machinery, quarantine research facility for research purpose to promote biotechnology, nanotechnology and bioinformatics, the plan allocation to fisheries should be increased to Rs. 300.00 crores with a total plan budgetary requirement to the tune of Rs. 800.00 crores.

OUTLINE OF RESEARCH AND DEVELOPMENT IN FISHERIES FOR NORTH EASTERN REGION

In North East Region of India consists of 7 States namely, Arunachal Pradesh, Assam, Manipur, Meghalya, Mizoram, Nagaland and Tripura and has immense potential for aquaculture development because of good amount of water resources. This region forms a part of eastern Himalayan zone of the fifteen agro-climatic zone into which this country has been divided for the purpose of agro-climatic regional planning. This zone is characterized by diverse agro-climatic and geographic situations in regards to parameters like topography, temperature, rainfall and soil type. Though the major areas of the region are hilly, having undulating terrain. all types of physical formations, from alluvian plains to table lands, mountain and valleys are found here. Majority of the soils of this region are acidic (pH 5.0-6.0) to strongly acidic (pH 4.5 – 5.0) because of excessive leaching losses of the bases due to heavy rainfall. The organic carbon content is rated high in most of the soils of the region except in the soils of Tripura where it is medium.

North East region encompasses a geographic water area of 255, 254 sq km. Fish production from this region during 1986-87 was as low as 73,500 tonnes which has enhanced to 112, 250 tonnes during 1990-91. During the year 1996, the fish production was almost doubled at any production to the tune of 206,769 tonnes. It is an accepted fact that fishery is the best area for diversion in the rural sector. Sufficient fishery resources exist in the region. Moreover, the people of north-east relish fish and are 100% fish eaters (except Assam which reportedly has 90% fish eaters). Yet fishery development was one of the most neglected area in this region till the recent past. Thus, it would be essential ways and means to develop this sector for overall growth of this region's economy.

Need for Development

Need for fish and fisheries, both call for adequate attention to be paid urgently for development of this sector in the northeastern region. As is evident from above, inspite of considerable increase in fish production in the region during the last decade, the present per capita availability of fish for the populace of the region, from its own production, is much below the desired level. Fish being the important constituent of diet of the people of these states in general, substantial quantity of fish is imported daily into the region from different parts of the country (Andhra Pradesh, Bihar, U.P., etc.) to partially fulfill the gap. This results naturally in draining out of funds from the region for a commodity which can be produced in the region itself with the available resources. Thus, it is imperative that fish production is augmented within the region to fulfill its need for fish and save the unnecessary drain of funds.

Scope and Constraints for Development

The potentials of fisheries and aquaculture development could be realized with proper extension of the available technologies and incorporation of new culture practices as components. The data base with regard to aquaculture require to be upgraded for proper planning and implementation of development projects. The coverage of aquaculture areas to semi intensive and intensive systems needs to be enhanced with requisite support in terms of seed production and stocking materials. Diversification of culture practices and incorporation of eco-friendly measures with integration with other farming practices would enable higher returns as well as sustained production levels. The network of Fish Farmers' Development Agencies and State Fisheries extension machinery must be strengthened and technical manpower provided at different stages of planning, financing and execution of aquaculture projects across the region. This becomes necessary in view of the varied agro-climatic conditions in the region where each technology needs to be tested and modified to suit the requirement and resource potentials of the area.

Further, governmental support is required in terms of provision of infrastructure facilities, marketing channels, insurance coverage, etc. which are non-existence in the region at the moment, for a making the aquaculture practices more organized.

Organised catfish culture has not yet developed in a big way though the demand for these fishes is great. There is also a great demand for the small air-breathing (*Clarias batrachus* and *Heteropneustes fossilis*) and non-air breathing fishes (*Ompak pabda, O. bimcaulatus*) in the eastern and North eastern states. Finally, it is most important to gear up the extension machinery and generate mass awareness amongst the farming communities about the improved aquaculture technologies through proper training to the extension Officers, farmers and entrepreneurs of the region.

To address the above issues, emphasis is needed on the following research areas for the development of fisheries in north east region during XI Five Year Plan :

- Aquaculture packages for commercially important indigenous fish species
- Data base on aquatic resources for fisheries and aquaculture
- Fish resources assessment
- Harvest technique for inland open water bodies
- Post-harvest improvement in traditional fish processing techniques and product development
- Conservation of fish genetic resources
- HRD in fisheries and aquaculture and related aspects

Fisheries Division under the ICAR has no research centers in the states of Sikkim, Mizoram, Arunanchal Pradesh, Nagaland, Tripura, Meghalaya and Manipur. However Cental Inland Fisheries Research Institute (CIFRI), Barrackpore has a researsch centre in Guwahati in the state of Assam. Specific research and other extension activities for development of fisheries and aquaculture in the aforesaid states under the North east component has been initiated by the Central Inland Fisheries Research Institute (CIFRI), Barrackpore: Central Institute of Freshwater Aquaculture (CIFA) Bhubaneswar; Central Institute of Fisheries Education (CIFE); Central Institute of Fisheries Technology (CIFT), Cochin; National Bureau of Fish Genetic Resources (NBFGR), Lucknow and National Research Centre for Coldwater Fisheries , Bhimtal.

Ongoing research programmes implemented by the above mentioned fisheries research institutes are as follows :

- Preparing the inventory of ornamental fishes of NEH States
- Preparing the inventory of indigenous crafts and gears of NEH States
- *In situ* conservation programmes for threatened fishes in the identified water bodies involving local communities
- Demonstration and training programmes on integrated fish farming and composite carp culture
- Training in fabrication, FRP and rubber-wood canoes for inland fishing activity

- Demonstration on preparation of various fish products and maintenance and repair of ice plants and cold storages
- Training in cage rearing for raising fish stocking material in floodplains wetlands
- Different threatened / endemic fish species namely *Ompok pabda, Puntius sarana, Channa aurantimaculata, Channa stewarti, Channa blehere, Chitala chitala., Labeo pangusia,* and *Rita rita* were collected from natural habitats and added to the NE regional Live Fish Gene Bank at Guwahati.
- To manage fish & fisheries in NEH region on scientific lines, a collaborative programme on "Rapid survey of fishery resources in Arunachal Pradesh" covering 14 districts is in progress. The data pertaining to morphology and bioecology of all the water bodies and their fish biodiversity is being recorded. In addition, this survey work will be validated through application of GIS.
- Pen culture technology demonstrated earlier in the north east states has become popular and is now being practised by farmers in Lali beel (Morigaon), Deochora beel (Badarpur, Karimganj), Hauder beel, Samaguri beel (Nagaon), Haribhanga beel (Nagaon), Morakolong beel (Morigaon).Further, this technology now has been included as bankable technology by NABARD, in the region for financing from commercial banks. The Assam Fisheries Development Corporation has made pen culture a mandatory activity for the lease holders of beels in the the state.
- Pig-cum-fish culture demonstration involving 25 beneficiaries covering 25 ponds in 16 districts of Arunachal Pradesh was conducted.
- Composite fish culture demonstration programme was done in Meghalaya involving 40 beneficiaries covering 40 ponds in 7 districts.
- Demonstrations in fish handling, processing and product development
- Use of ice box for preservation and transportation of fresh fish

Women in Fisheries and Aquaculture

Gender relations in Fisheries

The fisheries sector is an important source of life and livelihood for millions of people around the world. Fish provide a vital source of protein as well as cash income for many families in the developing world. It is estimated that more than 120 million people through out the world are dependant on fish for all or part of their incomes. As per the FAO's estimates about 35 million people world wide are directly engaged in fishing and fish farming activities. The highest number of fishers and aquaculture workers are in Asia (85%) followed by Africa (7%) and rest in other countries. There are hardly any authentic statistics available on the number of women involved in fisheries related work, though it is well known that women play important roles in the sector. In India around 7 million people are engaged in the fishing profession and women contribute significant share in all the fisheries development activities. Women engaged in wide range of activities in the fisheries and aquaculture are –

1. As workers (paid or unpaid) within the fisheries in pre and post-harvest activities and also in inland fishing and aquaculture.
2. As workers in seafood processing plants
3. As caretakers of the family and maintain social networks and culture of the community
4. As workers in non-fisheries sector to supplement household income
5. As members of fish worker movements and fisher's organization

Apart from bringing in issues of concern to themselves as workers in the fisheries, they have more significantly raised concerns about the quality of life in fishing communities, focusing on access to health, sanitation and education.

Key gender issues to be addressed during the XI Five Year Plan need to be focused on the following areas :

- Awareness programmes on conservation of fish resources
- Formation of Self Help Groups and their role in cottage industry based on fish processing and fish products
- Involvement in fishing net fabrication
- More participation of women folk in aquaculture and related activities
- Hygiene and fish handling
- Marketing
- Health, hygiene and education
- Family welfare and civic amenities
- Socio-economic aspects
- Demography of fisher and fishermen community

On-going / completed programmes for Women in fisheries and aquaculture

- Demonstration of freshwater aquaculture technologies involving large number of farm women
- Training programmes on freshwater pearl culture and ornamental fish farming
- Special training workshops for women self groups on selected technologies of CIBA
- Special summer camps on (action research on community based coastal zone management with specific involvement of women).
  Topics covered included responsible fishing methods, net making, rain water harvesting, mushroom cultivation, preparation of vermicompost, fish ensilage and fish cutlet
- Training programme in production of value added fish products to women community of gram panchyat and SHGs in Kerala
- For sustainable development of fisheries, empowering the women folk to take decision on different fisheries activities are the most important inputs. With a view to improving the socio-economic status of women and weaker sections of society, a number of programmes were implemented by the Fisheries Research Institutes.

On-going Programmes for less privileged communities including women folk

- In Bihar and Jharkhand, a package of practices for freshwater prawn culture and composite carp culture was given to the SC/ST/OBC in consultation with the Director of Fisheries of the states.
- During the period, a total 580 numbers of fish farmer/fishermen belonging to SC, ST and OBC were trained in various programmes of implementation of fishery development interventions in beels which are located in West Bengal and Bihar.
- Training- cum-demonstration of mud crab fattening technology and cage culture of seabass for tsunami affected fisherfolk at Pulicat was conducted. CIBASTIM, the immunostimulant developed by CIBA was demonstrated in the farmers meet at Kakinada.
- Mass awareness programmes with regard to conservation and development of fisheries were organized for fishing communities including SC/ST /OBC population in the NE region.
- Demonstration of composite fish culture was undertaken in Kalahandi of Orissa and Bastar of Chhattisgarh. While in Kalahandi district of Orissa 26 ponds covering a total water area of 20.86 hectares are covered for demonstration purposes, in Bastar district 16 ponds of 12 ha. water area have been adopted. A total number of 325 beneficiaries were involved in the programme.

Sectoral Programmes /Schemes for Tribal Areas

The Population and Distribution

The tribal population of the country is 8.43 crores as per the 2001 Census, constituting 8.2% of the total production. The population of tribes grew at the rate of 24.45% during the period of 1991-2001. This is slightly more than the decadal growth rate of 22.66% for the nation as a whole. One concentration of tribes lives in a belt along the Himalayas stretching through Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh in west, to Assam, Meghalaya, Tripura, Arunachal Pradesh, Mizoram, Manipur, and Nagaland in the northeast. Another concentration lives in the hilly areas of central India (Madhya Pradesh, Orissa and to a lesser extent in Andhra Pradesh); in this belt, which is bounded by the Narmada River in the north and the Godavari River in the southeast, tribals occupy the mountain slopes of the region. Other tribals, the santals, live in Bihar and West Bengal. There are smaller numbers of tribal people in Karnataka, Tamil Nadu, and Kerala, in western India in Gujarat and Rajasthan and in the union territories of Lakshadweep and the Andaman and Nicobar Islands.

The tribal population in statesvaries considerably. In the northeastern states of Arunachal Pradesh, Meghalaya, Mizoram, and Nagaland, more than 90 percent of the population is tribal. However, in the remaining northeast states of Assam, Manipur, Sikkim and Tripura, tribals contribute between 20 and 30 percent of the population. The largest tribes are found in central India, although the tribal population is around 10 percent of total population of the region. Major concentrations of tribal people live in Maharashtra, Orissa and West Bengal. In the south, about 1 percent of the populations of Kerala and Tamil Nadu are tribal, whereas about 6 percent in Andhra Pradesh and Karnataka are members of tribes.

The Status

It is a matter of concern that the Human Development Indices (HDIs) of the ST population continue to be much lower than the rest of the population in terms of all parameters, such as, education, health, income, etc. To further compound the problem, these deprived sections of the society also suffer from geographical and cultural exclusion, which is a deprivation not reflected in the HDIs.

The lifestyle of the tribal people is conditioned by the ecosystem and is in tune with nature and natural resources. Tribal people, being essentially ecosystem people, vary widely over the country matching the country’s wide-ranging diversity in nature and natural resources. In general most tribal populations inhabit under developed areas of the country which are remote, have low density of population and lack adequate access to basic amenities, education, employment opportunities and affordable health care services.

The gap in infrastructure in the tribal areas *vis-à-vis* the rest of the country is widening at a much faster rate. For example, while on the one hand the quality of roads, healthcare services, telecommunications, distribution of power, drinking water supply, education, etc. are improving in the country through participation of the private sector, conditions are deteriorating in the tribal areas due to poor maintenance of existing assets. The private sector would perhaps never find it economically viable to invest in tribal areas, as investments would rarely meet the commercial objectives of the private sector.

The Development of Tribals through Fishery Intervention

The major of districts having tribal population are bestowed with varied water resources, which can be developed for inland fisheries and aquaculture. Accordingly, some programmes, which can be executed in these districts, have been identified for their inclusion in XI Plan approach.

During the XI Five Year Plan, following sectoral programmes have been identified to address improvement in socio economic aspects of tribal areas particularly in the state of Orissa, Jharkhand, Chhatisgarh, West Bengal and the tribal population in the North Eastern Regions, Western Ghats, Islands and other tribal regions in India through fisheries and aquaculture activities. The focus is mainly enhancing fish production and productivity in the tribal areas by using indigenous traditional knowledge of fish culture activity. Besides, traditional knowledge some scientific interventions would also been involved to achieve enhanced production. The activities also include promoting formation of Self Help Groups and introduction of Community Based Management Aquaculture practices in selected areas. Development of aqua shops and better marketing system would be part of the programme. The focus would be also made on integrated fish farming, ornamental fish breeding, etc.

The sectoral programmes and schemes of the fisheries sector to address the issues related to tribal population during the XI Five Year Plan are given below :

S. No.	Programme	Quantifiable Outputs	Quantifiable Outcomes
1	Economic and livelihood development of SC / ST population through freshwater aquaculture technologies in some tribal districts of Orissa, Jharkhand and Chhatisgarh.	The aquaculture activities with intervention of induced breeding, seed rearing of carps, composite fish culture, prawn culture and integrated farming would help in enhancing the fish production to minimum of 2t/ha/yr.These activities will be supported through development of Aquashop and marketing system by the	• Production and productivity enhancement in existing ponds • Improving livelihood of the tribal folk and weaker sections of the society • Economic empowerment of scheduled caste and tribal community

		involvement of SHG for sustainability and profitability. This will improve the production of presently cultured aquatic resources and help in horizontal expansion of the activities to contribute to the total production of the state including employment generation.	including tribal women • Employment generation • Enhancement of aqua business • Encompassing more area under aquaculture particularly in the selected areas • Community based aquaculture practices through self help groups
2.	Installation of FRP Carp hatchery, induced fish breeding and seed production in some tribal districts of North-East Hill region.	There is immense scope and demand of fish seed of Indian major carps and exotic carps. The hatcheries would help in producing quality seeds for culture in ponds and in combination with paddy. Depending upon the area availability seed production can be planned. This would help in enhancing the seed production to at least 50% more.	• The tribes of the state would be greatly benefited in producing large number of seed for rearing and selling to other areas.
3.	Integrated pig-cum-fish culture in some selected districts of NEH states.	In view of the great demand for pork and fish in this area, the scheme would help the tribes to produce both fish and pig meat.	• The scheme would be beneficial for the tribes to get dual benefit of sufficient animal protein in their diets as also improve their financial status from limited land and water holding.
4	Ornamental fish breeding and culture	In view of the domestic and International demand of the indigenous ornamental fish species, the programme will help in producing large numbers of this species prevalent in the hilly areas.	• The scheme would be highly beneficial for the tribes in terms of income generation and support in conserving of endemic ornamental fish resources of NEH region.

5.	Carp based inland aquaculture*	More seasonal water bodies will be brought under fish culture	Increased livelihood for tribals with 20% share of ST population
6.	Diversification towards air breathing fish farming*	More hatcheries for seed production will be established	Empowerment of tribal women folk with skill in fish farming who constitute 50% population
7.	Integrated fish farming*	The present average fish yield of 700 kg/ha will be doubled	Likely reduction in population migration for alternative livelihood.
8.	Documentation of traditional knowledge and practices related to fisheries resources of India The programme will be a part of the larger network programme on fish resource explorations envisaged for XI Plan. This will focus on North eastern States, western Ghats, Islands and other tribal regions in India, covering issues related to resource conservation, fishing practices and preparation of products.	Comprehensive documented information on traditional practices related to fisheries available with various tribes in India.	• IPR protection of traditional knowledge. • Could be a source of non conventional methods with potential commercial application. • Will help in improving socio economic status of tribal populations.
9.	Up scaling of Paddy-cum-Fish Culture in NEH Region	Development and refinement of technology to augment fish production in paddy fields	The technology will be disseminated to tribal farmers, particularly women at varied zones and altitudes
10.	Mixed fish farming in	Package of practices for aquaculture of Chinese carps in	More fish production per unit area of water is

	uplands	far flung rural and tribal areas	expected in existing and newly created ponds through scientific inputs
11.	Propagation of trout	Transfer of technology for propagation of high value exotic trout in highland tribal areas	The farm production of trout will boost the economy of the region and the seed ranching in suitable water bodies would attract eco-tourism
12.	Conservation and mgt. of prioritized endemic mahseers and snow-trouts	Breeding and culture of suitable varieties of mahseers and snow-trouts in tribal hilly areas	Ranching of farm reared fingerlings in the natural systems will sustain the depleting population of the species besides table production in captivity.

*These programmes can be implemented in Bankura, Purulia, Midnapore (West) and Jalpaiguri districts in the State of West Bengal,

Institutional Mechanism for Strengthening, Monitoring and Evaluation System in Agricultural Research and to suggest efficient Measures including steps to be taken for strengthening public - private partnership

For strengthening, monitoring and evaluation of fisheries research carried out by the fisheries research institutes functioning under ICAR, there are Committees *viz.*, Research Advisory Committee (RAC), Institute Research Committee (IRC), Institute's Management Committee (IMC) and Quinquennial Review Team (QRT). Research Advisory Committee consisting of subject experts meets once in a year to review the research work carried out by the Institute and suggest amendments, new programmes, etc. as required. There is a provision of RAC to review the progress twice in a year. Institute Research Committee meets once in a year and discuss thoroughly the R & D activities of the concerned institute. The Institute Management Committee meets quarterly in a year to review the management aspect of the Institute supporting the research programmes and other related administrative matters. The QRT meets once in five years to review the entire research work carried out by the Institute over the period of 5 years. Mechanisms are already existing in the form of MOUs between ICAR and SAUs for effective coordination of agricultural research so also between ICAR and private sector consultancy agreements are signed for collaborative research programmes. Besides, regular Interface Meetings are held between ICAR research institutes and private sector for strengthening research activities.

10. BIOTECHNOLOGY, GENETIC ENGINEERING AND BIO-SECURITY

Meeting of the sub-group on Biotechnology, Genetic engineering and Bio-security was held under the chairmanship of Prof. Deepak Pental, Vice-Chancellor, University of Delhi, in the committee room of National Research Centre on Plant Biotechnology from 2.30 PM to 6.00 PM on September 25, 2006. The following were present:

1.	Prof. Deepak Pental, University of Delhi	Chairman
2.	Dr. Anant Rai, IVRI, Izatnagar	member
3.	Dr. A.K. Singh, Genetics Division, IARI, New Delhi	member
4.	Dr. N.K. Singh, NRCPB, IARI, New Delhi	member secretary
5.	Prof. P.K. Gupta, CCSU, Meerut	Special Invitee
6.	Prof. A.K. Pradhan, University of Delhi, South Campus	Special Invitee
7.	Prof. Anil Grover, University of Delhi, South Campus	Special Invitee
8.	Dr. S.S. Gosal, PAU, Ludhiana	Special Invitee
9.	Dr. Kuldeep Singh, PAU, Ludhiana	Special Invitee
10.	Dr. K.V. Prabhu, Genetics Division, IARI, New Delhi	Special Invitee
11.	Prof. K.C. Bansal, NRCPB, IARI, New Delhi	Special Invitee
12.	Dr. P. Anand Kumar, NRCPB, IARI, New Delhi	Special Invitee
13.	Dr. T. Mohapatra, NRCPB, IARI, New Delhi	Special Invitee
14.	Dr. P. Sateesh Kumar, Nuziveedu, Hyderabad	Industry representative

Members Dr. B.M. Khadi, CICR, Nagpur and Dr. Prabhakar Rao, Nuziveedu Seeds Limited, Hyderabad and Special Invitee Dr. Subhra Chakraborty NCPGR could not attend due to prior commitments. Dr. P. Sateesh Kumar presented industry perspective in place of Dr. Prabhakar Rao.

1. Background:

There is general concern amongst specialists in agriculture that apart from rice and wheat no major gain in productivity has been made in other crops. Further, it is a matter of deep concern that more recently there is stagnation also in the yield of these two major cereal crops. But for the increased production in milk and poultry sectors, the country would have been facing sever malnutrition problem. In general, the number of quality papers in the top international journals from India in the area of Plant Breeding and Genetics is declining. Our competitor country China with similar agricultural problems has attained significantly higher levels of productivity for crops mainly through the application of heterosis breeding. China has also made more obvious progress in the area of publishing in high impact journals in the area of Genetics and Plants Breeding. India needs to strengthen agriculture related research in the XI Plan.

In the past twenty years major advances have occurred in the area of plant and animal molecular biology. Advances in the area of genetic transformation, genomics and gene expression hold high promise for tackling problems of breeding for yield and also for stabilization breeding. Molecular biology and tools of biotechnology hold great promise for both crop and animal genetics and diagnostics. Two major technologies have emerged to deal with complex traits and demanding breeding objectives. These are molecular markers and transgenic technologies. It must be borne in mind that these technologies are not a substitute for conventional breeding, micro-propagation, integrated pest management and good agronomic practices; these techniques provide us additional tools to address problems of breeding. Precision breeding using the new tools is, therefore, a reality which should be grabbed and practiced, if we want to break the glass ceiling of yield stagnation.

Both molecular markers and transgenic technologies need to be given equal and high importance in the XI Plan. There is a need to strengthen work on molecular and genetic aspects of host-pathogen interaction and allele mining of genes for disease and pest resistance. Research work on vaccines and diagnostics for the common disease of domestic animals will also provide rich dividends as the farmers need to move from extensive cropping pattern to a mixed farming system including crops, orchards, animals, poultry and fisheries for a greater livelihood security and higher farm income.

Each crop, field or horticultural, requires multiple trait improvement. Traits required in each major crop have been highlighted in the Swaminathan-Chopra Committee Report. In the XI Plan, research agenda should be devoted to meeting these breeding objectives by proper combination of conventional breeding, molecular marker assisted breeding and transgenic technologies.

Given the state of the art tools that are available for crop breeding, the breeding projects should be treated like engineering projects where the design of experiments and time schedule is worked out right at the beginning of the program and the desired genotype (varieties) will be developed in a specified time period. Molecular breeding techniques have the potential to compress the breeding cycle by nearly fifty percent as compared to conventional breeding.

2. Comments on the Xth Plan Initiatives:

The objectives of the Xth Plan were circulated among all the committee members and it was appreciated that some beginning has been made in many of the recommended areas, though progress may not have been up to the expectation in all the areas. A significant achievement was the completion of rice genome sequencing target ahead of the schedule. Due to late finalization of the EFCs of the Xth Plan, several new initiatives in Agricultural Biotechnology were started during the last two years of the Plan and did not have enough time to show the impact. These include: **DBT** network projects on (i) **tomato genomics** (both structural and functional), (ii) **National Consortium on Functional Genomics of Rice** for yield and biotic stress tolerance; and **ICAR** network Projects on: (i) **Transgenics in Crops** (including functional genomics of selected traits in rice, wheat, maize, mustard, chickpea, banana and tomato and transgenic development in 14 crops for insect and virus resistance (ii) **Gene Pyramiding** for disease resistance genes in crops, (iii) **Molecular Breeding** in crops (iv) **Application of Microbes in Agriculture and Allied Sectors**, and (v) **Indo-US Agriculture Knowledge Initiative (AKI)**. These initiatives aim to use Biotechnology in tackling the problem of stagnating Agriculture productivity. The committee felt these and other important ongoing projects should be supported during the XIth Paln. Over and above these the following priority areas and change of strategies is recommended for the XIth Plan.

3. Recommendations for the XI Plan:

3.1. Crop breeding using molecular markers and transgenics

1. **Breeding objectives** outlined in the Swaminathan/Chopra Committee Report should serve as the base document for breeding objectives. A Committee should be immediately constituted to review progress in both basic and applied work in each of ten major crops and work out an overall strategy for breeding major crops by meeting objectives outlined for each crop in the Swaminathan/Chopra report. This Committee should make recommendations on how to use the available knowledge to meet identified objectives and identify areas where new knowledge is required to meet the above breeding objectives.

2. **Ten premier institutions** should be identified where breeding of specific crops should be carried out by integrating the tools of both conventional and molecular methods of plant breeding. These laboratories should develop pre-breeding materials which could be used by regional Universities and Institutes to introduce mapped or transgenic traits into region specific varieties. Major mandate of these premier institutions/laboratories should be on genetics and breeding, development of genomic resources, mapping populations and marker aided breeding. The research teams in these institutions/laboratories will have to work in a multidisciplinary mode, on a model which has worked well in the CG Institutions. The ten crops identified for the molecular breeding are: **Rice, Wheat, Maize, Soybean, Brassica, Pigeonpea, Chickpea, Tomato, Cotton and Sugarcane.**

3. Efficient **training and use of human resource** will be the key to success of programs being mentioned in the proposal.

4. **Transgenic technologies** should be developed in a decentralized manner as significant expertise lies in many universities and institutions in addition to the ICAR and SAUs.

5. **Genome sequencing and functional genomics** work can also be carried out in many institutions (Universities, NARS etc.) where talent and expertise is available.

6. **Recruitment of trained human resource in the area of agricultural biotechnology** needs to be given high priority. Attracting trained scientists back from abroad and their utilization in the identified institutions to meet the crop-specific breeding targets should receive very high priority. Current hiring and posting procedures of ARS scientists needs to be amended to suit the project objectives.

7. **Selected ARS scientists should be sent to the best laboratories within India for 2-5 years research stint**. ARS scientists should be posted initially in the crop breeding programs that are proposed to be taken up in the ten Premier Institutions. In areas where within country expertise is lacking some of the bright ARS scientists should be encouraged to do post-doctoral work for two years in the leading laboratories in the Western countries.

8. While the major effort in genetics and pre-breeding of specific crop should be located at a few places. The available markers and pre-breeding lines could be made available to all the regional Universities and institutions so as to **expedite marker assisted transfer of multiple traits into regional varieties and hybrids**.

9. **Genotyping service centres** should be developed at five of the premier institutions identified in the point 2 above to help the regional institutions carrying out quality genotyping work on payment basis.

10. **Five institutions** could be selected for new programs in Agricultural biotechnology. Students for this program should be admitted in **B.Tech. (Ag) degree** with emphasis on Genetics, Breeding, Biochemistry, Bioinformatics, Maths and Statistics. The **Indian Agricultural Research Institute** should be developed as a premier institution in crop biotechnology, education and training. It would be useful if this institute and some **SAUs** could start a high impact B.Tech. (Ag) program in agricultural biotechnology with multidisciplinary training to develop plant and animal breeders of future.

11. **Biosafety testing capability for toxicity and allergenecity** should be enhanced to instill public confidence in the transgenic technology. The ICAR should be given the mandate of field testing of transgenic crops so that farming community could be

informed about the merits and demerits of the transgenic material developed both in the public and private sector in an impartial manner.

12. **In all the externally funded projects,** scientists should be given full freedom of operation. Principal Investigator along with members of the research team should have full sanctioning power and freedom to choose the brand of chemicals and equipment to be used for their research. The biotechnology consumables and equipment are quite specific and usually the choice of protocol will determine which brand will be used rather than the lowest quotation. It is also wasteful on time to keep experimenting with different brands to find out if the cheapest option works or not. Procurement process must be streamlined so that the valuable time is not lost. This has been achieved in many institutions in the country. We should follow already established good practices.

13. **ICAR should acquire critical technologies and gene sequences from outside India and** make these available to both public and public-private partnership projects for further development and commercialization of products (varieties, vaccines, diagnostics etc) in India. This will help to keep the cost of seed low and thereby reduce the input costs of the farmers.

14. **Public-private partnership** in developing superior seeds should be encouraged. ICAR can study NMITLI model of CSIR and modify it to meet the special requirements of agricultural biotechnology in developing institution-industry interaction.

3.2 Animal Biotechnology

1. Designing of diagnostics and vaccines for major diseases of cattle, poultry and other domesticated animals should receive very high priority.

2. Development of new generation vaccines, nucleic acid based vaccines, recombinant viral/ protein/peptide based vaccines against important viral diseases like, rabies, canine parvovirus, canine distemper, Ranikhet disease, avian influenza, avian encephalitis, PPR, IV, IBD, FAV4, Swine fever and bacterial diseases like, Brucellosis, John's disease, HS, TB, fowl cholera should have high priority.

3. Worldwide studies on genomics of cattle and other animals are being carried out in a very involved way. Yield increase and resistance to diseases requires strong conservation and breeding programs. India should participate in the major genomic initiatives on domesticated animals.

4. Strong breeding programs based on molecular markers should be initiated to increase yield and disease resistance in domesticated animals.

3.3 Recommended XI Plan Financial Outlays for the proposed inititatives

Sr. No.	Area for which support is required	Estimated budget (Rs in crores)
1	Precision molecular breeding in crops and animals	1000
2	Acquisition of technologies e.g. gene constructs, markers, transformation events, protocols etc.	500
3	International research collaboration, including those with CG institutions in the frontier areas of biotechnology e.g. genomics and gene expression studies and product delivery	500
4	Enhancement of Biotechnology training facilities in five selected institutes/universities in India including B. Tech Agriculture courses	50
	Total	2050

3.4 Implementation of New Ideas

A Committee may be constituted to develop 'Breeding by Design' program for the major crops and animal species. This Committee will select subject experts to develop a comprehensive strategy and roadmap of activities for each crop and animal species. Advisor from outside India could be also contacted for inputs. Experts will be paid reasonable remuneration for reviewing status of R&D in each crop and for developing 'Breeding by Design' strategies. The Committee will also take services of economists and other experts to elaborate on economic, ecological and nutritional impact of the breeding goals and time scales required to achieve those. The Committee should submit the report in six months time. A budgetary allocation of Rs. 50 lakh be made to initiate reviewing, planning and strategizing research on both crop and animal species.

11. AGRICULTURAL EDUCATION

Executive Summary

1. Agricultural education system comprises of 40 State Agricultural Universities, four of the ICAR Institutes as Deemed Universities (IARI, IVRI, NDRI, CIFE), Allahabad Agricultural Institute and one Central Agricultural University, Imphal. In addition, four Central Universities, namely Banaras Hindu University, Aligarh Muslim University, Vishwa Bharti and Nagaland University have strong agricultural faculty. In addition to this, there are large number of private colleges both affiliated and non-affiliated to SAUs which also annually admit larger number of students.

2. With the **support from ICAR during X Plan**, Agricultural Universities have been able to initiate and implement measures for quality improvement of agricultural education. Support provided for curriculum delivery has led to education improvements. Computer laboratories have been established, lecture halls modernized with LCD facility, computer literacy enhanced internet facility provided to all SAUs and Colleges. Construction of girls hostels has led to increase in girl students enrolment in Universities. Support for international hostels has contributed significant increase in foreign students.

3. Some of the **activities of X Plan are seen as continuing** to be relevant in making immense contribution to quality of agricultural education. These initiatives viz. Niche Area of Excellence, Best Teacher Award, Text Book Writing, Centres of Advanced Studies, Accreditation and Emeritus Scientists are recommended to be continued in the XI Plan. Scheme of Agricultural Education cuts across all the sectors hence **AICRP on Home Science may be made independent** of the scheme on Agricultural Education.

4. The support led to improvement in quality of education to some extent; still **there are many constraints.** These constraints include lack of modernity and state of the art equipments commensurate to world technology development, inadequate financial support and lack of access to latest information. The need for sweeping reforms in agricultural education for improving quality and standards is well recognized now than ever before because of emerging challenges of making Indian agriculture not only sustainable but also internationally competitive.

5. Challenges faced by the Agricultural Education system include, shifting employment opportunities from public sector to private sectors; severe resource constraints due primarily to poor financial support from the state on one hand and unplanned proliferation of universities by states on the other hand; course curricula not meeting global competitiveness and poor link with technology transfer.

6. Despite the fact that there was stepping up in the financial support from Education Division to AUs, the **gap especially in the areas of teaching** could not be filled and this gap continues to haunt the system. It is necessary that massive step up in investment be made for infrastructure development as well as for human resource development so that agricultural education system is able to produce graduates who posses skills matching the present day requirement.

7. Resources are required to initiate/strengthen research and facility/faculty development in **new and emerging areas** such as: Nano-technological applications in agriculture; Precision agriculture: Automation, biosensors; Biotechnology and biosafety-testing facilities; Micro-array and BAC resource center; Hi-tech horticulture esp. floriculture; Modernization of libraries and Farms; Establishing Centre of Distance Education and video-conferencing facilities.

8. Central assistance is recommended for **construction** of girls hostels, international students hostels and creation of faculty and student amenities such as indoor games facilities, playgrounds, swimming pool, gymnasium etc. Support is recommended for **renovation** of hostels, laboratories, classrooms, library and other academic buildings; **curriculum delivery tools**; preparation of instructional materials; contingency for conduct of practicals; laboratory strengthening; library and information system; instructional farms/facility; clinical and diagnostic facilities, **automation**/IT/computerization and **student counseling** and placement services.

9. For building professionalism and **practical work experience** among students, support is recommended for skill development initiatives such as experiential learning facilities, RAWE/in-plant training, vocational training and distance education and fellowships/scholarships. Support is also recommended for examination and performance evaluation of students.

10. Human resources development through career development planning including building and rebuilding of faculty competence through **regular training** should be an over riding priority. This is particularly important in view of rapid developments in science and technology. Life long learning should be inculcated in the faculty. For this purpose induction training and training needs assessment of faculty for national and overseas trainings is recommended. A thorough regional and national agricultural human resources needs analysis through planning and management is recommended. Skill up gradation of para-professional and other staff of AUs is also recommended.

11. In order to take advantage of inherent strength built in our educational system, concerted effort is recommended for marketing of Agricultural Universities overseas. Some of the institutions like IARI, IVRI, NDRI, CIFE as well as SAUs could be supported for **opening off campus colleges and programmes in Asian, African and Middle East countries.**

12. National Agricultural Research and Education System is a very well developed and vast system. **Public-public, public-private and private-private linkages** should be forged for maximizing the outcomes of agricultural education for agricultural development and prosperity, economic and social security of millions of small and marginal farmers and farm workers.

13. For effective implementation of reforms in agricultural education, an appropriate policy of governance is critical. The Committee therefore recommends that the ICAR be vested with the **Statutory Powers** to regulate agricultural education for quality assurance. Such a step will go a long way in ensuring relevance and quality of education in addition to soundness and vibrancy of the national agricultural education system.

14. The Sub-Group recommends **Rs 4900.00 Crore** as an outlay for XI Plan on Agricultural Education.

Final Report of the Sub-Group on Agricultural Education of XI Five Year Plan Working Group on Agricultural Research and Education

Working Group on Agricultural Research and Education vide F.No.5(5)/2006-PIM dated July 12, 2006 constituted a Sub Group on Agricultural Education with a following terms of reference (TOR):

(i) To make critical review of X Plan achievements in terms of Agricultural Education and productivity enhancement in contrast to the objectives and targets set during X Plan.
(ii) To identify critical in scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as to enable the nation to enhance its agricultural competitiveness in the context of WRO & IPR regime.
(iii) To draw/suggest specific schemes/programmes pertaining to Agricultural Education to address the problem of less privileged regions.
(iv) To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R& D priorities.
(v) To identify institutional mechanism for strengthening, monitoring and evalution system in agricultural education/research, and to suggest efficient measures for effective coordination of agricultural education/research in SAUs, ICAR and private sector including the steps to be taken for strengthening public-private partnership.
(vi) To draw/suggest specific schemes/programmes/research area pertains to agricultural education.

Chairman of the Sub Group requested all Vice-Chancellors to give their views on each TOR giving one or two bullets of their major achievements in Agricultural Education during X Plan. The Sub Group had a preliminary meeting on September 22, 2006 in the Education Division and held discussions on TORs with particular reference to the needs of Agricultural Education during XI Plan.Following is the Interim Report of the Committee on different TORs.

1. To make critical review of X Plan achievements in terms of Agricultural Education and Productivity enhancement in contrast to the objectives and targets set during X Plan.

A. Objectives, Targets and Achievements in respect of Agricultural Education in X Plan

Development grant for strengthening the Agricultural Education has led to development of infrastructure, skill development access to information and gender equity. The major objective during Xth Plan was to accelerate the pace of improvement in quality of agricultural education. Therefore, support was provided for various activities having bearing on quality of education including skill development. The achievements are as under.

Targets	Achievements
Construction of girls and inter-national hostels, augmentation of existing facilities of operation theaters/lecture halls and instruct-ional farms;contingencies for U.G./ P.G. practicals, books, computers; participation in seminars/symposia etc; students educational tours; library strengthening central instru-mentation lab; students amenities and educational development by Deans; promotion of games and sports and cultural activities.	• 10 International students Hostels have been constructed against the release of grant for 10 SAUs. 48 Girls Hostel have been constructed in 33 SAUs and CUs involving an investment of Rs.3905.32 lakhs. Support for repair and renovation of academic block and hostels has led to improvement in the work environment in all SAUs. With the support of Rs. 7480.05 state of the art Equipments have been purchased by SAUs/CU/DUs which is leading to provide better practical skills to the students. This has also led to improvement in the quality of Post Graduate research. With the support of Rs.942.39 lakhs, the Libraries of SAUs have been able to purchase foreign journals and text books. However this support has been too an adequate support for in ter out has allowed staff and students access to information online. • Provision of Rs.22013.43 lakhs for Contingencies for UG/PG practicals, books, participation in seminars / symposia etc., Students amenities, Games, Sports and participation in academic activities have led to providing better conduct of practicals, skill and entrepreneurship development expertise in new and emerging areas. More than 700 faculty members have attended Seminar, Symposium nationally and internationally and this has been instrumental in developing linkages besides updation of knowledge support for student activities has been crucial for all round development of personality and better placement.
<u>Rural Agricultural Work Experience:</u> RAWE started in all SAUs to give exposures to the students in respect of rural life and environs.	All the students (11157) of Under Graduate level have benefited greatly under this programme. The support provided made it possible to have compulsory RAWE programme in SAUs. This has provided confidence to the students and also work experience of working in villages with farmers. This programme has been of tremendous benefit not only to the student community but also for the faculty since it provided feed back. The programme needs further strengthening.

<u>Centre for Advance Studies:</u> 31 Centres of Advance Studies established for providing training in getting arid science subjects.	All the 31 CAS organized 232 training programmes in which 4390 Scientists/Teachers were trained in new emerging areas. This is not only led to updation in their knowledge but also in joint development of projects and considerable savings since the quality of training was at International level in most case.
<u>University level books:</u> Development of text books quality.	16 University level text books have been published by ICAR. There has been concerted efforts to involve the best faculty for quality text books development. In the e-text books needs to provide training faculty in e-content developed and support need to be deliver for development of new quality text books useable in electronic mode.
<u>Establishment of Jammu Agricultural University:</u> Support for development of infrastructure facilities for quality education and research.	• The Administrative and Academic Blocks have been constructed with a support of Rs. 55.60 crores and state of the art equipment purchased by the University worth Rs. 12.40 crores. With this support the University now has modern facilities for U.G. and P.G. teaching and training.

To formulate palatable combi-nations of cereal, pulses, vegetables and animal products to enhance the nutritive value of foods through locally adoptable preserving and processing techniques; to build livelihood of security for quality/decent living by increasing income from various on-farm occupations and enterprises. To reduce drudgery and alleviate health hazards by enhancing efficiency through capacity building. Empowerment of farmwomen to conserve natural resources to make most efficient use of farm and non-farm produce/animal waste and **develop linkages with** Government and non-Governmental Organizations.	For nutritional security at the national level, the AICRP has successfully developed a **nutritional guide** as a powerful tool for dietary counseling at various levels for different age groups. Each Centre has established farm crèche in the adopted village and is providing desirable stimulation to the under 3 year old children. **Drudgery Reduction** tools such as sickles for fodder cutting, dibbler for dibbling the seeds have been developed in collaboration with the Central Institute of Agricultural Engineering, Bhopal. Based on the indigenous and scientific information, sets of nine **Technological Kits** were prepared. Commendable research work has been done in the area of **Value Addition to Agro and Animal Fibres and Indigenous Dyes**. Most significant contribution of the AICRP has been **Development of a strong Data-Base on Rural Farm Women**. which has enabled to gain an insight into the realm of all the traditional practices used by farmwomen in farming and animal husbandry. This need to be further strengthened.

Central Agricultural University, Imphal: (i) College of Home Science, Tura, Meghalaya (ii) College of Agricultral Engineering and Post Harvest Technology, Sikkim (iii) Initiation of College of Post Graduate Studies, Barapani, Meghalaya .	The College of Home Science in Tura , Meghalaya has been established and laboratory facilities in Food and Nutrition, Clothing Construction, Textiles, Audio-visuals, and Housing and Space Management developed. The College is offering UG programme in Home Sciences for girls, with intake capacity of 22 students. The College of Agricultural Engineering & Post Harvest Technology has been established in Ranipool, Gangtok , Sikkim. The Government of Sikkim has transferred an existing farm having about 5 ha of land, along with 2 buildings, a small workshop, and some farm structures etc., which were with the Department of Food Security and Agricultural Development. The Government of Meghalaya has transferred 6 ha of land for the establishment of Post Graduate College at Barapani, Shillong. The plan and estimates for Administrative and Academic Blocks, Hostels, Residences and other infrastructures have been finalized and construction work has started. The College is likely to be functional in XI Plan.. Remaining civil works for creating infrastructure at College of Fisheries, Lembucherra, College of Veterinary Sciences, Aizawl, Mizoram, College of Horticulture, Pasighat ,Arunachal Pradesh and College of Home Science, Tura, Meghalaya as envisaged in Xth Plan have already started. The work at College of Agricultural Engineering in Sikkim has started & will be completed in XI Plan.

<u>NAARM, Hyderabad:</u> Targets Organize Foundation courses, Refresher courses and Senior programmes, Workshops, Summer/ Winter Schools, Off-Campus programme. . Foundation Course . Refresher Courses . Senior Programmes . Workshops . Summer/Winter Schools . Exe. Development Progm. . Off-Campus Progm.	Organized respectively 6, 18 and 104 Foundation, Refresher and Senior Programmes in which 243, 326 and 2433 participants participated. In addition organized 19 Workshops in which 669 participants attended and 16 Summer and Winter Schools in which 403 Scientists and Faculty Members were given knowledge about the new developments. Five Executive development programmes organized in which 129 participants benefited. Institute also organized 21 Off-Campus programmes in SAUs and Institutes in which 759 Scientists/ Faculty Members benefited. Institute Scientists completed 3 projects funded by Institute and 11 externally funded projects. Currently 16 projects are in operation provided consultancy and policy support.
To undertake research activities in the specialized area of Agricultural Research and Education. To function as think tank for National Agricultural Research System	Completed three projects funded by Institute and eleven projects by external agencies. Nine projects funded by institute and seven project funded by external agencies are on-going.

Development of net-based technologies and deployment on academy's web . Academic research . Publications . 4 International Programmes . Capacity building of SAU faculty through off-campus programmes	Provided consultancy and policy support on the following areas: . Training need strategy for NAIP . Human resource planning in ICAR . Strategies for use of ICTs in agriculture and rural development . Performance assessment of research organizations . Commercialization of agricultural technologies . Strategies to encourage rural female students in agricultural education . Guidelines for IP management in ICAR . Management of biological resources for research. Online technological forecasting system . Call-log system . Office automation suite . Manpower forecasting Simulation model . Instrument for qualitative rating of agricultural colleges . Modules on agriculture (60 No.) for deployment in info-kiosk . Information system on fisheries . Virtual learning courseware . Guidance provided to twenty UG/PG students projects. . 5 Books . 105 Research Papers . 65 Conference papers . 28 Technical bulletin / Training manual. . 10 Programmes & 224 Participants . 16 No.

With the support from ICAR during X Plan, Agricultural Universities have been able to initiate and implement measures for quality improvement of agricultural education. Support provided for curriculum delivery has led to education improvement in various Universities which is seen from the fact that students of more Universities are now getting JRF than ever before. Computer laboratories have been established, lecture halls modernized with LCD facility, computer literacy enhanced internet facility provided to all SAUs and Colleges. Construction of 57 girls hostels has led to increase in girl students enrolment in Universities. Support for ten international hostels has contributed significantly to increase in foreign students intake and also bringing goodwill in African, Middle East and SAARC countries. Linking of libraries has helped for access of information on line. However, bandwidth is not commensurate to the kind of demand, which exist for libraries. It is time that all major journals be made available to faculty and students on line and also bandwidth substantially increased for AUs. ICAR has provided support for infrastructure development. The Universities have developed infrastructure utilizing the grants made available by ICAR. But the support still is not commensurate to the requirement of the system and technological advancement. However, one commendable initiative of the ICAR has been providing support for experiential learning in all SAUs and for niche area of excellence in 22 AUs for building state of the art infrastructure in one area per University. Additionally special grants have also been provided to Aus of J&K, Himachal Pradesh and Punjab. This has helped in providing excellent practical training and skills to our graduates. A total support of nearly Rs.920 crores was provided in the X Plan.

1.1 The spectacular growth in agriculture has been on account of development of skilled human resource, which played major role in developing technologies, their assessment and dissemination to farming community. This was coupled with higher participation and receptivity of farming community and sound policies of Government of India. The establishment of postgraduate school at IARI was an important milestone, in 1958, heralded growth of agricultural universities in the country. Based on Dr. S. Radhakrishnan Commission on university education and subsequent two Joint Indo-American Study Teams (1955, 1959) recommendations, first agricultural University was set up in Pantnagar in 1960, which paved the way for establishment of agricultural universities in other states.

At present, there are 40 State Agricultural Universities, four of the ICAR Institutes as Deemed Universities (IARI, IVRI, NDRI, CIFE), Allahabad Agricultural Institute and one Central Agricultural University for northeastern region at Imphal. In addition, four Central Universities, namely Banaras Hindu University, Aligarh Muslim University, Vishwa Bharti and Nagaland University have strong agricultural faculty (Annexure I). These institutions annually enroll about 15,000 students at UG level in as many as eleven disciplines and over 7,000 students at PG level in Masters and 1700 in Ph.D. programmes. At any point of time, there are over 75,000 students studying in AUs. In addition to this, there are large number of private colleges both affiliated and non-affiliated to SAUs which also annually admit larger number of students. The Human Resource Development by these institutions has played a pivotal role in agricultural transformation in the country. Green, blue yellow and white revolutions have been responsible for bringing in prosperity to the farming community.

In order to have quality assurance in agricultural education, ICAR initiated a series of steps. These include setting up of Norms and Accreditation Committee followed by establishment of Accreditation Board in 1996, course curriculum revision through Deans Committees, networking and strengthening of SAUs through development support etc. Courses in the agricultural universities system have been revised based on the recommendations of the Deans Committee. The major exercise was done at the time of Third Deans Committee, which submitted its report in 1995, and this was followed by dialogue with different stakeholders in developing detailed curricula and syllabi for various under-graduate and post-graduate courses by the Education Division of ICAR under Agricultural Human Resource Development Project supported by the World Bank. Recognizing the need for quality improvement in agricultural education, World Bank supported ICAR through Agricultural Human Resource Development Programme with an outlay of US $ 74.2 million for bringing in much needed reforms in agricultural education. The major reforms brought in through this project and subsequently included:

- **Establishment of Accreditation Board –** The new Accreditation procedure has been institutionalized which involved preparation of Self Study Report by the institutions, validation of Self Study Report by a Peer Team and finally decision by the Accreditation Board on accreditation of the institutions. The Board is assisted by three sectoral committees viz Accreditation Norms and New Institutions/Programmes, Curricula and Equivalence, Governance and Personnel/Financial Policies.
- **Norms and Standards for improving education** – Uniform academic regulations, examination and evaluation system including grading system made in SAUs. Rural Awareness Work Experience included in the programme, courses in new emerging areas such as Computer Applications, Bio-Statistics, Biodiversity, Biotechnology, Agri-Business Management, Marketing and Environment incorporated in all degree programmes.
- **Capacity Building for Human Resource Development –** The HRD programme were strengthened by supporting, modernization of class-rooms, library strengthening, establishment of students laboratories at college level, students counseling and placement cell, supporting construction of International student hostels, girls hostels, education technology cells and providing support for modernization of UG and PG practical and research labs.
- **Faculty Competence Improvement** – In order to improve the faculty competence, large number of training programmes were organized through Centres of Advance Studies, Summer and Winter Schools in which 9,000 scientists benefited. Besides nearly 1000 scientists were sent for training in best of the institutions overseas. Sabbatical leave rules as well as Visiting Scientists scheme operationalised. To promote excellence in teaching, five Best Teacher Awards were instituted both at university and national level. Faculty made computer literate and support provided for participating in seminars, symposia both nationally and internationally.
- **Reducing Inbreeding –** Extensive inbreeding is the single factor contributing largely for decrease in quality of education. From 1995-2000 major steps were taken for reducing inbreeding:
    - All India Competitive Examination each year to fill 15% UG and 25% PG seats in all SAUs. Through this examination each year about 1500 students at UG level and 1000 students at PG level are sent from one Institution to

other. This has changed the cultural life on campuses, brought healthy competition, promoted national integration, leading to improvement in instruction.

- National Talent Scholarships at UG level awarded to all students who opt to move out of their state of domicile. This is to attract talent to agriculture and promote national integration
- Award of 475 Junior Research Fellowships each year to students on merit for M.Sc programme only if they join programme in the University other than from which they obtained UG degree. This has been a major step in reducing inbreeding to a large extent.
- Recruitment at Assistant Professor level in all SAUs based on NET conducted centrally by Agricultural Scientists Recruitment Board.
- Support for Niche Area of Academic Excellence and experiential learning.

While all these steps led improvement in quality of education to some extent, still there are many constraints. These constraints include lack of modernity and state of the art equipments commensurate to world technology development, inadequate financial support and lack of access to latest information. The need for sweeping reforms in agricultural education for improving quality and standards is well recognized now than ever before because of emerging challenges of making Indian agriculture not only sustainable but also internationally competitive. Nationally and internationally there are three major pillars of quality assurance:

(i) Competence of faculty and periodic updating skills and knowledge
(ii) Modern infrastructure
(iii) Curriculum and curriculum delivery

Analysis of the present agricultural education system indicates that despite finalization of academic regulations for UG and PG programmes after Third Deans Committee report and initiatives under the Agricultural Human Resources Development Project (AHRDP), many of the institutions have not yet followed these in letter and spirit and wide variations exist. Universities still suffer from poor governance. The system as a whole has not taken full advantage of modern tools of management for efficient governance. The faculty in SAUs has dwindled with major chunk of the posts remaining vacant due to financial crunch. Besides, curriculum and curriculum delivery have not been changed keeping in view global technology development. There is also no link of curriculum to employment needs of private agribusiness and processing industries and meeting the demands of extension. Quality of education suffers due to obsolete equipments, outdated and poor laboratory facilities, lecture halls, library and instructional farms.

2. **To identify critical gaps in scientific infrastructure in frontier areas of technology and to suggest the ways to bridge the gap, so as enable the nation to enhance its agricultural competitiveness in the context of WTO and IPR regime.**

Despite the fact that there was stepping up in the financial support from Education Division to AUs, we have not been able to fill the gap specially in the areas of teaching and this gap continues to haunt the system. It is necessary that massive stepup in investment be made for infrastructure development as well as for human resource development so that agricultural education system is able to produce graduates who posses skills matching the present day requirement which are vastly different from the requirements major disciplines, where there is a critical gap including (1) biotechnology (2) precision agriculture (3) organic farming (4) quality certification (5) agri business management (6) integrated nutritional management (7) remote sensing for land use planning (8) dry land agriculture (9) processing and value addition (10) specialty foods (11) vaccine development (12) Inland aquaculture (13) reducing drudgery of farm women (14) resource conservation technology (15) water harvesting and management.

2. 1 Agricultural Education vis-à-vis Concerns and Challenges of Agriculture

During the initial phases of establishment the purpose of education was to develop graduates capable of assisting in modernizing agriculture. The aim was to produce graduates who take up careers with the development departments. Postgraduate education was evolved to prepare for undertaking research to provide solutions to location and situation specific problems. This approach was appropriate at that time. It led to substantial improvement in productivity of food grain crops. Country became self-sufficient in most of the food items with adequate buffers to tide over any adverse situation arising from crop failure in any part of the country. This impressive record would not have been possible but for the availability of technically qualified human resource.

Today the problems of agriculture are not the same what they were a decade ago. Issues of sustainable agriculture have become far more complex when factor productivity is declining and quality of natural resources is deteriorating. Small and marginal farmers number grows and land holdings shrink in size with every passing year and we do not have surpluses. For them dependence on low cost high benefit yielding technologies has become far more crucial now than in the past. As the country’s economy grows and people’s incomes increase, demand for processed foods in the consumption basket rise. Diversification of agriculture and food processing has become important. Agriculture has to become competitive price-wise and quality-wise. This necessitates different kind of technically qualified human resource. Therefore, agricultural education to remain relevant to emerging concerns and challenges has to be reoriented.

There is urgent need for change in rainfed regions where productivity gains have not been much. Appropriate research, education and training are seen to deal with recurring droughts and expand opportunities for undertaking alternative agriculture by decreasing dependence on arable farming as the sole source of livelihood for people in the rainfed areas.

Nearly 250 million people are poor/undernourished and 40 million are unemployed or underemployed. They are largely rural based (4 out of 5) and represent marginal farmers, landless labourers and school dropout youth. Investment in human capital by imparting knowledge and building technical skills is a potential strategy to fight deprivation and unemployment. Institutions of higher learning must wake up to this reality to take responsibility and organize non-formal education.

Between 5 and 25% of the total produce lost after it is harvested and by the time it is consumed. Wastage stands at a colossal Rs. 25000 to 80000 crores annually. Currently less than 2% of the total produce is processed and around 7% is value added. By the end of the current decade proportion of total produce is targeted to rise to about 10%. In order to reach this target Indian food industry needs technologists and world-class technologies to compete effectively with international products. Current research portfolio does not have focus to develop innovative products, processes and machinery of global standards. In order to feed high quality produce to fast expanding food processors, guidelines on federating small farms supporting contract farming with stronger legal protection come to the fore.

Rapid growth of information and communication technologies (ICT) and use of knowledge as a basic power to deal with global competitiveness have revolutionized all higher education systems. Need for using modern ICT tools in the formal educational process and non-formal lifelong learning of farmers are necessary for building capability and competence of rural communities. Cultivating electronically mediated knowledge and skill revolution is a highly potent strategy to achieve the goals of productive, profitable, stable and competitive agriculture.

With the growing promise of biotechnology in crop and livestock improvement need for training agricultural graduates in using biotechnology tools and techniques comes in the forefront. Currently, agricultural universities are poorly equipped in terms of facilities and competent faculty to prepare human resource in this frontier area of science.

For meeting new challenges a strong science and technology input, infusion and application system will be necessary to support sustainable and equitable development of agriculture. Building rural knowledge economy and capability to access and use what is new in science and technology come as a first ranking strategy. Need is for: (i) scientists to generate appropriate knowledge and technology (K&T), (ii) professionals and para-professionals who help in dissemination and application of that K&T and (iii) farmers who have knowledge, skill and are resource-sufficient to adopt and practice that K&T for productive, income and employment generating agriculture. In pursuance of these requirements, it is a imperative to eliminate constraints faced by agricultural education through necessary reforms and strengthening of basic infrastructure.

2.2 Constraints faced by the Agricultural Education

- Employment opportunities: With the passage of time, career opportunities in agricultural education, research and extension have declined substantially. Ongoing rapid industrial activity growth in service sector and large-scale migration of rural people to cities has overshadowed the importance of agriculture as a direct source of employment. Future opportunities are seen in commercial/industrial agriculture owned by private sector. The activities that are likely to dominate agriculture are: high value high quality produce, processing and packaging. Village based services (private extension through agri-businesses and agri-clinics) are seen to expand tremendously, opening vast opportunities for self-employment. Lack of hands-on-training and internship programmes at graduate level and skill-specific vocational courses to prepare para-professionals at the lower levels are the major constraints separating education from emerging employment markets.
- Investment in higher agricultural education: Agricultural education new faces severe resource constraints due primarily to poor financial support from the State Governments. Agricultural education system therefore has not been able to integrate teaching, training and research for harnessing the enormous potential of cutting edge technologies such as biotechnology and information technology. Incidentally, both biotechnology and information technology are investment intensive and agricultural universities do not have matching financial resources.
- Orientation of course curricula to meet global competitiveness: Recent trends such as globalization of trade, lifting of trade barriers, mobility of agricultural scientists and professionals and the protection of Trade Related Intellectual Property Rights are exerting as much pressure on the agricultural education as they are exerting on agriculture itself. In order to produce world-class human resource to meet the demands of global competitiveness in rendering professional agricultural services, it has become imperative to infuse excellence in quality of agricultural education. The overall purpose should be to attract international stamp of quality in that Indian qualifications become universal acceptance.
- Poor link of agricultural education with quality and spread of extension services: Forging a close relationship between agricultural education programmes, extension system and farming community is necessary. Apart from preparing students capable of dealing with economic and environmental aspects of modern farming, agricultural universities and institutions also have responsibility of training and providing subject-matter support to extension specialists. They also maintain direct links with farmers to take up frontline extension for validation of their research findings. Besides, regular contacts with farmers and other stakeholders are highly valuable for evolving new research. There exists a typical dearth of public or private extension services to respond to these emerging demands.
- Unplanned proliferation of universities: Over the period of there has been both horizontal and vertical expansion of number of agricultural universities and number of campuses and colleges. Sectoral division of universities into different subject areas also taken place. All this have contributed to precarious financial health of universities.

2.3 Strategies for Enhancing Relevance of Agricultural Education

For infusing excellence in science and technology output and application the emphasis should be on: (i) building professionalism at the graduate level, (ii) basic and upstream research at postgraduate level and (iii) applied down stream research built on strategic research extension plans developed with the involvement of various stakeholders but imbibing a system based platform and multidisciplinary team format.

In order to make way for teaching in real life subjects and expanding room for innovativeness through hands-on training and postgraduate research, the strategy needs to build competence and capability of teaching faculty in imparting technology mediated education and learning in upcoming areas of science and technology and market appropriate vocational subjects.

For infusing analytical and professional brilliance, the plan should be to: (i) strengthen and modernize the existing outdated teaching and learning facilities, (ii) provide state-of-the-art equipments for supporting first class postgraduate research and (iii) establish model food processing plants, engineering workshops and instructional farms for experiential learning. Involving students in extension activities, field surveys, development programmes, seed farms and modernization of agricultural farms processing units will be the blueprint of developing professionalism and entrepreneurship spirit.

For lifelong education and training of teaching faculty, scientists and graduate professionals, the untapped potential of open and distance mode of education. Creation of e-based learning should be harnessed.

In order to sustain quality and right track relevance of agricultural education, the strategy should be to enforce time-bound accreditation of agricultural universities, colleges and programmes. Regular monitoring of the action taken on the recommendations should be institutionalized.

3. Central Assistance for Strengthening Higher Agricultural Education

Over the years we have been able to develop a sound base for Agriculture Education in almost every state mainly on account of tremendous support provided by ICAR. In 1960s and 70s major support was provided under development grant for infrastructural development including construction of buildings, hostels, library, faculty trainings nationally and internationally, library strengthening including procurement of text books, journals and databases, student and faculty amenities, students study tour, development of facilities for practical training as well as hands- on-training including internship. Upto the VI Plan almost 33 per cent of the ICAR budget was devoted for strengthening agricultural education in the country and this is the major reason that most of the Universities established during that period have excellent infrastructure, which was largely contributed by ICAR.

The share of agricultural education within ICAR budget increased from 8.9 % in VIII Plan to 14% in X Plan. However, there is a need to step up this support for agricultural education to at least 20% of ICAR budget. The states contribution related mainly to establishment costs as well as sharing of infra structure development especially civil works. Realizing the importance of Agricultural Education for propelling agriculture development in 60s & 70s states, various state governments were also very liberal and in fact accorded high priority. The situation changed drastically and became worst after the implementation of the Fifth Pay Commission recommendations. Many factors have contributed to decline in the quality of agricultural education but the main contributing factor has been lack of adequate financial support for infra structure development, faculty improvement and library strengthening.

During IX and X Plan, ICAR has stepped up financial support and this has now made reversal of the decline to some extent in the quality of agriculture education. But it is still much below the stakeholders' expectation and certainly not in consonance with the developments taking place globally. Since quality assurance is the national over riding priority for bringing in research excellence, it is essential that adequate central assistance is provided for strengthening of Higher Agriculture Education. This is the only and surest way of providing world-class human resource to meet the demands of global competitiveness and meet highly professional competence requirements of modern agriculture. Higher investments are required for supporting Agriculture education to bring professionalism and to produce graduates who are job providers rather than job seekers.

- **New areas : resource allocation and functional freedom**

The new resources are required to initiate/strengthen research and facility/faculty development in areas such as:

- Nano-technological applications in agriculture
- Precision agriculture: Automation, biosensors,
- Biotechnology and biosafety-testing facilities : At one or two selected AUs/DUs
    - Biosafety testing facilities for transgenic crops (for testing substantial equivalence, protein production by the transgene, single copy or otherwise of the transgene etc.)
    - Micro-array and BAC resource centre (for genomics)
- Hi-tech horticulture esp. floriculture
- Modernization of libraries
- Farm modernization
- Establishing Centre of Distance Education, video-conferencing facilities.

- Civil Work: Support should be provided for repair, renovation, modernization and furnishing of academic infrastructure and student hostels. The quantum of support may be linked to age of the building, area of jurisdiction of the university (e.g. tribal, difficult or backward area. Following specific support for new construction is recommended:

- Girls Hostels: In the last two decades in most of the universities, there has been welcome change in respect of girls students enrollment. In fact, even in north, in many universities enrollment of girls students has doubled. In Dr. Y.S. Parmar University of Horticulture and Forestry, the girls students enrollment is about 50%. Most of the state governments now have provided for reservation of girl students in higher education. One of the major difficulties for girls in pursuing higher studies in agriculture sciences is the lack of availability of residential accommodation. Recognizing the role of women technological empowerment, the ICAR developed a very sound pro-active policy of fully supporting construction of girls hostels. This has paid rich dividends in terms of girls enrollment. With the increasing number of girl students coming to agricultural sciences, it is necessary that adequate infrastructure is built for residential accommodation. For this purpose, based on assessment of the number of girls, support for construction of girls hostels need to be provided for which in the XI plan period a provision of Rs.45.0 crore is recommended.

- International Hostel: There is need to provide support for construction of International Hostel in view of increasing number of students seeking admission in AUs. For this provision of Rs. 15.00 crore on 50% finance basis is recommended.

- Faculty & Student Amenities: Support for outdoor games, playgrounds, swimming pool and indoor halls for gymnasium, TT, badminton may be provided. The support should be limited to construction cost only by the Council. The maximum one time support may be limited to Rs. 25 lakh per SAU in a plan period.

- Renovation of Hostels, Laboratories and Class Rooms: Most of the Universities have created facilities of boys and girl hostels, laboratories and other buildings. In most cases they are old and with small investment could be modernized. Therefore support for renovation and modernization of these buildings is recommended.

Renovation of laboratories and class rooms	Rs. 300 lakh
Hostels more than 50 years old	Rs. 100 lakh each
Hostels between 25-49 years old	Rs. 25.00 lakh each
Hostels less than 25 years old	Rs. 15.00 lakh each

Total budget required for this activity would be around Rs. 300 crore. Which would be one time support.

- Curricula Delivery: Outcome of the modern curricula and syllabi mainly depends upon its effective delivery. The major components of the delivery are latest delivery tools, modern equipments, latest instructional material and needed contingency support for conduct of practical and skill/practice courses. The following support for curricula delivery is recommended.

- Contingency for Practicals: The contingent support may be used for recurring materials and small accessories/component of equipments of routine use. The following contingent support for conduct of practicals is recommended per student per year.

- UG: Rs. 5000
- PG: Rs.10,000
- Ph.D: Rs.20,000

- **Laboratory Strengthening:** Globally technological developments are taking place at a very fast pace. In fact, the capacity of scientists to undertake research has undergone major transformation on account of availability of modern state of the art electronic equipments, which make it possible to do analysis and interpretation of data at a scale unthinkable before. The manual work has given way to automation in analysis at enormous scale and capacity. The developments in Molecular Biology and Biotechnology, Natural Resources Management, GIS, Remote Sensing, etc. have come mainly because of the rapid growth in instrumentation. Our universities could not keep pace with the technological development in instruments on account of financial inadequacy. The equipments in most universities are still primitive or obsolete and this has impacted on the quality of PG training and research work. In view of the higher stakes for attaining international leadership, it is necessary that universities are provided modern equipments in new and emerging areas. This will enable our students to compete internationally by virtue of having better exposure and capability to use latest tools and technologies for advance research. For the instruments, which are costly and sparingly used, it is necessary to provide them in Common Instrumentation Laboratory so that optimization of the limited resources is ensured.

  For this purpose, the sub-group recommends one time grant of Rs.1.0 crore per university, for development of Common Instrumentation Facilities at University level. It would also be essential to provide support for two skilled technicians so that scientists needing the services of the centre could avail on first-cum-first serve basis. The second tier support for instrumentation relates to procurement of most commonly used equipment at college level for undergraduate and postgraduate students. These equipments be open to students use independently and individually so as to acquire skill, competence and confidence. For this purpose one time grant of Rs.50.0 lakhs for each PG College and each Undergraduate college Rs.20.0 lakhs is recommended.

- Preparation of Instructional Material: For effective curricula delivery and conduct of practicals and practice/skill-based courses it is equally important to have quality instruction materials. The use of manuals, power point presentation, multi media, interactive study materials, soft tools, digital specimen, real life experimental procedures etc. need to be enforced in teaching of various courses. For preparation of such modern curricula delivery tools and materials, annual support of Rs. 2.00 lakh per college be provided. Additionally, for establishment of a Teaching Technology lab a one-time support of Rs. 5.00 lakh and Rs. 10.00 lakh respectively for per UG and PG college is recommended.

Niche Area of Excellence: This is a new initiative taken in the X Plan for providing skills and ensuring global competitiveness. Support for twenty three Niche Areas of

Excellence has already been provided during the X Plan. Moily Committee on expansion of higher education has also recommended strengthening of Niche Areas of Excellence. In the X Plan this initiative on Niche Area took off in the later phase of the X Plan and cross only few area. This need to be further expanded & strengthen to achieve internal excellence to providing needed support to the ongoing Niche Areas and creation of new Niche Area in each AU. A funding support of Rs. 300.00 crore is recommended.

Best Teacher Awards: This has been a good initiative to provide incentive and encouragement to faculty for attaining excellence in teaching in agricultural and allied sciences. To make it more attractive, increase in award money from the present the Rs. 10,000/- to Rs. 25,000/- per award is recommended. Also it exposes (TA/DA) including honorarium for Award Committee members need to be provided total support. For this support of Rs. 10.00 crores is recommended.

Text Book Writing Scheme: There is great dearth of quality student-affordable text books containing India data, experiences, agricultural conditions and current national perspective. This initiative is recommended to be continued, instead of individuals submitting titles of their choice, a need analysis for Text Book titles based on recommended curricula and syllabi for different disciplines may be done by inviting experts constitute of additional boards and quality development of quality text book and even having international collaboration.

Centers of Advanced Studies: Centers of Advanced Studies were created for undertaking advanced teaching, research and extensions and also training and retraining of faculties/scientist of other ICAR Institutes/AUs in enhancing their capabilities in use of educational innovations, modern teaching and research methodologies along with serving as repository of ideas and information in concerned discipline/department. In the X Plan 31 such centers were functioning until now all the CASs were actively organizing atleast two training programmes of 21 days duration annually and large number of faculty and scientists participated in these programme, which resulted in acquisition of new skills & knowledge in new & emerging areas.

The Committee recommends further strengthening of these centers in view of their major outcome are also creation of new CAS in areas like Biotechnology, Organic Farming, Food Processing and GATS including IPR, WTO etc. The mandate of CAS is recommended to also include long-term customized training and benefit of CAS trainings may also be extended beyond ICAR institutes/Aus on payment basis. A budgetary support of Rs. 30.0 crore is recommended with a minimum of Rs. 10.0 lac CAS year.

Emeritus Scientists: This activity facilitates outstanding scientists to complete the nationally important research already being undertaken at the time of their superannuation. Normally research is a teamwork and in every nationally important research project, the continuance of research is always ensured by the institute/AU through other scientists of the team. Also two years period is generally not long enough to get a meaningful outcome from the project. In view of this it is recommended that

this initiative may be primarily used for utilizing talent of outstanding superannuating teachers for writing text books, teaching courses, developing instructional material and extension activities. This would also ensure a structured outcome from the outstanding superannuated faculty/scientists.
In view of the fast advancement in Science and Technology in the developed world, it is essential that agricultural education system is able to develop in its stature and functioning which is comparable to the best in the world. Over the years while some basic talent has been identified in SAUs and National deemed universities in the ICAR, in most of the universities such persons or departments have not emerged out as the outstanding and leads centers for different critical and important disciplines in agriculture, be it crop or sciences. Though some agricultural universities have large department but most of the universities do not have defined centers which attract scientific talent or have scientific support necessary for functioning of centers of excellence.

Centres of Excellences

To develop the national capacity for manpower development and also to pursue need based basic and transferable research, it becomes essential to have centers of excellence in agricultural research system in the country in different Agro-ecologies. Such centers should have adequate competent scientific staff component and assured financial support so that the targeted programme could be pursued with the scientific reckoning comparable to the best in the world. Such laboratories will function as the lead centers for the country in different subjects matter. It is therefore proposed to have a fully supported research centers in State Agricultural Universities and Deemed Universities to pursue advanced research in new and emerging areas, develop and cutting edge technologies and answer the regional needs of stakeholders. Such centers will have research standards comparable to the best leading laboratory in the world and will be associated with manpower development programme to serve as the fountain for high quality advanced research training.

Each center will be centrally supported through the faculty component of 10 persons:-

One Team Leader and Prof; three Senior Research Officers/ Associate Prof; six

Research Officers/Asstt. Prof.

This faculty will be nationally recruited. The Center will be supported besides nationally recruited faculty salary, with state of the art equipments and one time infrastructural support. As the training center for young talents, these centers will enroll students for masters and doctoral research programmes and such students will be admitted through an All India Competitive Test conducted by ICAR.

It is expected that this programme will involve total expenditure of Rs.500 crores with one centre to each SAU/DU.

Commercial Agriculture

Agricultural universities and deemed universities which are engaged in teaching, research and extension activity lack commercial venture and corporate culture at present. Jobs in academic institutions, research institutions and government line departments are limited whereas huge employment opportunities have opened up in private sector like input agencies, seed production, marketing, banking and agro based industries etc. These organizations commonly say that Agricultural universities graduates are lacking the entrepreneur skills, commercial and corporate culture. Therefore it is felt essential to establish a corporate unit which can take up commercial business venture and service like land development, irrigation layouts, seed production, cultivation of medicinal and aromatic plants, commercial cultivation of flowers and vegetables, poultry, dairy, sericulture, apiculture, vermi-compost, bio-control agents, value addition, packing, labeling, branding and marketing services, etc. Therefore, graduates who are now only towards professional careers can also become entrepreneurs and service providers. Therefore, establishment of these corporate units with commercial venture is felt as most essential part of the academic programmes. This will also give experience to not only teachers and students but also will stand as a model for farmers and others to establish such units individually for the service of the farming community. Hence it is better to establish such units in all agriculture universities/college campuses and also deemed universities so as to train the students in commercial agriculture through this corporate approach. However, the profit earned by these units can be shared to the benefit of the institution and also the scientists and for further development of the commercial unit itself in certain fixed proportion. The units also should have technology parks which become technology incubators for upscaling of the technology. It is recommended that to begin with such technology parks be created in 20 institution with an budgetary provision of Rs. 75 crore @ of Rs. 3.5 crore for each.

- **Library:** With ever increasing knowledge explosion the cost of acquisition of journals and other publications have been increasing. With the financial squeeze most of the SAU libraries are not in a position to even purchase textbooks, which is adversely impacting on quality of education. Therefore, it most essential to have network of libraries and access to journals on line with one hard copy and electronic mirror image at least at one location. All SAUs need to be provided 2 Mbp connectivity, hosting on ICAR portal and at least 50 journals on line with connectivity given to respective colleges for concerned journals. For renovation, furnishing and modernization of libraries, a one-time grant of Rs. 50.0 lakh is recommended for the Central library of each university. At least 50 percent of this amount should be used for modernization of the central library. Library support is also recommended for annual fee of ICAR-ERNET network and for purchase of textbooks for book banks.

Library Networking & online journal subscription

Sr.	Description	Crore
1	Bandwidth cost @ Rs. 30 crore per annum for 200 sites for 5 years (2MBps (1:1) for 60 sites, 512 kbs for 140 sites)	150.0
2	Video conferencing and IP telephony for SAUs / CAUs / approx. 40 nos) capital one time	10.0
3	Annual Maintenance @ 10% pa (Rs. 15 lakh) for 5 years	1.0
4	Internet Data Center Infra for 20000 users (Servers, SANs Backup, firewall, IPS/IDS, softwares, Anti-Virus, EMS, Portal,	20.0
5	Recurring cost of softwares @Rs. 2 Cr. PA for 5 years	10.00
6	On line subscription for 100 Journals (Archived mirror copy)	80.0
7	Digitization of thesis abstract	50.0
7	Campus network in 40 institutions	20.0
8	Recurring cost for AMC of Hardware @ Rs. 30 Cr. PA for 5 years	150
9	Bandwidth of 90 Mbps for Data centre for 5 year	14.0
10	Manpower cost and operations of DC and DR	10.0
11	Training	2.0
	Total cost for 5 years	**382.0**

- Student Placement and Counseling: With the shrinkages in job opportunities in government sector, the graduates have to find placements in private sector. For this purpose, it is necessary to have campus interviews. In order to have university-private partnership and linkages, each university should have modern Student Placement and Counseling Centre. This will play a major role in bringing awareness among the students about the new national and international opportunities for employment as also entrepreneurship development. The centre should also play an important role in personality development, and enhancing communication skills. For this purpose, a provision of one time grant of Rs.30.0 lakhs to each university including development of communication center is recommended.
  - Instructional Farms/Facilities
- Farms: In order to equip students with actual field environment and impart training on University Agricultural farms (Agriculture, Horticulture, Livestock, Poultry, Fish ponds etc.) in agricultural and allied sciences, it is important to provide support for establishment and maintenance of instructional farms complexes commensurate to the requirements of individual faculty. Support to the tune of Rs. 100 lakhs is recommended to each college after making the need based assessment.
  - Clinical and Diagnostic Service Centers

-Veterinary Clinical Complex: Veterinary Clinical complex is the primary and essential unit to impart training in health management and treatment of livestock, & sick animals. One time support of Rs. 75 lakh for establishment of Clinical Complex is therefore, recommended.

-Soil Plant Clinic: At present except for one or two universities organized plant clinic is non-existent. Such clinics will help in control and management of plant diseases and also useful in circumvent deleterious effects of insecticides, fungicides, weedicides and certain known and un-known toxicological agents, plants etc. for soil plant clinic financial support of Rs. 20 lakhs per college is recommended.

- **Automation/IT/Computerization: Following is recommended**

- Internet connectivity in hostel rooms for PG students.
- Internet connectivity in every department and Lecture hall.
- One computer for every faculty member identified as excellent teacher/ research/ extension worker.
- LCD Projector in every class room.

- **Skill development**

-Experiential Learning: Experiential learning is necessary for bringing professionalism and practical work experience in real life situations to graduates. In all disciplines experiential learning programme for imparting hands on-practical Training is recommended by the IV Dean Committee. In order to bring in high quality entrepreneurship skills and professional competence, it is essential that adequate budgetary support is built for infra-structure facilities for providing experiential learning. These programmes will build confidence, facilitate skill development through experiential learning and facilitate in producing job providers rather than job seekers. Modification in course curriculum necessitates change in methodology in teaching and learning and development of facilities like model farms, dairy plants, food processing facilities, workshops, procurement of state of the art equipments for practical training, ICT facilities etc.

-RAWE/ In-plant training: For this important activity students need to be provided stipend as they have to mostly live outside and have to incur expenditure. Of this amount Rs. 1500/- should be contributed by central assistance of ICAR and Rs. 500 should be states share. Of the Central Assistance of Rs. 1500, Rs. 1000 should go as stipend to the student and Rs. 500 towards operationalizing the programme (meeting faculty expenses, contingency expenses POL, medicines during clinic etc). The states share should go towards stipend to the student. In case states provide more support the same should be provided to the student. This should be for the duration spent in the village or for inplant training outside the university.

- Fellowships and Scholarships: Inbreeding in education and faculty is a serious issue affecting both quality and relevance of education. The proportion of persons obtaining all the three higher degrees from the same university including faculty members has rapidly increased over time. This trend needs to be arrested by appropriate policies and support. Some beginning has been made to tackle this problem by way of filling 15 % and 25 % seats respectively in UG and PG programmes through entrance test conducted by ICAR. This initiative can be made further effective by providing fellowship/scholarship to all the candidates who choose to move out of their State from where the education for eligibility examination was passed.

Human Resources Development

-Faculty Competence Improvement: Educational institutions world over are known because of the competence of the faculty. Recruiting quality faculty is the first step but it is the continuing quality updation in knowledge and skill of faculty which holds the key for quality education. Therefore, career development planning including building and rebuilding of faculty competence through regular training should be an over riding priority. This is particularly important in view of rapid developments in science and technology. Life long learning should be inculcated in the faculty and mechanism developed whereby each faculty member undergoes mandatory training at regular span of 5 years The sub group recommends training of at least 21 days for Assistant Professor, 10 days for Associate Professor, 5 days for Head of Departments and 3 days for Deans every five yearly. The training programme must be properly developed taking into consideration the current status of competence of the faculty, requirements of new curriculum with focus on acquisition of knowledge and expertise in frontier areas such as biotechnology, information technology, food technology, market intelligence, modeling, agri-business management, GIS, IPR and international trade besides entrepreneurship, communication, project development and assessment skills, etc. This career development plan envisages that every faculty member should have opportunity of participation in one training programme every five years which means that 20 per cent of faculty under goes training every year.

In many frontier areas, there is tremendous technology gap. In order to bridge this gap four per cent of the must have opportunity of training in the best institutions overseas. This investment in building competence of the faculty is not only critical and essential but would ensure continued high quality education and training which is a prerequisite for bringing excellence in research for accelerating agriculture growth in the country. For this purpose budgetary provision of Rs100 crore is recommended. This support may be used for national and international trainings in cutting edge technologies and modern curriculum delivery.

-Skill Up-gradation of Para-professionals and other Staff: Trainings may be organized in the university or outside preference may be given for group trainings in computers, laboratory skills and modern office management, administrative and finance procedures. Rs. 2.0 lakh per annum is recommended for each university for this purpose.

-Human Resource Planning and Management: Presently human resource development is largely based on adhoc-ism in total disregard of man power need assessment in different sectors of Agriculture for example large state like Bihar has a very limited student intake in Agriculture compared to Maharashtra which admits disproportionately high number of students. Sectorally there is a high demand for competent human resources in the area of Dairy Technology, Food Technology, Horticulture, Fisheries, Agri Business Management and Veterinary and Animal

Sciences but the number of graduates coming out in these disciplines is lower than the needed requirement. In fact there is no creditable system of human resources need assessment. In order to have proper and adequate development of human resources it is necessary that human resources planning is undertaken on scientific basis so that enrollment in different disciplines could be regulated. This would require need assessment for professionals in specific subject areas, review of their training needs for sustainable performance and career advancement. It would also be important to consider knowledge and skill profile needs of prospective job market. Studies on man power need assessment and organization of workshops sectorally at national level and involvement of different stakeholders in review and assessment of skilled human resources sectorally is essential. This will help tremendously in forecasting potential placement opportunities nationally and internationally. In order to take advantage of inherent strength built in our educational system, concerted effort should be made for marketing of Agricultural Universities overseas. Some of the institutions like IARI, IVRI, NDRI, CIFE as well as SAUs could be supported for opening off campus colleges and programmes in Asian, African and Middle East countries. For human resources planning, manpower need assessment and marketing of agricultural education overseas, of Rs.100 crore is recommended.

- Support for Examination Reforms: Major reforms in the examination system of both UG and PG courses is need of the hour. For the implementation of reforms including external examination in UG and PG courses, several new mechanisms will have to be put in place. Evaluation of experiential learning, inplant training, skill and practical courses etc. would need, never before used examination/evaluation processes. For these, a support of Rs. 40 crore during Plan period is recommended.

- Support to Deans for Academic Improvements and Management: For management of quality and relevant education and for effecting improvements in education, several new and innovative actions and steps are needed to be taken by Deans of the colleges. Many of such requirements can not be envisaged before hand, some examples of such needs could be, to meet travel and hospitality expenses for lecturing by outstanding national and international academicians who happen to be in the region of the university/college, for exposing students to management experts, successful farmers, agribusiness persons etc. some other exigent situations and needs may also arise in the conduct of practicals, skill courses, experiential learning etc. or for exposing students to newly or just available techniques and tools for which regular support is not available. For all such needs and to meet any other emergent and exigent expenditure for education management and improvements a support of Rs. 4 lakh per annum, for each college is recommended.

- **Vocational Training:** Small and marginal farmers, landless labourers, farm women and school drop outs in villages constitute bulk of the 40 million unemployed or semi employed work force of the country. They are not able to have gainful employment mainly because of lack of technological empowerment. On the other hand State Agricultural Universities with faculty strength of about 25,000 churn out only about 12,000 graduates, which is much below the HRD capacity of these institutions. Universities are concentrating mainly on formal education while there is need for non-formal education especially in respect of knowledge and technological empowerment of vast section of work force in rural areas. This will expand the opportunities for off farm employment and decrease dependence of large segment of population on agriculture resources for livelihood. Neglect of middle level skill and manpower development appears to be major lacunae for ensuring livelihood security. The absence of well structured vocational programmes have created communication gap in not only effective transfer of technology from lab to land but also becoming partner in agriculture transformation. Vocational training on a large scale in various fields can partly bridge this gap. Rural youth unable to pursue higher education, school and college drop outs, women in agriculture who have no facilities of higher education can easily be provided skills and oriented towards agriculture vocation as per their traditional occupations. Typically introduction of vocational courses in animal husbandry, dairy technology, fisheries, horticulture, vegetable, fruit, poultry production, medicinal and aromatic plants cultivation, plantation crops, nursery raising, fruit and vegetable preservation, milk processing, poultry, sericulture, maintenance and custom hiring of farm machinery, hybrid seed production, vermi-composting, hi-tech horticulture, precision agriculture and organic farming, etc. offer vast potential to create productive profitable, sustainable and self employment in agriculture. With small investment necessary skills can be built using the infrastructure and faculty resources available in SAUs specially in KVKs. However, the essential requirement is for ensuring quality of vocational programmes. These programmes should basically have inbuilt mechanism for extensive experiential learning so that participants acquire professionalism, skills and entrepreneurship which allow them to have self-employment. This will lead to total transformation in rural areas.

In order to have quality vocational instructions, it is important that each of the University be liberally supported for infrastructural development. The programme should be partly financed for contingent support. Each University should aim and initiate vocational training programmes in 3-4 areas on the basis of need assessment for a fixed duration. The programme may consist of training from 21 days to 6 months or certificate/diploma course but the major objective should be to provide adequate skills so that trainees have confidence and be gainfully self-employed. It would also be important to have end-to-end approach so that the participants also have expertise relating to marketing. For this purpose the support of Rs75-100 lakh for infrastructure development at each college with a total investment of Rs.200 crore for all colleges AUs is recomended.

- **Distance Education:** Distance education is becoming a reality. The distance education technologies could be used effectively to share under-graduate and graduate level courses, extension programmes, research findings and national and international speakers. Current technologies include audio-video, multimedia via satellite and computer system. We need to provide global environment through internet. Infact, computer aided instructions consists of text, graphics, photographs, animated images, video, audio and mixing real time information on various issues like weather forecast, insect-pest development, land use planning, etc. The internet based courses promote continuing education. It is estimated that 75% of the students drop out by 10+2 stage and this is the major work force in rural India who have no access to modern technology. Through distance education, it is possible to reach those un-reached and technological empowerment of women for accelerating pace of agricultural development. For technology mediated learning through distance mode a provision of Rs. 300 crore for hardware content development and establish centres of Distance Education in each all is recommended.

ICTs are evolving as a new mode of distance education to reach the un-reached anywhere, in less time and with less cost. There is an urgent need now to technologically empower people living in far-flung areas through distance mode. Agricultural Education Media Research Centres should be established for content development.

Since farm is the basic unit of agricultural activity, it has to be kept at its highest level of utility and modernity so that the activities performed on it will ensure maximum returns and quality outputs. If the farm has all the facilities for precision experimentation it will lead to excellence in research, education and training alike. Such a farm could also be used commercialization for of activities and entrepreneurship development. It is high time that the funding support crucially needed in this regard is provided to the AUs.

- **Support to Deemed Universities:** Although ICAR institutes, which are Deemed Universities, gett financial support under ICAR budget, they are discharging very important task of HRD. A grant of Rs. 2.50 crore annually to each Deemed University for upgradation of Library, Practical Labs, Class rooms, Instructional material development faculty and student amenities, etc. is therefore recommended. Total budget needed for this will be rs. 50.0 cores.

- **Support to Central Universities:** Central universities having agricultural faculty and not receiving UGC grants for agricultural education and research should be treated at par with one faculty of an agricultural university, provided it follows curriculum and academic regulations prescribed by ICAR and grant restricted only to the programs of agricultural sciences. The items of support may include contingency for practical, purchase of lab equipment including computers, library strengthening, instructional farm development, participation of faculty in seminar, workshop, conferences etc. Provision of Rs. 15 crores is recommended.

4. To critically examine the on-going programmes specific to farm women, small and marginal and tribal farmers and outline the R&D priorities.

Presently AUs are focusing on technology empowerment of farmwomen, small and marginal and tribal farmers. But the support provided is far too inadequate. As a result of which major impact is not visible except the areas where ICAR institutes/AUs are working. Unless the impact reaches to most farmers, livelihood security would remain a distant dream. Technological empowerment of farmwomen, small and marginal and tribal farmers holds key to assuring prosperity. For this purpose, because of vastness and variations in clientele it is necessary to use modern technologies for reaching the un-reached. What is most important is to undertake R&D for suitable technology for farmwomen, small and marginal farmers and tribal farmers. The major focus needs to be on increasing productivity with lesser input and to reduce drudgery of farm operations. There is need to get more output per unit input since these categories of farmers are poor and do not have money to invest. AUs need to develop model villages where all different types of usable technology are disseminated. This will lead to livelihood security of disadvantaged groups of farmers.

5. To identify institutional mechanism for strengthening, monitoring and evaluation system in agricultural education/research and to suggest efficient measures for effective coordination of agricultural education/research in SAUs, ICAR and private sector including the steps to be taken for strengthening public-private partnership

ICAR has developed mechanism of strengthening and monitoring of agricultural education and research. The mechanism consists of Vice-Chancellors Conference annually to deliberate on major issues facing agricultural education and University. There is also mechanism of accreditation of Universities and colleges for which guidelines had been developed by ICAR, which include submission of self-study report, peer review and final approval by Accreditation Board.

In addition annual meetings are also organized with individual faculty to know progress under various schemes. In order to further strengthen monitoring and evaluation especially of teaching, the IV Deans Committee has also suggested mechanisms. The main features of the IV Deans Committee Report have been taken into consideration while developing recommendations XI Plan support.

In view of globalization and fast pace of development of technologies it is necessary for AUs and ICAR to forge linkages with private sector and support of public funded institutions along with institution overseas. This is the only way which rapid progress can be made especially in frontier areas.

5.1 Performance Linked Support: It is well recognized that despite very many efforts made, the quality of graduates both at undergraduate and postgraduate students do not conform to the expectations of various stakeholders. The efforts made under AHRD project had reversed the trend of decline in quality education but there is still a lot needs to be done for quality improvement in agricultural education. In order to motivate the faculty and bring total quality management in educational institutions, it is also critical and important to build in performance-linked support systems, which includes incentives for performance and disincentives for non-performers. With the sound system of management it is possible to have major strides for quality assurance in agricultural education. For this Rs. 20 crore.

5.2 Assessing Training Needs and Performance of Teaching Faculties

In the University system there are three pillars- faculty, infrastructure and curricula, on which education quality assurance is built. The most important of which is the quality of faculty and its continued competence updation. During early phase of agricultural university establishment, recruitment of faculty was largely done on the basis of quality and competence in open selection at national level. However, with passage of time this has given way in many cases to balkanization and parochialism with the result that most universities have extensive inbreeding, which is one of the factors contributing to poor quality education. Additionally it is seen that though universities were established on US Land Grant pattern of integration of teaching, research and extension education, there is still wide spread lack of complete integration. With rapid developments in science and technology especially cutting edge technologies, the technology gap is widening. This has become worse due to lack of recruitment of new faculty largely during last decade or so. The opportunities which were available during 60s and 70s to have training of faculty in best of the universities overseas specially in United States under USAID have almost disappeared and neither the state nor the center has made provision for adequate funds for knowledge updation of faculty in structured manner, so essential for quality assurance in SAUs.

ICAR took bold policy decision in 1997 of making provision for training of each faculty once in five years nationally through increase in number of summer schools, winter schools and training programmes through Center of Advance Studies (CAS) and Terms of Excellence (TOE). TOE and CAS have been instrumental in giving first-rate training in many of the new and emerging areas because ICAR provided enough funds for purchase of state of the art equipments and necessary budget for training. This benefited largely the faculty at Assistant Professor level mainly because of the requirement of two training programmes for assessment and promotion to higher grade. Such a requirement does not exist for higher level of scientists and managers as a result of which the very aim of updation in competence of senior faculty was not achieved.

It is, therefore, in the interest of the organization, for improving quality of education, to have a structured mechanism for career development of faculty through need assessed regular training at different levels so that faculty is not only abreast with current developments, but have adequate knowledge and expertise in cutting edge technologies. Remaining forefront in new and emerging areas is a prerequisite for providing knowledge and expertise to our graduates in real life situations. Therefore at least one mandatory training every five year for every faculty member is recommended.

The Committee also recommends the following:

- **Induction training**: ICAR has been organizing induction training for scientists at initial entry level and all has appreciated this. Similar induction training is recommended built-in in SAU for a period of 3-4 months with a focus on pedagogy, computer literacy, knowledge about national and international agriculture, curriculum development, financial and administrative rules and procedures, etc.

- **Training overseas:** In key emerging areas such as biotechnology, processing and value addition, GIS, remote sensing, IPM, INM, agribusiness management, diagnostics, IPR, speciality foods, packaging, international quality standards, exports, entrepreneurship development, etc. faculty should be trained in best of the institutions globally. It is recommended that as an institutional goal four per cent of the faculty be sent for training overseas every year for a period ranging from three months to one year depending upon the area and the time required for necessary skill acquisition. The training should also be provided to ICAR scientists as well. Since knowledge and qualification of teachers holds the key for quality of education, building and rebuilding of faculty competence assumes importance. The focus needs to be in basic and applied sciences relevant to different branches of agricultural sciences. Building faculty competence will ensure skill and entrepreneurship development among graduates for taking up enterprise and be job providers. ICAR should develop HRD policy to make mandatory training and retraining of the faculty. For this purpose to the extent of Rs.150 crores is recommended. Out of this, Rs. 25 crores be earmarked for providing facilities to the faculty members on return for maximizing the impact and benefit from training overseas.

5.3 Reforms in Governance

- **Statutory powers for regulation and quality assurance of Agricultural education:** With a view to provide common base for establishment and academic governance of the SAUs, ICAR brought out first Model Act in 1966 which was revised in 1984 and again in 1994. The basic premise underlying development of Model Act has been bringing uniformity in the Acts of SAUs and ensuring good governance through established structures for managing and coordinating education, research and extension education. Despite having common Model Act, different states developed Acts for their SAUs at striking variance with the model Act mainly because agricultural education is not on the concurrent list. These deviations primarily relate to the appointment of Vice Chancellors, constitution of Board of Management, Academic Council etc. In fact in some of the states politicians or bureaucrats dominate Board of Management and as a consequence autonomous functioning of SAUs is impinged. Since ICAR does not have statutory authority to regulate agricultural education it does not have much say in enforcing the provision of the Model Act. In addition as a consequence ICAR is not in a position to even enforce norms and standards for quality education and institutions keep on mushrooming both horizontally and vertically.

The Committee therefore recommends that the ICAR be vested with the **Statutory Powers** to regulate agricultural education for quality assurance. Such a step will go a long way in ensuring relevance and quality of education in addition to soundness and vibrancy of the national agricultural education system.

- **Financial Health:** During the early phase of establishment of state agricultural universities funding from state and center was liberal and that helped development of excellent infrastructure in terms of laboratory facilities, equipments, library, research farms and sports facilities. Additionally Central Govt. provided funds for training of the faculty in the best universities overseas. This contributed to the competence of the faculty and resulted in quality assurance. However, with passage of time the number of state agricultural universities has increased whereas the budgetary allocation did not increase proportionately resulting in decline in funding and most universities are now facing acute financial crunch. With the implementation of Fifth Pay Commission recommendations the situation turned from bad to worse in respect of operational support. Today almost in all SAUs about 80-85% of the budget goes towards salary and other establishment costs. The ICAR share also has dwindled and varied from 33% in V Plan to almost 9% in VIII Plan. The situation has improved somewhat in IX and X Plan but is still far from ideal. With the severe resource crunch there is hardly any support available especially from state budget towards contingency and maintenance and what to talk of state of the art facilities. The stark reality is that in all SAUs 25-30% posts are not filled on account of squeeze in budget and this has seriously impacted quality of instruction. The Committee therefore recommends proactive role for ICAR in bringing message home to the states that agricultural universities need to be funded liberally for agricultural development in their state. ICAR on its part should support SAUs liberally for curriculum delivery, updation of faculty competence, library up-gradation, networking, procurement of the state of art equipments in new and emerging areas, infrastructure for student and faculty amenities, faculty exchange and vocational education programmes. With the limited possibility of any increase in the allocation by respective states, development funds under Plan need to be provided for modernization of laboratories, class rooms, library strengthening, access to information, equipments, faculty training and exchange etc.

- **Movement of Faculty:** Despite the efforts made under AHRD project from 1996 to 2000, there has been practically no faculty exchange or movement of faculty across universities. In order to share the experiences and effect improvement it is essential that a system is developed for the exchange of faculty by making Sabbatical leave and Visiting Scientists Schemes more attractive.

- **Linkages**

-ICAR Institutes: In 1997 under the joint meeting of Vice chancellors of SAUs and Directors of ICAR Institutes it was resolved that Scientists of ICAR institutes after due accreditation by the academic bodies of SAUs will be taken on faculty and be eligible for guidance of Ph.D. students as co-Chairman. Facility at ICAR institutes will be open for such students' research. While some SAUs have taken benefit it has not been formalized in most cases. Therefore it should be mandatory for each SAU to have linkages with at least one ICAR Institute for joint research guidance. Similarly it should be made mandatory for each ICAR Institute to have linkage with at least one SAU depending upon commonality of research thrust, geographic location and faculty capability for guidance and facilities for research. For the students who move for joint research to ICAR Institutions additional contingency grant of Rs. 15,000/- per annum per student is recommended.

-Private Institutions, General Universities and IITs: Over the years India has developed sound educational system, which in the last decade or so has shown fatigue and decline largely due to financial constraints, poor governance and lack of partnership and linkages with institutions. Era of individual research has given way to teamwork. Globally institutions are partnering and institutions under NARS are no exception. In order to capitalize on the strength, which exists among private R&D institutions, IITs and general universities, it is necessary to open a dialogue with national institutions and private R&D institutions, which have proven track record. In fact, the quality of our education programmes will improve substantially with such a linkage. The major question is how to operationalise? In this regard AUs must change their policy and aggressively initiate dialogue with institutions, outside NARS which have proven national and international standing. This would be mutually rewarding. For AUs which open such a dialogue and sign MOU for effective quality improvement, a provision of Rs. 10 lakh per university/year is recommended

-Overseas Universities: During the early phase of SAUs establishment there was tie up with Land Grant universities in USA which helped tremendously not only in establishment of integrated education, research and extension education programmes but also in development of skilled faculty which was instrumental in successful implementation of the new initiative. There is a need once again to have such tie ups and linkages for major rejuvenation of our agricultural education taking advantage of Indo-US Knowledge Initiative and National Agricultural Innovation Project. Operationalisaiton of this is most crucial for leap forging. To begin with, the collaboration can be in specialized areas like biotechnology, processing and value addition, water management, integrated natural resource management and development of curriculum and delivery. The collaboration should not only be in respect of joint research work but also exploring the possibility of sandwich post graduate programmes leading to Ph.D degree as also post doctoral research. Cornell University, Michigan State University, University of

California, Davis, Ohio State University, A&M Texas University and California State University could be considered for linkages.

-Line Departments of State Governments: Despite the fact that country has developed excellent national agriculture education research and extension education system, the linkage between NARS and line department is weak and varies from state to state. In order to have the major impact of the initiatives taken under NARS system it is necessary to develop a mechanism of continuous dialogue and synergy among AUs, ICAR institute and line departments of the states. It is true that AUs have been established to develop region specific technologies, yet there are ICAR institutes in almost all disciplines, which have strength for excellence in research and development of technology, which could be boom for different regions. Presently the mechanism of Regional Committee meeting is too institutionalized and there is a gap in communication and adoption of technology. Therefore mechanism need to be developed for regularly holding at least two meetings in a year at state level for bringing together AUs, ICAR institutes and line-departments in the state. In these meetings the representation of ICAR should not only be of the institute level but also from ICAR head quarter. With this there will be synergy and complementation in the efforts of the three major institutions-for agricultural development.

- **Forging/strengthening partnerships and linkages**

Indo US-India Agricultural Knowledge Initiative (AKI) is an emerging example of global partnership. Education Division of ICAR has recently launched AKI in the identified priority areas viz. (i) human resource development and institutional capacity building, (ii) agri-processing and marketing, (iii) emerging technologies such as biotechnology and nano-technology, and (iv) natural resource management and to develop linkages with universities in USA. Sandwich degree programmes, especially in frontier areas, in collaboration with foreign universities and national premier education institutes/AUs may be initiated. Research/training of foreign students in Indian AUs has to be facilitated. Within the country linkages should also include KVKs (district outreach centres). Feedback from farmers, line departments, KVKs and consumer organizations could be very helpful in formulating relevant courses and thesis work programmes.

Linkage is particularly weak for public-private sector hampering commercialization and entrepreneurship development especially in the changing scenario with IPRs, contact farming, etc. Liaisoning/linkages/partnerships/tie-ups are also needed with other AUs, private sector and entrepreneurs for collaborative projects/ventures, piloting, up-scaling and technology incubation for commercialization, industry attachment of students, etc.

Faculty Recruitment

-Entry level: The essential requirement of NET for entry-level post in teaching is again emphasized. In addition Ph.D. be made as essential requirement for recruitment at entry level, except for Veterinary and Technology disciplines, where Master degree holders may be considered eligible till the time Ph.D. degree holders are available in sufficient numbers. For posts funded 100% by ICAR, no permission be required from States for filling and this be made part of MOU.

-Higher level: All management positions should be filled laterally by open competition on tenurial basis initially for 5 years, extendable for another two terms based on transparent assessment of their work performance. To attract outside candidates the parent university should have provision to maintain lien for substantive posts of concerned employees.

For national integration and reducing current extensive inbreeding, recruitment of at least 15% of the posts at entry level on the basis of open national selection from outside the state is recommended. This condition be made mandatory for appointments from 2007 for receiving full development grant. Faculty joining from outside should be given full benefit of transfer of service including post retrial benefits.

- **Honorary, Adjunct & Visiting Professorship:** The faculty competence is the determining factor for quality assurance. With the freeze on faculty recruitment over the years, quality faculty is not available in many institutions. To overcome this, it is essential that at National level the scheme for Honoary, Adjunct & Visiting Professorship be developed and adopted. AUs should identify the outstanding teachers, researchers, and R&D managers with proven track record and invite them to join University as Honorary / Adjunct Professor. The only condition should be to deliver at least 20 lectures per annum for continuance. For initiating this programme annual support of Rs. 10 lakh for meeting TA/DA & honorarium. Such experts could be requested to come twice in a year with local hospitality and office facility to be provided by the University.
- **Information Technology:** India has emerged as world leader in Information Technology. ICAR has also invested considerably under NARP and NATP to develop connectivity. IT can make substantial difference in curriculum delivery and quality of instruction. The entire system could take advantage of pockets of excellence that exist among our Universities. At least 2 Mbp connectivity should be provided to each AU and major institutes of ICAR with separate transponder and dedicated servers for information storage, sharing, retrieval and management. Each AU also should have video conferencing facility with up link to a common control system. It could also be used for effective and quicker communication of technologies to different clientele. Development of content and sharing will help substantially skill up-gradation. IT could lead to improved governance efficiency and make the system more responsive to the needs and aspirations of different stakeholders

- **HRD & HRM:** These are important not only for bringing efficiency in the organization but also for qualitative improvement in education. HRD should consist of training need assessment, developing action plan for training and impact assessment. It is recommended that each faculty member including management position incumbents should undergo compulsory training programme / workshop (Asst. Prof. atleast 21, atleast 10 days, Heads & equivalent atleast 7 atleast 3 and a two day retreat for VC/DU-Directors). Such trainings are considered necessary and should be undergone for the release of annual increment once in five years.

Summary of Recommended Financial XI Plan Support Rs. In Crore

Sr.	Component	Support
1	Civil Works	400.00
2	Curricula Delivery	300.00
3	Equipments for UG and PG/Ph.D. laboratories	450.00
4	Library	382.00
5	Student Counseling and Placement	30.00
6	Instructional farm/Plant animal Clinic etc.	500.00
7	Automation, Communication, IT and e-governance	100.00
8	RAWE, Skill Based and Inplant Trainings including Internship for Veterinary	90.00
9	HRD and HRM including Faculty mobility and Guest Faculty	150.00
10	Examination Reforms	40.00
11	Grant to Education Managers	55.00
12	Experiential Learning	609.00
	• Home Science 50.00	
	• Food Technology 30.00	
	• Dairy Technology 80.00	
	• Agricultural Engineering 69.00	
	• Agriculture 200.00	
	• Fisheries 50.00	
	• Forestry 25.50	
	• Horticulture 29.50	
	• Veterinary Science 75.00	
13	Centre of Advanced Studies Contribution	30.00
14	Best Teacher Award at AU level	10.00
15	Niche Area	300.00
16	Emeritus Scientist	60.00
17	Technology park/corporate house	74.00
18	Performance Linked Support	20.00
19	Vocational Education	300.00
20	Distance Education	250.00
21	Support to Deemed Universities	100.00
22	Support to Central Universities	50.00
23	ICAR Network	100.00
24	Centres of Excellence in AUs in new and emerging areas	500.00
	Total	**4900.00**

Annexure 1

Summary Information on Agricultural Universities

S.No.	State/University	Year of Establishment	Faculty/ Colleges (No.)
	State Agricultural Universities		
	Andhra Pradesh		
1	Acharya N.G. Ranga Agricultural University, Hyderabad	1964	10
2	Sri Venkateswara Veterinary University, Tirupati	2006	3
	Assam		
3	Assam Agricultural University, Jorhat	1969	6
	Bihar		
4	Rajendra Agricultural University, Pusa	1971	6
	Chattisgarh		
5	Indira Gandhi Krishi Viswavidyalaya , Raipur	1987	6
	Gujarat		
6	Anand Agricultural University, Anand	2003	3
7	Junagadh Agricultural University, Junagadh	2003	3
8	Navsari Agricultural University, Navsari	2003	2
9	Sardarkrushinagar-Dantiwada Agricultural Univeristy, Banaskantha	2003	3
	Haryana		
10	Chaudhary Charan Singh Haryana Agricultural University, Hisar	1970	7
	Himachal Pradesh		
11	Chaudhary Sarwan Kumar Krishi Viswavidyalaya, Palampur	1978	4
12	Dr. Yashwant Singh Parmar University of Horticulture & Forestry, Solan	1985	2
	Jammu & Kashmir		
13	Sher-E-Kashmir University of Agricultural Sciences & Technology, Srinagar	1982	3
14	Sher-E-Kashmir University of Agricultural Sciences & Technology, Jammu	1999	1
	Jharkhand		
15	Birsa Agricultural University, Ranchi	1982	4
	Karnataka		
16	University of Agricultural Sciences, Bangalore	1965	3
17	University of Agricultural Sciences, Dharwad	1986	7
18	Karnataka University of Animal and Fisheries Sciences, Bidar	2005	3
	Kerala		
19	Kerala Agricultural University, Thrissur	1972	10

	Madhya Pradesh		
20	Jawaharlal Nehru Krishi Viswavidyalaya, Jabalpur	1964	11
	Maharashtra		
21	Mahatma Phule Krishi Vidyapeeth, Rahuri	1969	5
22	Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola	1969	6
23	Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli	1972	6
24	Marathwada Agricultural University, Parbhani	1972	9
25	Maharashtra Animal Science & Fisheries University, Nagpur	2000	7
	Orissa		
26	Orissa University of Agriculture & Technology, Bhubaneshwar	1962	7
	Punjab		
27	Punjab Agricultural University, Ludhiana	1963	4
28	Guru Angad Dev University of Veterinary and Animal Science, Ludhiana	2006	1
	Rajasthan		
29	Rajasthan Agricultural University, Bikaner	1963	5
30	Maharana Pratap University of Agriculture & Technology, Udaipur	1999	6
	Tamil Nadu		
31	Tamil Nadu Agricultural University, Coimbatore	1971	10
32	Tamil Nadu Veterinary & Animal Science University, Chennai	1989	3
	Uttaranchal		
33	Govind Ballabh Pant University of Agriculture & Technology, Pantnagar	1960	10
	Uttar Pradesh		
34	Chandra Shekhar Azad University of Agriculture & Technology, Kanpur	1975	3
35	Narendra Dev University of Agriculture & Technology, Faizabad	1975	4
36	Sardar Ballabh Bhai Patel University of Agriculture & Technology, Meerut	2000	3
37	UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Viswavidyalaya evam Go Anusandhan Sansthan, Mathura	2001	3
	West Bengal		
38	Bidhan Chandra Krishi Viswavidyalaya, Mohanpur	1974	3
39	West Bengal University of Animal & Fishery	1995	1

	Sciences, Kolkata		
40	Uttar Banga Krishi Viswavidyalaya, Cooch Behar	2001	1
	Central Agricultural University		
1	Central Agricultural University, Imphal	1993	5
	Deemed Universities		
1	Indian Agricultural Research Institute, New Delhi	1958	1
2	Indian Veterinary Research Institute, Izatnagar	1984	1
3	National Dairy Research Institute, Karnal	1989	1
4	Central Institute of Fisheries Education, Mumbai	1989	1
5	Allahabad Agricultural Institute, Allahabad	2000	5

	Central Universities		
1	Vishva-Bharati , Sriniketan	1901	1
2	Banaras Hindu University, Varanasi	1916	1
3	Aligarh Muslin University, Aligarh	1920	1
4	Nagaland University, Medziphema	1994	1

12 AGRICULTURAL IN EXTENSION EDUCATION

SUMMARY

The development of agriculture is mostly dependent on the effectiveness of agricultural extension – methodologies, processes, and location specific operationalisation . Several important concerns were identified for finding appropriate solutions like creation of an enabling environment that will promote research in extension , promotion of participatory research processes , greater research efforts on research approaches in extension education along with a basic and applied research as a base for growth of the discipline, capacity building professionals for increased use of ICT in virtual extension education, development and standardization of methodologies of understanding rural knowledge systems and innovation processes and developing location specific models of technology integration, assessment, refinement and transfer.

The research in extension education remained the weakest link in the growth of the discipline since its inception. Several reasons could be ascribed to this state, the most significant being a lack of focus and poor institutional support. There had been lack of any network research project covering a wider theme in system perspective at several locations for providing necessary backstopping to the technology transfer system for reorientation of the process, mode and methodology.

The recent advances in the field of communication and information technology, behavioral sciences including management have great implications for improving research in extension education as well as development of models of technology generation –assessment and refinement. To meet this end , it is proposed create a **knowledge driven eco-system.** There is an urgent need of establishment of **National Research Centre for Agriculture Knowledge Management (NRCAKM),** an institutional structure for undertaking various research activities with a bearing on process of agriculture knowledge management and extension education programmes, processes and methodologies. It is proposed to have an **All India Coordinated Project in a network mode at six locations representing varied agro-eco systems on "Agriculture Technology Integration and Application".**

The financial requirements are of Rs 200 lakh during the XI plan period, including establishment and infrastructure for the proposed National Research Centre for Agriculture The cost may vary depending upon the approvals **. This is in addition to the ongoing programmes of the Division.**

A few Suggestions concerning teaching and extension education have also been made.

Background

As the process of achieving technological change in agriculture involves three basic steps, each a component of the research , teaching and extension system, responsive extension research, education and technology transfer system is needed to complement each of the system. Extension Education is more than it used to be as its functions and tasks are increasingly assumed by multiple, public and private organizations. A new vision for the discipline therefore, must explore research aspects at various levels like strategic , applied and adaptive research. The development of agriculture is mostly dependent on the effectiveness of agricultural extension – methodologies , processes, and location specific operationalisation .

CONCERNS

Some of the major concerns expressed by the Panel Members which need to be addressed in the XI plan document are:

- Creation of an enabling environment that will promote development of teaching, research and extension in the discipline of extension.
- Promotion of participatory research processes and its integration into the teaching of extension education discipline.
- Reorienting the course curriculum at the UG and PG level in line with the demand from extension professionals.
- Greater research efforts on research approaches in extension education along with a basic and applied research as a base for growth of the discipline.
- Capacity building activities among all actors viz. those engaged in teaching, research and extension education.
- Development and standardization of methodologies of understanding rural knowledge systems and innovation processes and developing location specific models of technology integration, assessment, refinement and transfer.
- Capacity building of the extension education professionals for increased use of ICT in virtual extension education.

In order to propose programmes and activities to meet the above concerns, the members discussed several structural issues which will promote coordination of various groups that contribute to the discipline of extension education, research and knowledge base of extension, how does this base relate to State Extension Programmes , developing new sources of research and knowledge , integration of extension programmes of the ICAR headquarters and ICAR Institutes, SAUs, CAU and Private Sector to achieve synergies, reorienting teaching in extension education to include for information technologies, applied research and emerging technologies, etc.

It is proposed to initiate the following actions for strengthening of research in extension education during XI plan.

The research in agricultural extension in India started in 1960s, required in partial fulfillment of the requirements of Post Graduate Degree. Though at a few locations, independent research programmes on emerging areas were carried out, yet these were largely single researcher, narrow location, narrow coverage and of small sample size. Most of the research therefore, focused on the adoption-diffusion paradigm and information seeking behaviour, having a little relevance to the policy planners and practitioners in extension. Whatever was published in the Journals of Research in extension were student research carried out to fulfill the PG degree requirements. There had been lack of any network research project covering a wider theme in system perspective at several locations for providing necessary backstopping to the technology transfer system for reorientation of the process, mode and methodology. Thus the research in extension education remained the weakest link in the growth of the discipline since its inception. Several reasons could be ascribed to this state, the most significant being a lack of focus and poor institutional support.

The recent advances in the field of communication and information technology, behavioral sciences including management have great implications for improving research in extension education as well as development of models of technology generation –assessment and refinement. Presently, the demand on extension professionals is to implement transfer of technology models with greater emphasis on demand driven extension and greater use of ICT for making available reliable and relevant information for appropriate decision support so as to ensure sustainability and enhanced income of the farming community with due concern for environmental issues and saving the natural resources from degradation. To meet this end , it is proposed create a **knowledge driven eco-system.**

There is an urgent need of establishment of **National Research Centre for Agriculture Knowledge Management (NRCAKM),** an institutional structure for undertaking various research activities with a bearing on process of agriculture knowledge management and extension education programmes, processes and methodologies. Some of the outputs of the proposed centre are likely to be:

1. Policy briefs/policy papers on selected themes such as Agriculture knowledge architecture, Development and implementation of Agriculture knowledge portal, Participatory approaches for technology assessment, HRD for extension professionals , Public –Private-Corporate partnership, Converting information to knowledge for decision support ,etc.
2. Methodology of research for preparation of resource materials like guidelines, manuals, handbooks, etc.
3. Methodology of research for development of case studies, technology directories, prototypes, etc.
4. Process monitoring tools for various extension interventions.
5. Participatory Resource Management - processes and toolkits for various planned interventions.
6. Procedures for technology assessment, refinement and scaling up of farm technology.
7. Procedures for collection, documentation, validation and integration of

indigenous farm technologies.

8. ICT based Expert system's manuals covering techno ware, human ware, info ware and or aware for farmer-friendly use.

As the proposed NRC is expected to contribute significantly to meet the emerging challenges as described earlier, the panel proposes that this NRC be set up on priority and an ADG in the Division of Agricultural Extension be designated as OSD to plan for its establishment. The proposed NRC may initially have four sections namely:

- Knowledge Structure and Mapping
- Virtual Extension
- Organizational and Data base Management
- Technology Evaluation and Assessment Info ware

Already there is a National Institute of Agriculture Extension Management (MANAGE) set up in 1987 as an autonomous society under the Ministry of Agriculture. The mandate of the MANAGE is to assist the State Government, the Government of India and other Public Sector organizations in effective management of agricultural extension and other agricultural management system. The overall mission of MANAGE is "facilitating the acquisition of managerial and technical skills by extension officers, managers, scientists and administrators and all sectors of agriculture economy to enable them to provide most effective support and services to farmers and fisherman for practicing sustainable agriculture. **Thus, there is no overlapping in the functioning of the proposed new institution which this group is suggesting during the XI Plan under the Indian Council of Agricultural Research.**

For the last three decades, the practices of extension have been guided by all pervasive, "Diffusion of innovations" tradition. This model was evolved in a particular institutional context, simplified a complex process into a step-wise linear sequence of activities, that was described without reference to the way, agenda of different stakeholders were addressed. Even today, the myth of the smooth progression of research to adoption and diffusion among farmers continues to influence the theory of practices of extension. At present, in the India scenario, a task of technology development and technology transfer to farmers have been performed by two completely separate organizations with tightly defined and mutually exclusive roles.

During the last decade or so, the literature in extension research has included holistic ideas such as agricultural knowledge and information system which recognizes the value of creating system that assist in the generation and dissemination of knowledge. Recently, several other models have emerged like interdependence model and the innovation system framework which include not only research and extension, but also technology users, private companies and NGOs and supportive structure such as markets and credits. This will call for a system perspective as a way of rethinking on a broader canvas.

Probably the extension research has not come to the expectations. A number of questions need to be answered, for which in the absence of any network project with long term time series data, no solutions are available. Some such questions are:

- Is there enough research information in extension education as regards different extension systems that operate in the rain fed farming areas in comparison to introducing the high yielding varieties in the irrigated areas and similar other eco-systems and resources?

- What kind of efficient marketing systems are required?
- How the farmers can be organized for entrepreneurship and better bargaining power?
- How from one to one extension system a multiplicity of one to many could be created?
- What are the implications of differences in expectations and the approaches in terms of farm sizes, management levels, entrepreneurial-ship capacities, designing of information for various categories of users in terms of dynamic and static content, flow of information and the enabling processes?

It is proposed to have an **All India Coordinated Project in a network mode at six locations representing varied agro-eco systems on "Agriculture Technology Integration and Application".**

Some of the research studies which could be initially taken up are:

1. Developing and standardizing methodologies for technology integration, evaluation and prioritization.
2. Methodology and impact studies on planned interventions
3. Developing and testing adaptive ISO specified institutional mechanism for grouping commodity, enterprises and product specific.
4. Product mix for institutional linkage and factor productivity over a period of time.
5. Social Capital Indices development needs under different farming systems
6. National repository of data on planned interventions and output and outcome in terms of time and space.

Required Scientific Staff: The following posts are proposed:

S.No.	Category	Nature of Post	Number
1	RMP	Director	1
2	Scientific	Head, Div. of Knowledge Structure and Mapping	1
3	Scientific	Head, Div. of Virtual Extension	1
4	Scientific	Head, Div. of Organizational and Data base Management	1
5	Scientific	Head, Div. of Technology Evaluation and Assessment Info ware	1
6	Scientific	Principal Scientist , 2 for each Division	8
7	Scientific	Senior Scientist, 3 for each Division	12
8	Scientific	Scientist, 4 for each Division	16
9	Administrative	AAO	1

10	Administrative	AF&AO	1
11	Administrative	Appropriate category of Senior PA, PA, Assistant, Clerk, and supporting staff	15

Financial Requirements: Rs 200 lakh during the XI plan period, including establishment and infrastructure for the proposed National Research Centre for Agriculture Knowledge Management (NRCAKM) , and the All India Coordinated Project in a network mode at six locations representing varied agro-eco systems on "Agriculture Technology Integration and Application". The cost may vary depending upon the approvals**. This is in addition to the ongoing programmes of the Division.**

CONTINUATION OF ADHOC PROJECTS

The penal members were of the view that the earlier provision of sanction of adhoc projects by the Subject Matter Division to encourage research in identified thrust areas of National significance should be continued. The Division of Agricultural Extension may redraw its list of thematic areas and widely circulate it.

The members of the panel also discussed some issues related to teaching and extension education which have a bearing on research agenda.

TEACHING

As the teaching forms the foundation of research in a discipline and vice-versa, course curriculum at the Under-Graduate and Post-Graduate level need to be integrated with a focus on the present day demands. The report of the 4th Dean's Committee constituted by the ICAR has very appropriately suggested greater integration of teaching research and extension education and augmentation of the Rural Agricultural Work Experience (RAWE). The course content in the discipline of extension education therefore, may specifically be updated with more emphasis on experiential learning. The Council may also frame minimum infrastructure and human resource requirements in the Departments and Colleges offering Under-Graduate and Post-Graduate programmes in the discipline..

There is further need for human resource development through capacity building and skill upgradation , specifically in cyber extension , on line management, monitoring and data base designing and management, of the personnel engaged in teaching of extension education, research in extension education and frontline implementation of extension education programmes. The discipline of extension education should therefore in its teaching programme built the competence of the students in :

a) Obtaining and evaluating data and information on technologies, markets, infrastructure and policies and its conversion to knowledge for optimum resource allocation decision support.
b) Methods and processes of communication with due concern to credibility, fidelity, capacity and distortions with different types, levels of stakeholders.

c) Processes and methods of organizing farmers for collective decision making and entrepreneurial ship development.

d) Methods of analysing threats and opportunities in a participatory mode with the stakeholders using information technology and proper integration of data to information to knowledge for decision support.

EXTENSION EDUCATION

A very high priority need to be accorded to evolve location specific and economically viable extension education approaches for transfer of technology. The approaches need to be tested and their efficacies demonstrated to the State Extension services for large scale adoption. It is envisaged to have well organized , efficient and result oriented agricultural extension research , education and extension system by bringing upgradation of agricultural extension education and further strengthening research –education –extension linkages to improve quality and effectiveness of the extension professionals and extension practitioners. There will be necessity of further strengthening cyber extension so as to create a pool of professionals in the discipline of extension education.

The proposed suggestions for teaching and Extension Education may be passed on to the concerned panels for necessary consideration.

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13. AGRICULTURAL ECONOMICS, MARKETING AND AGRIBUSINESS

RECOMMENDATIONS FOR THE XI FIVE YEAR PLAN AND THEIR FINANCIAL IMPLICATIONS

A. STRENGTHENING AEMA EDUCATION AND RESEARCH

(1) Changing socio economic, technological and physical scenario has created new challenges and increased the role of agricultural economists and agribusiness experts in government, private and other institutions concerned with agricultural and rural development. It is expected that the demand for agricultural economists and agribusiness experts well surpass the supply. The current output may be approximately one-fourth of the expected demand. Considering the supply demand gap, there is an urgent need to increase the output of trained manpower in agricultural economics and agribusiness to meet the new challenges. However, the available infrastructural facilities, limited teaching faculty and very low budget in SAUs are the major constraints in admitting adequate number of students to the disciplines of agricultural economics and agribusiness to enhance the output of trained manpower to meet the future demand. Hence, the Sub Group recommends that appropriate strengthening of departments of AEMA in SAUs and ICAR institutes should be done to improve the education and research in agricultural economics and agribusiness to enhance the output of well trained manpower to suit future needs.

Financial Implications: Rs. 8160 Lakh

(2) There has been a dilution in the quality of agricultural economics education during the last two decades. The main reason has been an imbalance in the academic staff structure of the SAUs. Several posts of faculty are lying vacant. There is a need to strengthen agricultural economics departments of SAUs. There is need to recruit young and dynamic staff which can contribute to the emerging needs of AEMA. There is also a need to start courses in agribusiness in all SAUs. The Sub Group recommends that agribusiness courses should be introduced in all SAUs and additional young and dynamic faculty should be provided to make the programme relevant.

Financial Implications: Rs. 50 Lakh (partly included in 1)

(3) AEMA is such a discipline, where everybody (particularly teachers) need continuous updation of knowledge in the changing economic and business environment. The periodic capacity building of teachers of

AEMA should be made mandatory. Centres of Excellence should be identified and the responsibility of revamping AEMA education programmes should be given to these institutions. The Sub Group recommends that a regular orientation programme for faculty of agricultural economists should be started and these should be carried out by identified Centres of Excellence.

Financial Implications: Rs. 100 Lakh

(4) Entrepreneurship development and self-employment oriented courses should receive high priority in the education of AEMA. Government has already introduced policies and schemes for developing Agripreneurship. There is need to effectively promote and implement such schemes. SAUs departments of AEMA should be actively involved in these programmes. The Sub Group recommends that SAUs should offer employment oriented agribusiness and entrepreneurship programmes.

Financial Implications: Included in 1 to 4.

(5) Emphasis should also be given on Distance Education in AEMA with extensive use of innovations in IT. There is need to orient the agricultural economics and marketing disciplines in SAUs aimed at meeting the needs of the stakeholders, private sector and NGOs. The Sub Group recommends that agricultural economics and marketing disciplines in SAUs should be transformed to meet emerging manpower needs in these areas.

Financial Implications: Included in 1 to 4.

(6) There is need to develop well trained human resources for undertaking continuous research studies in advanced areas of AEMA, which can make Indian agriculture globally competitive. Further, there is need to have a paradigm shift in such studies from single discipline orientation to multi-disciplinary approach. There is a need to adopt PPP model in research also and institutionalize the planning, monitoring, evaluation and assessment as core component of research management process. The Sub Group recommends that the disciplines of AEMA should be strengthened in SAUs and ICAR institutes by creating positions of research faculty.

Financial Implications: Included in 1 to 4.

(7) There is need to have total quality management in AEMA education. For that, there is need to focus on improving quality of courses, instructional processes, human centered development, students support services, building strong work culture and electronic communication system.

Ultimately, the quality and skills being imparted must inculcate expectations of different stakeholders. Infrastructure for this purpose must be provided in SAUs. The Sub Group recommends that a comprehensive programme of improving the quality of education in AEMA in SAUs should be launched.

Financial Implications: Rs. 680 Lakh

(8) There is a need for network projects like All India Coordinated Research Project (AICRP) in the area of agricultural economics. Similarly, the effort to network agribusiness management education and research to provide academic platform and connectivity for this emerging discipline is important and has to be pursued. This would require a strong subject matter division for the areas of AEMA at the ICAR Headquarters. The Sub Group recommends that a new division at ICAR headquarter for AEMA research and education should be created to plan and implement AICRPs in AEMA related fields.

Financial Implications: Rs. 1500 Lakh

(9) The Eleventh Five Year Plan should consider setting up Indian Institutes for Agri Business Management one in each region (north, south, east, west and north east). In such Institutes, agribusiness management teaching should obviously centre around agricultural technologies in various sub sectors of agribusiness sector like input supply, horticulture, food processing, high tech agriculture (floriculture, Bio tech, etc.), farm engineering, veterinary pharmaceuticals, live stock, etc. which are under commercial application. It should be operated as a multi and interdisciplinary subject in NARS with the active involvement of basic sciences, humanities, mathematics, statistics, agricultural engineering and the technology related disciplines. Well trained faculty to teach courses in about one-third of courses in core management areas is a pre requisite. The Sub Group recommends that four Indian Institutes of Agribusiness Management should be established, one in each region, by the ICAR.

Financial Implications: Rs. 21000 Lakh

(10) ICAR should increase financial support for scientific societies like Indian Society of Agricultural Economics (ISAE) and Agricultural Economics Research Association of India (AERA) and also provide liberal support to hold special seminars, workshops, symposia on important themes related to AEMA. The Sub Group recommends that the support of ICAR to professional societies related to AEMA should be sufficiently enhanced.

Financial Implications: Rs. 25 Lakh

(11) The group felt the scheme of National Professor in ICAR is very noble and would promote excellence in science. It is recommended that National Professor should be mandated and supported to deliver lectures on topical, methodological, and policy issues for competence building and mainstreaming NARS faculty to the national and global thinking. The Sub Group recommends that the scheme of National Professor in ICAR should be expanded and National Professor's mandate should be widened.

Financial Implications: Rs. 500 Lakh

(12) A suitable new course in agribusiness management needs to be introduced in SAUs UG programme. There is a need for inclusion of optional courses, such as retail marketing, project management, marketing and financial management, commodity and capital market in the curriculum of the final year undergraduate students of SAUs. Offering a few optional courses in agribusiness to the postgraduate students of agricultural economics and other disciplines of agriculture and allied faculties within SAUs is also necessary. The Sub Group recommends that more courses in agribusiness should be formulated and offered in SAUs.

Financial Implications: Included in above recommendations

(13) For achieving these objectives, the budget allocation by ICAR to agricultural economics, agribusiness and statistics, which is quite small i.e. less than one percent of the total allotment to education and research, may be increased to 5 per cent to improve the infrastructural facilities of those departments in SAUs. The number of ICAR junior fellowship and senior fellowship to the students of agricultural economics and agribusiness may also be increased significantly to encourage the students to opt for these subjects at the all India level. Further, with closing of AP Cess Fund, funding for project based research for individual/team of researchers in the field of AEMA has ceased to exist. ICAR must make provision for Rs. 50 crore per annum for project based funding for individual/group of researchers during XI Five Year Plan in place of AP Cess Fund. The Sub Group recommends that the allocation of funds for AEMA component in ICAR should be increased to 5 percent for improving infrastructure and increasing the number of fellowships. Further, a sum of Rs 50 Crores should be provided for research projects.

Financial Implications: Rs. 500,00 lakh

(14) KVKs are key institutions now for agricultural transformation. Each KVK should be provided with at least one position specifically for

professionals trained in AEMA. The Sub Group recommends that a post of scientist in the field of AEMA should be positioned in at least one KVK in four districts of the country.

Financial Implications: Rs. 3750 Lakh (For only 150 KVKs).

B LEADERSHIP ROLE OF NCAP

The group discussed at length the role of NCAP in strengthening and providing leadership role to AEMA. The group felt that the establishment of National Centre for Agricultural Economics and Policy Research (NCAP) by ICAR was a significant milestone for giving impetus to growth of agricultural economics and policy research in Indian agriculture. It is envisioned that this Centre will eventually become a think-tank, like International Food Policy Research Institute (IFPRI) for world agriculture, for not only providing policy advice to the ICAR on agricultural research prioritization, education and matters related to technology but also provide leadership for a resurgent and reoriented agricultural economics research and education in the country. The Centre as a model has demonstrated the worth and utility of Agricultural Economics to NARS and the Country. It has sensitized NARS about imparting economics input in technologies and impressed other government organizations and departments about importance and relevance of combining scientific knowledge of agriculture and economics in policy planning.

Given its small faculty, NCAP has demonstrated its strength in both research and policy advice in selected areas like technology policy, impact assessment, trade and food policy, public investments, livestock economics, research prioritization. The Centre also enjoys some advantages in terms of location, infrastructure and strong financial and other support from the Council which it richly deserves. However, Indian agriculture is very vast and complex, with tremendous regional diversity. NCAP as such is not in a position to address all the challenges at national and regional level. Therefore it is suggested to further strengthen NCAP and forge linkages with NARS institutions and other departments for providing policy responses and strengthening policy research in NARS. The idea of networking and having Memorandum of Understanding (MOUs) with SAUs having strong foundation in micro and macro economic issues was highly appreciated. But collaboration with Non-National Agricultural Research System institutions and general universities also needs emphasis. However, at present, potential of NCAP is restricted by a very small size of faculty and highly inadequate administrative and technical manpower. NCAP should focus on training of agricultural economists in NARS and improving the quality of post-graduate education in SAUs. To achieve above mentioned goals, the Sub Group recommends that:

(15) The status of NCAP should be elevated to national Institute level within ICAR with faculty strength around 35 drawn from various fields related to AEMA. This Institute should have 5 divisions catering to frontier research and capacity building in NARS. This proposed institute can be named as National Institute of Agricultural Economics, Agribusiness and Policy Research (NIAAP).

Financial Implications: Rs. 6500 Lakh for all components of NCAP.

(16) NCAP should have a strong programme of faculty exchange with foreign institutions and effective programme of Visiting Scientists and Post Docs. At present there are hardly any beneficiaries of existing Visiting Scientist programme of ICAR in AEMA. This needs to be appropriately redesigned to make the scheme attractive.

(17) After NCAP/NIAAP attains sufficient faculty strength, each NCAP faculty member should develop and lead a network programme with NARS faculty. NCAP/NIAAP should be mandated to regularly organize capacity building programmes for NARS faculty and take lead in curriculum development and all other matters concerning AEMA.

(18) NCAP/NIAAP should also establish an agro economic forecast unit for providing regular and timely projections and forecast of emerging agro economic scenario in the country to facilitate timely policy decisions impacting welfare of farmers and consumers.

<u>Total Financial Implications for XIth Plan: Rs. 922 Crores</u>

14. ORGANIZATION, FINANCE AND MANAGEMENT

Preamble

The sub-group on "Organization, Finance and Management" deliberated under the chairmanship of Professor Pritam Singh, Director, Management Development Institute (Gurgaon). The discussions were primarily guided by the Government's thrust on enhancing accountability and outcome of the public institutions involved in achieving inclusive agricultural growth. The group followed an interactive approach to arrive at the recommendations. Several interaction meetings were organized to invite suggestions from research managers, scientists and administration and finance staff. Details of these meetings and participants are given in the annexure. The group also revisited other reports on this topic and contemporary developments in agricultural research and development (R&D). The group was conscious of the fact that there should not be any overlapping of the issues discussed in this sub-group with other sub-groups. However, there are some issues relating to extension and education management which might have been discussed in other sub-groups constituted for these subjects. Nevertheless, recommendations made here will be useful for effective implementation of the recommendations of other sub-groups. The group is grateful to all the special invitees, especially Dr Mangala Rai, Secretary, DARE and DG, ICAR, for sharing his invaluable thoughts.

Introduction

Vision. Organization and management (O&M) reforms are useful tools to improve efficiency and effectiveness of an organization. Institutionalization of these tools in an R&D organization is however a challenging task. The choice of reforms and their institutionalization is mainly guided by their likely contribution to realization of the organizational vision and goal and their consistency and alignment with contemporary developments in science. In the context of the Indian Council of Agricultural Research (ICAR), the choice of reforms should be guided by the vision of

strengthening its competence and capacity to play a global leadership role in cutting-edge agricultural science and to promote knowledge-intensive, sustainable agriculture.

The immediate objective could be to meet the challenges arising from international agreements like those under the World Trade Organization, link research programs with the national priorities, and blend cutting-edge science with indigenous knowledge to accelerate agricultural growth. The strategy and measures suggested in this report will contribute to preparedness of ICAR in realizing this vision and meeting immediate goals and objectives.

Interactive approach. Realization of the vision requires its translation into an operational **strategy**, which often entails fine tuning or change of current strategy. For successful implementation of the strategy, following conditions must be satisfied:

- appropriate institutional **structure** should be in place,
- **processes and systems** consistent with the strategy and structure should be strengthened,
- **capacity and skills** of the personnel should be developed, and
- **management style** should be changed accordingly.

How a perfect harmony among these management components could be achieved and what are their implications for organizational innovations and efficient uses of resources? This report is developed around these issues.

While making the recommendations it is considered that how these will contribute to three essential components of organizational efficiency, viz. **responsiveness, speed of response and openness or transparency**. Importance and urgency of the changes were also considered and only those changes were recommended which could be achieved during XI Plan. The notable areas suggested for changes or reforms are management of intellectual property, research partnerships and networking, holistic monitoring and evaluation (M&E), and mainstreaming gender in agricultural R&D.

Strategy

Decentralization, participation of stakeholders and evolving suitable incentives for R&D professionals are key and vital elements of the strategy for achieving excellence and increasing efficiency and effectiveness of agricultural R&D. This strategy should be reinforced and realigned with institutional, economic and technological developments taking place in the recent past. In particular, emergence of private R&D for agriculture, strengthening of intellectual property rights (IPRs) regime, participation of stakeholders and low intensity of research funding deserve special considerations.

Integration of research, frontline extension and education is essential for creation, dissemination and application of new knowledge—the main source of agricultural growth in future. Present structure of science and technology institutions is tuned to convert new knowledge into a usable technology and then transfer it to the clients. Recent advancements in science and incentive structure facilitate generation and flow of knowledge in several forms, namely technology, intermediate products, or information. This provides an opportunity for various kinds of interactions and integration of research-extension and education activities.

Management of intellectual property. The strategy of commercialization and transfer of technology would witness a major shift in the era of IPRs. ICAR should now manage its intellectual property for creation of wealth through commercialization of technologies and providing incentives for innovativeness. *IPRs regime will thus facilitate* *rapid transfer of technologies, develop linkages with industry and generate resources in this process.* This is a major shift from the present policy of 'open access' to all intellectual properties generated by ICAR institutes. In order to align IPR policy with the development objective and its effective implementation, ICAR should take a leadership role in the following:

a) ICAR should align its IPR policy with the objective of sustainable agriculture development and develop the guidelines to implement the policy. The key elements of the IPR policy should be *use of IPRs for transfer of technology, sharing benefits with scientist innovators, fostering partnership with private sector and establishing an institutional mechanism in the Council* to facilitate IP management and commercialization of technologies.
b) An immediate follow-up action of these guidelines could be increasing IPR literacy and skills among research managers, scientist and entrepreneurs.
c) Substantial investment will be required to build the capacity to seek, maintain and assert rights of IPs generated by the system and their commercialization.
d) The options of in-licensing of IPs to reduce cost and IPR-associated risks and pooling of public IP resources should be explored to increase efficiency of research.

Partnership and networking in R&D, especially with the private sector, will be another important aspect of shift in the strategy. The new strategy should entail development of research consortia around value chain, sharing of resources for cost reduction, facilitate exchange of knowledge and experience, technology up-scaling and commercialization etc. ICAR could use these institutional arrangements for resource generation and integration of research efforts in the NARS.

The strategy to reduce costs and increase efficiency may also involve change in organization of various operations. The institutions may find it more economical to *shift to outsourcing of non-core operations from insourcing, and to virtual integration from vertical integration*.

Strengthening capacity in cutting-edge science is essential to play a global leadership role. This will require clear identification of priority areas and institutions for development as global centres of excellence. These centres should have strong linkages with applied research and educational programs. The Council should assume leadership in developing such capacity in partnership with other public research systems.

Decentralization for developing leadership. Decentralization and devolution of administrative and financial powers are essential in developing research leadership at the institute level and increasing research efficiency. The shading away routine work of the directors and other senior research managers will help them concentrate on substantial management issues and policy matters. Therefore, the process of decentralization should be seen as a strategy to strengthen the system and empowerment of scientists.

Resource mobilization. ICAR being a public research organization should not over emphasize resource generation. Nevertheless, it should not miss an opportunity to mobilize resources through commercialization of technology when it does not compromise with its broader social objective. ICAR institutions should be more innovative in mobilizing resources, availing matching grant and using resources thus generated. The option of raising fee in deemed universities should also be explored.

Enhancing research outcome. In order to enhance research outcome, planning should be output and outcome-centric rather than input-focused. The initiative of outcome budget by ICAR is a welcome shift in this direction. This concept should trickle down to project level in the institutes. Further steps required to enhance research outcomes are:

a) *Dissemination of knowledge and technology to non-traditional clients* like small and medium entrepreneurs (SMEs) and corporate sector, besides farmers, should also be given due attention. Capacity building for developing linkages with these non-traditional clients for commercialization of technology is quite critical for ICAR.
b) Farm women form a large part of end-users or clients of agricultural research and extension services. There is increasing "feminization of agriculture" in some parts of the country because of migration of male labor. Also, some sectors of agriculture like livestock are largely managed by women. Therefore, R&D system should cater to technological needs of these farm women.
c) Leading institutions and deemed universities for agricultural research and education in the country should provide innovative models for developing partnerships with the industry and farming community.

Mainstreaming gender issues. Agricultural research is a powerful tool to reduce rural poverty and malnutrition, especially for vulnerable and disadvantageous sections of the society. There is evidence that women and children have directly benefited from adoption of modern technology. However, there are sporadic attempts to mainstream gender issues in agricultural research. This requires *incorporating gender concerns in research planning, gender related courses, development of facilities for women and gender representation in research personnel and decision making*. Specific measures to achieve this could be:

a) One way to balance gender in different stages of R&D continuum is to increase number of girl students in different educational programs. The schemes to encourage women participation like girls hostel by ICAR should be allocated more resources. There could be incentives/fellowships in those disciplines which are of direct relevance to gender-related issues. *Establishment of new facilities should be on the principle of "Ardhanareshwara" – equal opportunities and facilities for girls and boys*.

b) There is a need for expanding scope of home science education in view of its increasing importance. This discipline should attract boys by changing the nomenclature of the discipline, course curriculum etc.

Institutional structure

Alignment of institutional structure is extremely important to actionalize new strategy initiative. An appropriate structure helps in accelerating the speed of response to new emerging challenging. The structural change may be with respect to organizational setup, structure of management functions and their inter-relationships, information system, organization of activities and financial responsibilities.

Coordinated research system and networking are powerful institutional mechanism to integrate research in the system. It is quite likely that there could be trends to exercise individual or institutional ownership over resources (e.g. germplasm) and outputs (e.g. inbred lines) in the era of IPRs regime. Such restricted flow of resources and products reduces the productivity of public research system. Therefore, there is an urgent need to sustain coordinated and theme-based multidisciplinary research and research – education linkages in the system. Collaboration and 'co-ownership' of resources and intellectual property may be order of the day for achieving better utilization of resources.

Decentralization and accountability. Decentralization and devolution of administrative and financial functions should also be accompanied by delegation of activities, which is more important for increasing efficiency of an organization. In fact, *delegation of activities should be the basis for delegation of financial powers*. An institutional structure thus organized would ensure accountability in terms of performance with respect to the assigned activities. It is also important that those structures and nodes which are not adding any value in decision making but slow the process should be reexamined and eliminated.

Institutional autonomy. Institutional autonomy is often considered in terms of the degree of freedom an institution enjoys in the area of its operation domain without interference of parent organization. Although this *external autonomy* is important, one should not loose the sight of *internal autonomy* which is equally important for institutional efficiency. ICAR institutes have considerable degree of autonomy in terms of planning of research, extension and education activities, and prioritization of their activities based on the plan allocations agreed by the Planning Commission and ICAR. This autonomy should be fully exploited for increasing relevance of research programs and speeding response to new emerging challenges like those arising from international agreements. Similar culture should be evolved for internal autonomy empowering R&D professionals to pursue their professional activities.

Management information system (MIS). Development of decision-support system facilitates informed decision making and for this MIS is an integral part. This accelerates the speed of response to strategic matters. MIS for agricultural R&D usually consists of on-line database of

- research resources (financial and manpower),
- research programs and projects, and
- technologies developed and commercialized.

This database should be supplemented with an information system of recent developments in the areas like world markets, patents and protected plant varieties, technological alliances etc which directly impact research. Developments in information communication technology have created tremendous opportunities for online data management system and exchange of information. Necessary infrastructure to avail these opportunities is in place which now should more productively be used for day-to-day management functions. E-connectivity of all ICAR institutes and SAUs for teleconference etc. should now be fully functional and reliable.

Partnerships and linkages

A number of public and private (for-profit and non-profit) organizations are active R&D. All these organizations have their own strengths and weaknesses. Co-partnerships among these organizations based-on the principle of comparative advantage in the area of mutual interest will

- generate synergies and reduce research cost,
- avoid duplication of research efforts, and
- accelerate the rate of flow of technologies to farmers.

Such partnerships could even be effective at the level of funding and donor agencies. For example, several national funding agencies and government departments support programs in ICAR institutes and State Agricultural Universities (SAU). In order to make these programs more effective and build "critical scientific mass" in frontier areas like biotechnology, some sort of technical collaboration, coordination or co-partnership would be useful, especially for the assessment of research priorities and human resource development (HRD) needs.

ICAR-industry partnership. With increasing participation of private sector in agricultural development in general and R&D in particular, linkages of ICAR with private sector would prove to be vital in rapid transfer of technology to farmers and also in generating resources. The IPRs regime is an opportunity to

- institutionalize and strengthen ICAR's initiatives like preparing a catalogue of technologies available for commercialization,
- initiate regular dialogue and consultation with private sector, and
- develop public-private partnerships for externally-funded programs and their system-wide up-scaling.

Industry federations like CII, FICCI and ASSOCHAM could prove to be helpful in fostering the partnerships. Learning from the experiences of academic institutions like leading management institutes and institutes of technology who are having co-partnership with the industry, could be helpful.

International linkages are useful to get a tab on international trends in agricultural research and align the national programs to increase technology spill-ins/overs. It is high time that the Government should participate in international research matters of strategic importance. This participation should be on the basis of equal partnership like proposed under the Indo-US Knowledge Initiative to strengthen collaboration between the agricultural universities in India and the US. The model of collaboration in this initiative changed to partnership from donor mode seen during the 1960s when SAUs were established.

Global leadership. ICAR should envision and plan a much greater role for itself in international agricultural research. For this, following steps are required.

- ICAR should enhance its influence in the matters relating to CGIAR system.
- There should be a clear strategy to increase ICAR's presence in Asia and Africa as a technology provider and research partner. Offering fellowships to students coming from these regions and placement of agriculture councilors in embassies could be some measures to achieve this objective.
- There should be an institutional mechanism for interaction with global leaders of science. This is already happening with the CGIAR leaders, but needs for establishing linkages with developed NARS.

Management Systems and Processes

Transparency and efficiency. Management systems and processes are main determinants of organizational efficiency and performance. Current management practices underscore organizational dynamism and health for improved performance and competitiveness. The focus is on *evolving "co-partnership or collective" management system through decentralization, and ensuring transparency in decision-making process.* The decentralization process should be followed by an examination of how the delegated responsibilities and functions are used at different levels in the system and also how the relations and interactions among different nodal positions are changing. This will enable identification and addressing of the weaknesses or constraints in achieving harmony among different decision making functions.

Envisioning. Articulation and sharing of a vision and translating this vision into goals and programs (i.e. envisioning) are extremely useful in maintaining relevance and dominance of an organization. Planning process must align research programs with perspective plan and vision of the institute. These links should be explicit and all projects should fit into broader research programs contributing to realization of the goal and vision. This is a difficult task in view of long planning horizon of R&D, but the institutional commitment can overcome this problem.

Harmony of management functions. Research, administrative and finance staff involved in planning and management should be seen as co-partners in the decision-making process, so that they own the responsibility of implementation of the decisions taken. In order to achieve this "ownership" in decision making, greater interactions among the groups and individuals are required. A perfect harmony among the management systems and functions will also help identification of the areas for speeding up the decisions like those done for the recruitment, foreign deputation and release and settlement of advances. For example, director of an ICAR institute can approve foreign deputation for already approved collaborative programs.

Monitoring and evaluation

M&E establishes effective relationship between resources and actions and ensures that actions are initiated in the framework of plan process. Lessons learned during M&E process guide mid-course corrections and feed into planning process. *An effective M&E system should be simple, transparent and decentralized.* It should use an objective set of criteria which could be different for research, education and extension, as these require different sets of skill and responsibilities. Also, the criteria should focus on key processes, outputs and outcomes, and the combined score should reflect entire contributions made. However, the criteria may differ from one level to another level, viz. scientist, project, program, institute etc. Ranking of institutions based on their performance should be initiated along with current practice of evaluation. Such a strategy would generate healthy competition among the institutes.

Autonomy and decentralization must be accompanied by accountability of actions and resources used. There are institutional mechanisms like Staff Research Council, Research Advisory Committee, Quinquennial Review, etc. to monitor and evaluate the performance. Experience however indicates that these are of routine nature and have not adequately improved the performance. Therefore, these must be revived and made effective. To do this,

a) All the institutes should be subject to *external evaluation which should be "holistic," involving finance and management experts*, besides scientists to evaluate technical programs.

b) There should be a balance between internal and external evaluation. The external evaluation like the quinquennial review should be more objective and clearly spell out the strengths and weaknesses of the institute. It should also indicate that how the institute stands in comparison to other institutes within and outside the country.
c) *M&E mechanism is to improve research performance and not to control scientific creativity*. Also, the mechanism should have direct linkage with funding and incentive for better performance.

Coordination of research evaluation. ICAR institutes are evaluated for several responsibilities and activities. There is a need for integration of outcome of these activities across the institutes, so that enriched information is made available to the government and other stakeholders. This will also enable ICAR to objectively assess its contributions to the national development objectives and also learn lessons to improve effectiveness of the system.

Financial management

Adequacy of resources, balancing of cost factors (salary, capital, operational) and allocation across institutes and programs are integral parts of financial management. Striking an effective balance in these aspects is rather difficult for a large system like ICAR. However, accelerated efforts to monitor the expenses would help achieve a desired ratio of 60:40 between salary and operational expenses towards which ICAR aims to move. Similarly, a formal research prioritization exercise will rationalize resource allocation among (a) types of research (basic and strategic, applied, and adaptive), (b) extension and (c) education. A correction in this regards has already been made to strengthen basic and strategic research by establishing the special fund, the issue of capacity building by allocating more resources to (HRD) should also be addressed on similar lines.

ICAR grants to SAUs. Increasing dependence of SAUs on ICAR for funds shows deterioration of their financial condition and weakening commitment of state governments to agricultural research and education. This problem is particularly acute in the eastern states. At the same time, ICAR should not be averse to support SAUs, but it should be strategic in nature. Faculty development, grant for coordinated programs and strategic partnerships, capacity development for frontier research areas etc. are potential support areas where ICAR should focus on. Block grant for development however should be linked with performance and the accreditation process.

Institute funds. Budgeting and resource allocation at the institute level should be a more rigorous exercise. Any deviation in the budget to the tune of 20% from that approved in EFC should be automatically allowed without concurrence of finance. Any request beyond this limit should be done by revision of EFC which should be permitted under exceptional circumstances.

Budget allocations across the divisions and projects within an institute should not be based on past trends. Research priorities and current needs should guide these allocations. Also, size of a project in terms of number of scientists associated with it and workload of a scientist should be given due importance in research planning process. Spreading resources thinly and research planning without financial implications may turn out to be counterproductive. The institutes should also workout the procedures for sharing of equipments and other research facilities to rationalize the expenses on equipments and other capital costs.

Procurement of goods and services. ICAR should adopt budget-based delegation of financial powers for procurement of goods and services. Any purchase within the approved budget and following the prescribed norms and financial rules should not require concurrence of finance. Also to ensure regular supply and reduce unit costs of essential items like chemicals, there should be empanelment of suppliers/distributors on the pattern of DGS&D and supply orders should be managed electronically.

Competitive research funding has been upscaled under the externally-funded projects, viz. National Agricultural Technology Project and National Agricultural Innovation Project. This is a powerful mechanism to link funding with performance, target and integrate research and enhance cost-effectiveness. In view of the abolition of the AP Cess fund, *there is a need for allocating nearly one-third of ICAR plan fund for competitive funding*. This funding should be open to public agricultural R&D organizations and provide support for contractual services including manpower, operating expenses and essential equipments.

Maintenance of infrastructure. Externally-funded projects are preferred by both scientists and institutes as they augment research resources. These projects sometimes create research facilities which need to be maintained by the institute (after completion of the project) from its own resources, which may not be adequate. Therefore there should be a provision of institutional fee as part of the project cost. This fee should normally be about 20% and it may go up to 40% in case of capital-intensive projects. The funds thus accumulated should be used to maintain the facilities after termination of the project.

International travel. Funds available for participation in international conference, seminar, symposium etc are limited. These funds should be increased and made available to scientists. However, some criteria may be evolved for awarding the grant. For instance, preference should be given to a scientist invited to chair a session over the one contributing a paper. Also, all the scientists should be given an opportunity to participate in an international conference or attend a training program abroad within a specified period of time, say once in five years. This will help to be in touch with global thought leaders and cutting-edge research carried-on globally.

Attracting and Motivating Scientists

Human resources. Although scientific strength is critical for system's performance, it is effective only when supported by proficient technical and administrative staff. Finance staff is at disadvantage, both in terms of number and career prospects, in comparison to their counterpart administrative staff. Therefore, a balance should be maintained in the number and quality of various categories of personnel. Presently, the ratio of scientific to technical, administrative and supporting staff is 1:1.6:1:2. Given the manpower-intensive nature of agricultural research because of field experiments, drastic reduction in number of people supporting a scientist may not be possible. But, some tasks of maintenance and supporting in nature could be outsourced. Similarly, dependence on permanent technical staff for managing labs and educational farms could be reduced by starting fellow program. Possibility of engaging scientific manpower on contract basis, especially for externally-funded research, should also be explored.

Rationalizing workload. A mismatch between the attrition and recruitment rate has increased workload of scientists, which may eventually translate into lower productivity and/or quality of research. ICAR should review the cadre strength, manpower planning process and recruitment policy in view of emerging R&D challenges and agricultural development priorities of the government.

Dichotomy of primary and higher education is often a misplaced notion in allocating public resources. This may be a problem when resource requirement at different levels compete for scarce public resources. But we should also recognize the fact that both primary and higher education are complementary when seen in the context of development of an education system. This concept also applies to agricultural education, especially when deciding the number of seats in various degree programs.

Knowledge and skill development

HRD for scientists. Innovations in research and its management are essential for improving efficiency of the system. In order to sustain innovativeness of the system, continuous investment in capacity development (knowledge and skill improvement) for scientists and research managers is essential. HRD through direct training is an integral part of capacity building, besides development of scientific infrastructure. But the scope of training should go beyond the conventional idea of imparting training to individuals, and the options for self and distance learning should be explored. Important activities under this could be:

- strengthening and linking the libraries,
- increasing access to international journals, and
- establishing centres of distance education.

At degree program level, course curricula should be revised by balancing theory and practice components. Furthermore, nearly 50% students at under- and post-graduate levels should be admitted through national competitive examination to check inbreeding of incompetency.

HRD for administrative functions. Some management problems arise because of poor understanding of administrative rules. Addressing these problems takes considerable time of staff and research managers. In order to address this problem, training on administrative and financial rules for different categories of staff should be organized periodically. In order to make these trainings more effective, focused training programs for teams (of director and heads of administration and finance) from institutes should be organized, besides training programs for individuals. Such training programs will be helpful in simplification of administrative and financial procedures. It will also enable the directors to understand and appreciate their roles as head of institutions more effectively.

Institutional capacity for HRD. National Academy of Agricultural Research Management (NAARM) has the mandate to meet HRD needs of the NARS. While it is important that the system should articulate its HRD needs, NAARM should also undertake periodic assessment of HRD needs and structure its core programs to meet these needs. *Development of NAARM's core faculty with desired vision and skills in management development and contracting guest faculty in highly specialized areas should receive high priority*.

Sabbatical leave. The provision of sabbatical leave should be linked to output, i.e. the scientist availing sabbatical leave should deliver research output, and scientists willing to work in high priority areas should be given preference in granting the leave.

Incentives

Incentive is a powerful policy instrument to attract, retain and motivate scientists and thereby increase scientific creativity and growth of the system. Incentives should be seen in a larger context of promoting scientific leadership and overall development of the research system. Incentives both for young and mid-career scientists are important. The existing mechanisms like career advancement scheme and schemes like national professors and fellows may not be sufficient for this purpose. The following options should be considered:

a) *De-linking incentives from promotion*. Some incentive (financial or professional) could be provided to outstanding scientists, and the criteria for such incentives should be transparent and robust.
b) Incentives could be in terms of allowing the scientist to use the funds for research which he/she has generated through consultancy, contractual research or commercialization of technology, or a higher retirement age, or training abroad.
c) The schemes like national professor and fellow should be output and outcome-centric rather than a fixed number of positions for which a large number of

scientists compete. Scientists qualifying the prescribed criteria should automatically be awarded the fellowship.

d) There should be incentives for 'best housekeeping' to motivate administrative and finance staff.

Recommendations

Without financial implications

1. ICAR is a global organization and thought leader in agricultural research and education. All the activities and resources of ICAR should be aligned for making it a truly global leader in cutting-edge agricultural research and innovations. ICAR should also envision a much greater role for itself in international agricultural research. It should in particular strengthen linkages with the NARS in Africa and Asia by offering fellowships to students coming to India for higher studies.

2. ICAR should develop centres of excellence in cutting-edge science which should emerge as global leaders in their respective field. These centres should have direct linkages with applied research programs.

3. Coordination, networking and partnership are important mechanism to increase effectiveness of research. IPRs regime should be used to foster these institutional mechanisms, especially with private sector, and linkages between research, extension and farmers. Annual ICAR-Industry meet should target area-wise and discipline-wise outputs

4. There should be a standing committee on gender-related issues in the council and it should be headed by a deputy-director general level person. This committee should guide the Council on the policy matters, promote the schemes to empower women, coordinate research programs, etc.

5. The efforts to integrate outcome of various programs undertaken by different ICAR institutes should be strengthened in the Council for greater visibility. If required, a special unit may be established in the Council for this purpose.

6. Decentralization and delegation of responsibilities should be linked with performance evaluation. An objective set of criteria which could be different for research, education and extension should be used. External evaluation should be mandatory for all the institutes and it should be holistic in nature involving management and finance experts.

7. Management style at the institute should be transparent and participatory, involving scientists, administrative and finance staff in taking decisions and their implementation. Also, MIS with information on research parameters (like

resources, programs, technologies and patents) and recent developments in the areas like world markets, technological alliances etc. should support the decision making process.

8. NAARM's role in management development should be strengthened and its capacity developed through training and outsourcing of faculty. The scope for self- and distance learning through better access to international literature and journals should be explored.

9. There should be registration and empanelment of suppliers and distributors for regular supply of essential day-to-day items on the pattern of DGS&D and management of supply orders should be web-based.

With financial implications

10. While there is a need for increasing intensity of funding for agricultural research and education, allocation of available resources should be more systematic, need-based and futuristic. In particular, there is a need for making a balance between funding from the central and state governments. Also, a desired ratio of 60:40 between salary and operational expenses should be achieved in XI Plan.

11. A centre for management of intellectual property and commercialization of technology should be established as a Plan Scheme with some seed money from the government and ICAR (say 5% of Plan budget). This centre should have required expertise (in-house and outsourced) and eventually become self-sustaining over a period of time.

12. Nearly one-third of plan funds of ICAR should be dedicated for competitive funding and only public institutions should be eligible to compete for such funds.

13. ICAR should continue to support SAUs but this support should be strategic in nature, mainly for capacity development, coordinated programs, filling critical resource and research gaps, etc.

14. There should be review of recruitment policy to address the mismatch between attrition and recruitment rate of scientific personnel. Also, a proper balance between various categories of personnel should be maintained, and if required, some tasks of maintenance and supporting in nature could be outsourced.

15. Innovative methods of providing incentives like award for 'best housekeeping,' flexibility is use of resources generated by a scientist and institute, participation in international conference, and performance based (rather than fixed number) award of grants like national professor and fellows should be considered.

16. Planning and budgeting at the institute level should be a serious exercise and it should be done a duly constituted budget committee. Procurement of goods and services within approved budget and financial rules should not require concurrence of finance. Revision of EFCs should be entertained only in exceptional cases—deviations more than 20% of approved budget.

17. For externally-funded projects, ICAR institutes should charge institution fee (20-40% of total budget) for maintenance of research infrastructure after completion of the project.

13. MEMBERS OF THE SUB-GROUP

1. Prof. Pritam Singh, Director, Management Development Iinstitute, Gurgaon, and Chairman
2. Dr Rita Sharma, Additional Secretary and Financial Advisor, DARE/ICAR, Krishi Bhavan, New Delhi, and Member
3. Dr K Vijayaraghavan, ED, Sathguru Foundation, Hyderabad, and Member
4. Dr Indu Grover, Professor, Home Science, CSS HAU, Hisar, and Member
5. Dr Suresh Pal, Principal Scientist, National Centre for Agricultural Economics and Policy Research, New Delhi, Member Secretary

List of special invitees

1. Dr Mangala Rai, Secretary, DARE and Director General, ICAR, Krishi Bhavan, New Delhi
2. Ms Sushma Nath, Additional Secretary and Secretary, ICAR, Krishi Bhavan, New Delhi
3. Dr K S Khokhar, ADG (PIM), ICAR, Krishi Bhavan, New Delhi
4. Dr AK Singh, Director, IARI, Dr SK Sharma, Director, NBPGR and Dr KR Koundal, Project Director, NRCPB, New Delhi, Joint Directors of IARI, New Delhi.
5. Sh. H C Pathak, Director (Finance), ICAR, Krishi Bhavan, New Delhi
6. Dr S Kochhar, Principal Scientist, ICAR, Krishi Bhavan, New Delhi

Details of the meetings held

Date: 27 July 2006
Participants*:* Sub-group members
Focus of discussion*:* Terms of reference of the sub-group, review of previous reports, Government's priorities and reform initiative

Date*:* 8 August 2006
Participants*:* Sub-group members, research managers and scientists from Delhi-based ICAR institutes
Focus of discussion*:* Suggestions on strategy and O&M reforms for increasing capacity to respond and speed of response of ICAR institutes, decentralization and autonomy, financial management, incentives, harmonization of management responsibilities, gender, etc.

Date*:* 28 August 2006
Participants: Sub-group members, Dr Mangala Rai, Secretary, DARE and DG, ICAR; Ms Suhsma Nath, Additional Secretary and Secretary, ICAR; administrative and finance staff from ICAR Headquarters and Delhi-based ICAR institutes

Focus of discussion*:* Strategy and management reforms for increasing responsiveness, decentralization and autonomy, incentives, harmonization of management responsibilities, gender, etc.

Date: 6 Sept 2006
Participants: Sub-group members
Focus of discussion: Finalization of structure, contents and recommendations of the report

COMPOSITION OF SUB GROUP

(1) CROP SCIENCE RESEARCH

Prof. R.B. Singh, Member, National Farmers Commission (NCF), Office Block, IInd Floor, NASC Complex, Opp. Todapur Village, PUSA, New Delhi –110 012	-	Chairman
Dr. E.Q. Siddiq, Ex-DDG(CS), ICAR, Jasmine Plot No. 81, Happy Homes Colony, Upperpalli, Hyderguda, P.O. Hyderabad – 500 030 (AP)	-	Member
Dr. S.V.S. Shastri, Ashoka, 202, Gautami Apartments, Barkatpura, Hyderabad – 500 027	-	Member
Dr. B.B. Singh, 18/529, Indira Nagar, Lucknow – 226 016	-	Member
Dr. K.V. Prabhu, Head, Division of Genetics, Indian Agricultural Research Institute, Pusa, New Delhi-110 012		– Member Secretary

(2) PLANT PROTECTION

(i)	Dr. S.N. Puri, Vice Chancellor, CAU, Iroisemba, P.O. Box 23, Imphal-795004 Manipur, Tel: 0385-2410414 Email: snpuri@rediffmail.com, snpuri@rediffmail.com,	Chairman
(ii)	Dr. Anupam Verma, Ex. National Professor, ICAR, 253, Jaimaa Apartments, Plot No.16, Sector-5, Dwarka, New Delhi-110 075 Tel: 25072511 Email:anupamverma@vsnl.net	Member
(iii)	Dr. S. Jayaraj, Chairman, S. Jayaraj Research Foundation, No.39, First Floor, Main Road, A.G.S. Colony, Velachery, Chennai-600042 Tel: (O) 044-22533806 email: profsjayaraj@rediffmail.com	Member
(iv)	Dr. S.N. Nandal, Prof. & Head, Department of Nematology, CCSAHU, Hisar-125004, Haryana	Member
(v)	Dr. T.P. Rajendran, Asstt. Director General(PP), ICAR, Krishi Bhavan, New Delhi-110 001.	Member Secretary

(3) HORTICULTURE & PROTECTED CULTIVATION

1. Dr. Kirti Singh, Formerly Chairman, ASRB – Chairman.
Dr. S.P. Ghosh, Formerly DDG(H), ICAR – Member
Dr. B.S. Chundawat, Vice Chancellor, Sardar Krushinagar Dantiwada Agricultural University, Sardar Krushinagar, Distt. Banaskantha-385 506, Gujarat - Member
Dr. K. V. Peter, Vice Chancellor, Kerala Agricultural University,Vellanikkara, Trichur-680656, Kerala. - Member
Dr. K.V. Ramana, Assistant Director General (PC), Indian Council of Agricultural Research, Horticulture Division, KAB-II, Pusa, New Delhi-110012. – Member Secretary

Special Invitees

Dr. G. Kalloo, DDG(H& CS), ICAR
Dr. S.N. Pandey, ADG(H), ICAR
Dr. R. Srivastava, Director, CARI, Post Blair (A&N)
Dr. D.P. Singh, Principal Scientist (H), ICAR
Dr. Umesh Srivastava, Principal Scientist (Veg.), ICAR

(4) NATURAL RESOURCE MANAGEMENT

1.	Dr. G.S. Sekhom, Former Director, Postash Research Institute, Gurgaon & Former Professor of Soils, PAU, Ludhiana	Chairman
2.	Dr. R.L. Yadav, Director, Indian Institute of Sugarcane Research (IISR) Lucknow, UP	Member
3.	Dr. Rajendra Prasad, Ex-National Professor, ICAR	Member
4.	Dr. P.D. Sharma, ADG (Soils), ICAR	Member Secretary

(5) CLIMATE CHANGE, RINSK AND DISASTER MANAGEMENT

Dr. S.M. Virmani
Retd. Climatologist, ICRISAT, Hyderabad
Dr. L.S Rathore
Head, Applications Division, NCMRWF, Noida
Dr. Y.S. Ramakrishna
Director, CRIDA, Hyderabad

Dr. P.S.N. Sastry
Retd. Principal Scientist (Ag. Met.), IARI, New Delhi

Dr. G.G.S.N. Rao
Project Coordinator (Ag. Met.), CRIDA, Hyderabad
Dr. R.M. Bhaghat
Professor, HPKVV, Palampur

Dr. P.K. Agarwal
Head, Division of Environmental Sciences, IARI, New Delhi

Dr. U.S. Victor
Principal Scientist (Ag. Met.), CRIDA, Hyderabad
Dr. V.U.M. Rao
Principal Scientist (Ag. Met.), CRIDA, Hyderabad
Dr. N.N. Srivastava
Principal Scientist (Ag. Met.), CRIDA, Hyderabad
Dr. A.V.M. Subba Rao
Scientist Sr. Scale (Ag. Met.), CRIDA, Hyderabad
Dr. V. Geethalakshmi
Professor, Dept. of Agrl. Meteorology, TNAU, Coimbatore
Dr. Y.P. Abrol
Professor, Society for Conservation of Nature, New Delhi

(6) RAINFED AGRICULTURE

a. Committee Members

Dr. J.C. Katyal, Vice Chancellor, CCS HAU, Hisar and Chairman.

Dr. S.M. Virmani, Ex.Agroclimatologist, ICRISAT, Hyderabad

Dr. N.K. Sanghi, Consultant, WASSAN, Hyderabad

Dr. S.P. Wani, Regional Coordinator, ICRISAT, Patancheru, AP

Dr. P.S. Minhas, ADG(IWM), ICAR, New Delhi and Member Secretary

b. Special Invitees

Dr. Y.S. Ramakrishna, Director, CRIDA, Hyderabad

Dr. V.M. Mayande, ZC, Zonal Coordinating Unit V, Hyderabad

Dr. K.P.R. Vittal, Project Coordinator, AICRPDA, Hyderabad

Dr. G.G.S.N. Rao, Project Coordinator(Agromet), CRIDA, Hyderabad

Dr. B. Venkateswarlu, Head, DCS, CRIDA, Hyderabad

Dr. G.R. Korwar, Head, DRM, CRIDA, Hyderabad

Dr. K.V. Subrahmanyam, Head, TOT, CRIDA, Hyderabad

Dr. Y.V.R. Reddy, Head, SDA, CRIDA, Hyderabad

Dr. J.V. Rao, Head, Agroforestry Cell, CRIDA, Hyderabad

Dr. M. Osman, OIC, RCMU, CRIDA, Hyderabad

Dr. G. Subba Reddy, Principal Scientist, CRIDA, Hyderabad

Dr. G.R. Maruthi Sankar, Prl.Scientist, CRIDA, Hyderabad

Dr. S. Desai, Sr.Scientist, CRIDA, Hyderabad

Dr. I. Srinivas, Sr.Scientist, CRIDA, Hyderabad

Dr. C.A. Rama Rao, Sr.Scientist, CRIDA, Hyderabad

Dr. S.S. Balloli, Sr.Scientist, CRIDA, Hyderabad

Dr. K. Srinivas, Sr.Scientist, CRIDA, Hyderabad

Dr. J.V.N.S. Prasad, Sr.Scientist, CRIDA, Hyderabad

Dr. Y.G. Prasad, Sr.Scientist, CRIDA, Hyderabad

(7) MECHANIZATION, PPOST HARVEST PROCESSING AND ENERGY MANAGEMENT

1.	Dr. B.S. Pathak, Director, Sardar Patel Renewable Energy Research Institute, P.B. NO. 2, Vallabh Vidyanagar 388 120	Chairman
2.	Dr. Anwar Alam, Vice Chancellor, Sher-E-Kashmir, University of Agricultural Science & Technology, Shalimar Campus, Srinagar, J&K 191 121	Member
3.	Dr. A.M. Michael (Ex-VC, KAU), 27/38, Vattekunmnarm, Methanam Road, Epappally North, Cochin – 682 024	Member
4.	Dr. N.S.L. Srivastava, Joint Director, Sardar Patel Renewable Energy Research Institute, P.B. NO. 2, Vallabh Vidhyanagar-388120	Member
5.	Dr. Pitam Chandra, Asstt. Director General (PE), ICAR KAB-II, Pusa, New Delhi	Member Secretary

(8) ANIMAL SCIENCE

1.	Dr. M.L. Madan, Anugraha, Madan Lodge, House No. 842/6, Urban Estate, Karnal – 132 001 (Haryana)	Chairman
2.	Dr. K. Pradhan, Ex-Vice Chancellor, RAU, Bikaner, C-24/HIG, Housing Board Colony, Baraminda, Bhubaneshwar – 751 003 (Orissa)	Member

3.	Dr. J.S. Dhillon, Ex-Dean, CoVS, Punjab Agricultural Univesity, 167-H, Bhai Randhir Singh Nagar, Ludhiana 141 004 (Punjab)		Member
4.	Dr. R.N.S. Gowda, Vice Chancellor, Karnataka Animal & Fisheries Science University, Nandinagar, P.B. NO. 6, Bidar, Karnataka		Member
5.	Dr. Lal Krishna, Asstt. Director General (AH), Animal Science Division, ICAR, Krishi Bhavan, New Delhi – 110 001		Member

(9) FISHERIES AND AQUACULTURE

1.	Dr. S.D. Tripathi, Former Director, CIFE, Mumbai	-	Member
2.	Dr. M.V. Gupta, Former ADG, World Fish Centre, Malaysia	-	Member
3.	Shri Haridas, Dy. Adviser (Fisheries) Planning Commission, New Delhi	-	Member
4.	Dr. A.D. Diwan, ADG(M.Fy.), ICAR New Delhi	-	Member Secretary

(10) BIOTECHNOLOGY, GENETIC ENGINEERING & BIO-SECURITY

1.	Dr. Deepak Pental, Vice Chancellor, Delhi University, Delhi	Chairman
2.	Dr. A.K. Singh, Principal Scientist, Division of Genetics, Indian Agricultural Research Institute (IARI, Pusa, New Delhi – 110 012	Member
3.	Dr. B.M. Khadi, Director, Central Institute for Cotton Research, P.B. No. 2, Nagpur – 440 010, Maharashtra	Member
4.	Dr. Anant Rai, In-charge Biotechnology Section, Indian Veterinary Research Institute, Izatnagar – 243 122 (UP)	Member
5.	Dr. Prabhakar Rao, Nu Zi BEE DU., 7C, Surya Tower, S.P. Road, Secunderabad, A.P.	Member
6.	Dr. N.K. Singh, Principal Scientist, National Research Centre on Plant Biotechnology, Pusa, New Delhi – 110 012	Member Secretary

(11) AGRICULTURAL EDUCATION

1.	Dr. S.L. Mehta, Vice Chancellor, M.P.U.A & T, Udaipur – 313 001, Rajasthan	Chairman
2.	Dr. J.C. Katyal, Vice Chancellor, CCSHAU, Hisar-125 004, Haryana	Member

3. Dr. M.L. Madan, Anugraha, Madan Lodge, House No. 842/6, Urban Estate, Karnal – 132 001, Haryana — Member
4. Dr. S.A. Patil, Vice Chancellor, University of Agricultural Sciences, Dharwad, Karnataka — Member
5. Dr. H.S. Nainawatee, Asstt. Director General (HRD-II), Education Division, ICAR, KAB-II, New Delhi – 12 — Member Secretary

(12) AGRICULTURAL EXTENSION

1. Dr. T.S. Sohal, Former Professor & Head,
Chairman
Division of Dairy Extension, NDRI, Karnal
H.No. 2041, Phase-X, Mohali, Punjab
2. Dr. V.G. Dhana Kumar, Director Incharge
Member
Indian Institute of Plantation Management, Bangalore
3. Dr. R. Vijay Raghavan, Professor — Member
Division of Agril. Extn., IARI, Pusa, New Delhi
4. Dr. R. Murlidhar Prasad, Associate Professor
Member
Extension Education, KAU, Vellanikara, Trichur
5. Dr. Rajinder Prasad, Asstt. Director General (Ag. Ext.)
Member-Secretary
ICAR, KAB-I, Pusa, New Delhi

(13) ARICULTURAL ECONOMICS, MARKETING AND AGRIBUSINESS

(i) Dr S.S. Acharya, Former Chairman, CACP, GOI — Chairman
Honorary Professor and Former Director,
Institute of Development Studies, 8-B, Jhalana Institutional Area, Jaipur – 302 004 (Rajasthan)
e-mail: ssacharya@idsj.org

Dr Jayati Ghosh, Professor — Member
Centre for Economic Studies and Planning, School of Social Sciences, J.N.U., New Delhi – 110 067

Dr C. Ramasamy, Vice Chancellor, Tamil Nadu Agricultural University, Coimbatore – 641 003 (Tamil Nadu) — Member

Dr Kilas Sarap, Professor, Department of Economics, Sambalpur University, Sambalpur, Orissa — Member

Dr V.P.S. Arora, Dean, College of Agribusiness Management, G.B. Pant University of Agriculture and Technology, Pantnagar – 263 145, Distt. Udham Singh Nagar (Uttaranchal) — Member

(vi) Dr. P. K. Joshi, Director — Special invitee
National Centre for Agricultural Economics and Policy Research,
Library Avenue, Pusa, New Delhi – 110 012
e-mail: director@ncap.res.in

Dr Ramesh Chand, National Professor, — Member secretary
National Centre for Agricultural Economics and Policy Research,
Library Avenue, Pusa, New Delhi – 110 012
e-mail: rc@ncap.res.in

(14) ORGANIZATION, FINANCE AND MANAGEMENT

Prof. Pritam Singh, Director, Management Development Institute, Gurgaon	Chairman
Dr Rita Sharma, Additional Secretary and Financial Advisor, DARE/ICAR, Krishi Bhavan, New Delhi Member	
Dr K Vijayaraghavan, ED, Sathguru Foundation, Hyderabad	Member
Dr Indu Grover, Professor, Home Science, CSS HAU, Hisar	Member
Dr Suresh Pal, Principal Scientist, National Centre for Agricultural Economics and Policy Research, New Delhi	Member Secretary