REPORT OF THE INTER MINISTRY TASK GROUP ON EFFICIENT UTILISATION OF WATER RESOURCES



PLANNING COMMISSION
NOVEMBER 2004

POEM OF SANGAM AGE (2000-2500 Years old)

Those who unite water and soil create
living bodies and life in this world
Even kings with vast domain strive in
vain when the land is dry,
When the fields sown with seed must look
to the sky for rain,
So, Pandyan king, who makes dreadful
war,
do not disdain my words, expand
quickly those watery places
built where water moves across the
land.
For those who harness water harness
rewards for themselves,
and those who fail cannot endure.

WHAT IS WATER (in a lighter vein)

Water is far from a simple commodity,
Water's a sociological oddity,
Water's a pasture for science to forage in,
Water's a mark of our dubious origin,
Water's a link with a distant futurity,
Water's a symbol of ritual purity,
Water is politics, water is religion,
Water is just anyone's pigeon,
Water is frightening, water's endearing,
Water's a lot more than mere engineering,
Water is tragical, water is comical,
Water is far from the pure economical
So studies of water, though free from aridity,
Are apt to produce a good deal of turbidity

CONTENTS

1. INTRODUCTION

1.1 There have been commendable developments in the country after independence and the country transformed from food scarcity to food security and then to food surplus. The transformation is marked by the green revolution, white revolution, blue revolution and now the golden revolution. But the dependence on monsoon, declining farm income and high cost of water-related infrastructure are causes for concern. Water scarcity and related issues has become one of the most important task for planners, scientific organisations and development agencies. Water Management is vital for intensive agriculture and received focused attention after the International Conference on Water and the Environment in Dublin (1992) and the United Nation's Conference on Environment and Development in Rio de Janeiro (June 1992) where efficient water use for sustainability of agriculture were emphasised.

1.2 Agenda 21 of the Rio conference states *"sustainability of food production increasingly depends on sound and efficient water use and conservation practices consisting primarily of irrigation development and management with respect to agriculture, livestock water supply, inland fisheries and agro forestry. Achieving food security is a high priority in many countries including India, and agriculture must not only provide food for rising population, but also save water for other uses. The challenge is to develop and supply water saving technology and management methods and through capacity building enable farming communities to adopt new approaches in irrigated agriculture."*

1.3 India is also committed to the Millennium Development Goals of the United Nations of halving by 2015 the proportion of people who are unable to reach or to afford safe drinking water and the proportion of people who do not have access to basic sanitation. This commitment coupled with the imperative to develop quickly the balance 45 m.ha. of irrigation potential will place a large strain on the demand side of water. Since the supply side is constrained (the hydrological cycle supplies only a fixed quantity of water), efficient utilisation of available waters to better manage the demand-side will have to be the corner stone of our water policy from now on, if a grave water crisis is to be averted in the non too distant future. All types and forms of water resources viz. rain water, ground water, surface water and soil moisture should be considered conjunctively. India is not insulated from the effects of a global change in the climate mainly due to warming from greenhouse gases. Successive droughts in recent years mainly due to El Nino and other climatic factors have accentuated the flood-drought syndrome.

1.4 The Prime Minister's office vide their letter dated 29.7.2004 to the Planning Commission inter-alia suggested setting up of an Inter Ministry Task Group on Efficient Utilisation of Water Resources to address the issues of over-exploitation of ground water and non-utilisation of created capacity and plan for efficient and optimal use of Water Resources. Vide order No. N-11017/7/2004-PC dated 4.8.2004, the Planning Commission constituted the above Task Group under the Chairmanship of Secretary, Planning Commission with Adviser (WR) in the Planning Commission as the Convener. Secretaries to the Government of India of the Ministries of Water Resources and Finance, Departments of Agriculture & Cooperation, Agriculture Research & Education, Expenditure and Science & Technology and Joint Secretary to the Prime Minister are the Members of the Task

Group. A copy of the constitution order of the Task Group is at Annexure 1.1.

1.5 The first meeting of the Task Group was held on 27th August 2004 when Power-Point presentations were made by the Ministry of Water Resources, Indian Council for Agricultural Research, Department of Agriculture & Cooperation and the Department of Science & Technology. The Task Group directed that a Support Group be constituted with representatives from the concerned Ministries/ Departments to first finalise the Terms of Reference and also discuss the finalise the scope and contents of the report.

1.6 The Support Group comprising Adviser (WR), Adviser (Agr.) from the Planning Commission, Deputy Director General (ICAR), Commissioner (PP) & Chief Engineer from Ministry of Water Resources, Head (NRDMS) and Scientist 'E' from the Dept. of Science & Technology and Additional Commissioner and Deputy Commissioner from the Dept. of Agriculture met on 15.9.2004 and suggested the following Terms of Reference to the Task Group.

(i) *To identify action plan for integrated development of water resources (both surface and ground) and for completion of continuing projects, especially those benefitting areas having high potential for dry crops, with a view to optimise benefits from utilisable water resources.*

(ii) *To suggest measures for implementing improved management practices with a view:*

(a) *to reduce gap between created potential and utilised potential.*
(b) *to bring down the level of demand for water for various purposes.*
(c) *to minimise losses in the water resources systems by adopting reform measures including participatory approach.*

(iii) *To identify action plan to enhance the level of utilisable water resources through further investigation, diversification of cropping and farming systems and management to enhance livelihood and employment.*

(iv) *To identify inter-department coordination required at the Centre and State in development and management of water resources.*

The Support Group also finalised the broad chapterisation and assigned responsibility to each of the Ministries/Depts. for preparation of a draft chapter(s).

1.7 Based on inputs received, the Convener finalised a draft report and this was discussed and accepted by the Task Group in its second meeting held on 16 November 2004 with minor modifications. This Final Report of the Task Group is an outcome of the above drill.

ANNEXURE 1.1

No.N-11017/7/2004-PC

Government of India
Planning Commission

Yojana Bhavan, Sansad Marg,
New Delhi, 4th August, 2004

ORDER

Subject : Setting up of an Inter-Ministry Task Group on Efficient Utilization of Water Resources.

In pursuance of the decision taken by the Prime Minister for setting up of Inter Ministry Task Groups to consider action needed for those areas of National Common Minimum Programme where the agenda is cross sectoral and requires action encompassing a number of Ministries / Departments, it has been decided to set up an Inter- Ministry Task Group on Efficient Utilization of Water Resources.

2. The composition of the Task Group is as under

(i)	Secretary, Planning Commission	- Chairman
(ii)	Secretary, Ministry of Water Resources	- Member
(iii)	Secretary, Department of Agriculture and Cooperation	- Member
(iv)	Secretary, Department of Agriculture Research and Education	- Member
(v)	Secretary, Ministry of Finance (Department of Expenditure)	- Member
(vi)	Secretary, Department of Science and Technology	- Member
(vii)	Sectoral Officer-in-Charge, Prime Minister's Office	- Member
(viii)	Adviser (WR), Planning Commission	- Convener

3. The Terms of Reference of the Task Group would be developed in the first meeting of the Task Group by the Group itself keeping in view the objectives and priorities laid down in NCMP relating to the subject of the Task Group after sharing with the Prime Minister's Office. The Task Group would, however, specifically address the issues of over exploitation of ground water and non-utilization of created capacity and plan for efficient and optimal use of water resources.

4 The Task Group may constitute a support group of domain specialists in the Ministries (i.e. officers in the rank of Joint Additional Secretaries) in its first

meeting to assist the Task group in the spadework and in preparing and finalizing its Report.

5. Each Ministry / Department concerning the subject of the Task Group should make a written presentation to the Task Group on what possibilities exist in their areas of concern.

6. The Task Group will have the powers to co-opt / associate professionals / domain experts into the Group. The Task Group will also have the powers to set up Sub Groups / Steering Committees of officials/non - officials to finalise its views on specific issues. The Task Group should, however, encourage active participation of the State Governments in the areas of concern of the Group.

7. The expenditure of the members on TA/DA in connection with the meetings of the Task Group will be borne by the Ministry / Department / State Government to which the members belong. In case of private members, TA/DA will be borne by the Planning Commission as admissible to the Class I officers of the Government of India.

8. The Task Group will submit its report to the Planning Commission within **Ninety days** from the date of its constitution.

9. The Task Group will be serviced by the Planning Commission.

Signed/-

(Rajan Katoch)
Joint Secretary to the Government of India

To

All Members of the Task Group

2. WATER AVAILABILITY, DEMAND & UTILISATION

2.1 As recognised in the National Water Policy (2002), water is a prime natural resource, a basic need for all forms of life on earth and a precious national asset. Water is essential for human existence and for propagation of wildlife and fisheries. Water is one of the most crucial elements in the developmental planning of a country. The sources of water are mainly surface and groundwater. The demands on water are competing and conflicting – irrigation, drinking water, domestic uses, industrial uses, hydropower, navigation and minimum flows required from environmental and ecological considerations. Land and water resources are also interlinked. Thus the accent in recent times has been on integrated water resources management, a process which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising on the sustainability of the eco-system.

2.2 The total global water availability is estimated as 1.39 billion cubic kilometers. 97.3% of this is saline and thus only 2.7% is fresh water. All the fresh water on earth can be captured in a cube with sides of 330 km. Although India has 16% of the world's population, it is endowed with only 4% of the total available fresh water.

2.3 The average annual rainfall in the country is 1170 mm which corresponds to an annual precipitation, including snowfall, of 4000 billion cubic metres (BCM). However, there is considerable variation in the rainfall, spatially and temporally. While annual rainfall is as much as 11000 mm in Mawsynram in Meghalaya, it is as low as 100 mm in western parts of Rajasthan. 75% of the precipitation is confined to the 3 to 4 months in the monsoon season (June to September). Annexure 2.1 is a schematic representation of the hydrologic cycle while Annexure 2.2 gives the rainfall pattern over the country.

2.4 It has been estimated that out of the average annual water resource potential in the country of 1869 BCM, the average annual utilisable water (surface and ground) is 1122 BCM of which 690 BCM is from surface water and 432 BCM is from groundwater. The basin wise break-down of average annual water availability and the utilisable surface water resources are at Annexure 2.3 and 2.4 respectively.

2.5 While the total water resources availability in the country remains constant, the per capita availability of water has been steadily declining since 1951 due to population expansion. A per capita availability of less than 1700 cubic metres (m^3) is termed water stress condition while if it falls below 1000 m^3, it is termed as water scarce condition. The per capita availability which was a healthy 5200 m^3 in 1951 declined to 2200 m^3 in 1991 and 1820 m^3 in 2001. It is estimated to further decline to 1340 m^3 in 2025 and 1140 m^3 by 2050. This reflects the average national scenario. However, many basins like Sabarmati and Pennar are already water scarce.

2.6 The Ministry of Water Resources constituted a Standing Sub Committee for assessment of availability and requirement of water for diverse uses in the country. The Committee in its report of Aug. 2000 assessed the water requirement for various sectors as below:

Sector	Water Demand in BCM			
	2000	2010	2025	2050
Irrigation	541	688	910	1072
Drinking Water	42	56	73	102
Industry	8	12	23	63
Energy	2	5	15	130
Others	41	52	72	80
Total	634	813	1093	1447

The Sub-Committee has observed that against the total utilisable water resource of 1122 BCM, the projected demand by 2025 and 2050 are 1093 BCM and 1447 BCM respectively. The supply side augmentation measures which could be taken are completion of storage dams, interlinking of rivers, recycling of domestic uses (80% of use is return flow), recycling of industrial use water (65% of use is return flow), recycling of irrigation return flow (10% of use is return flow), desalination of sea-water and artificial recharge of groundwater and rainwater harvesting. On the demand side improvement of irrigation and urban water use efficiency and downscaling of norms for various water uses would have to be implemented. A multi-pronged approach is thus called for if a water crisis is to be averted.

2.7 The National Commission for Integrated Water Resources Development Plan in its report of September 1999 has concluded that there is no need to take an alarmist view. However, according to the Commission, three major considerations have to be kept in the forefront while formulating an integrated water policy. First the balance between the requirement and availability can be struck only if utmost efficiency is introduced in water use. Secondly, average availability at the national level does not imply that all basins are capable of meeting their full requirement from internal resources. Thirdly, the issue of equity in the access to water, between regions and between sections of the population, assumes greater importance in what is foreseen as a fragile balance between the aggregate availability and the aggregate requirement of water.

2.8 Since the rainfall is confined to a few months only, it is not surprising that construction of storages through major, medium and minor dams to conserve monsoon run-off has been the bulwark of our water resources development strategy so far. There are about 4050 large dams in the country with an aggregate storage of 213 BCM (which was only 15.6 BCM at the time of Independence). Storages under construction will add under another 76 BCM while the contemplated projects have an aggregate storage of 108 BCM. Notwithstanding this, the per capita storage in India of about 207 m^3 is way below that in other countries like Australia (4733 m^3), Brazil (3145 m^3), U.S. (1964 m^3), Turkey (1739 m^3), Spain (1410 m^3), Mexico (1245 m^3), China (1111 m^3) and South Africa (753 m^3). Even if all storages, contemplated and under construction, are completed, India with about 400 m^3 per capita storage (at current population level), cannot catch up with the above countries. Increasing population will only aggravate the situation both in regard to per capita water availability and per capita storage. Local water conservation measures will slightly improve the situation.

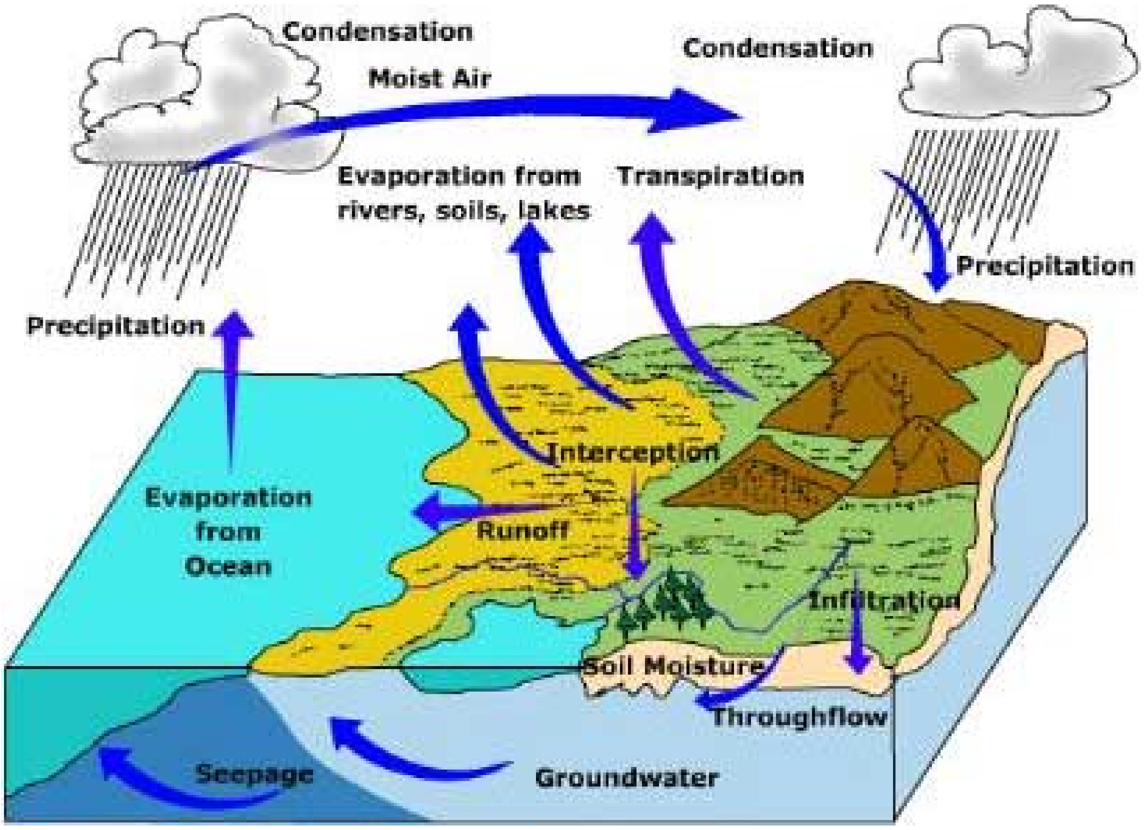
2.9 Two other areas of concern are the large number of on-going incomplete irrigation projects and the wide gap between the potential crated and potential utilised. About 388 incomplete major

& medium irrigation projects with a spill over liability of about Rs.91000 crore (as on April, 2004) spilled over from the Ninth Plan. These projects on completion will yield about 12.5 m.ha. additional potential. The Accelerated Irrigation Benefits Programme (AIBP) launched in 1996-97 to assist in completion of the last mile projects has no doubt made a small contribution to project completion but due to various infirmities in the operation of the programme, it could not make a significant dent in project completion as envisaged. Although till the end of the Ninth Plan, 94 m.ha. total potential was reported created, the utilisation reported was only 80 m.ha. The large gap of 14 m.ha. can be attributed to lack of field channels below outlet, change in cropping pattern to water intensive crops and silting (especially minor irrigation tanks) in the case of a few projects.

2.10 One of the main reasons for this situation is that water being a State subject, the Centre has no control over the States in regulating taking up of new projects or any say in budget allocations for irrigation which have been declining over the various Plans. States take up projects on the plea of regional imbalances or imperatives of quickly using Tribunal allocations of inter-State waters. Expansion of irrigation facilities is no doubt the only insurance against adverse effects of droughts and also to control the migration of rural population to urban areas by providing gainful employment both during the project construction and post-project agricultural operations. However, unplanned and haphazard development of irrigation potential, through thin spread of scarce resources over many projects, will not deliver the desired objectives.

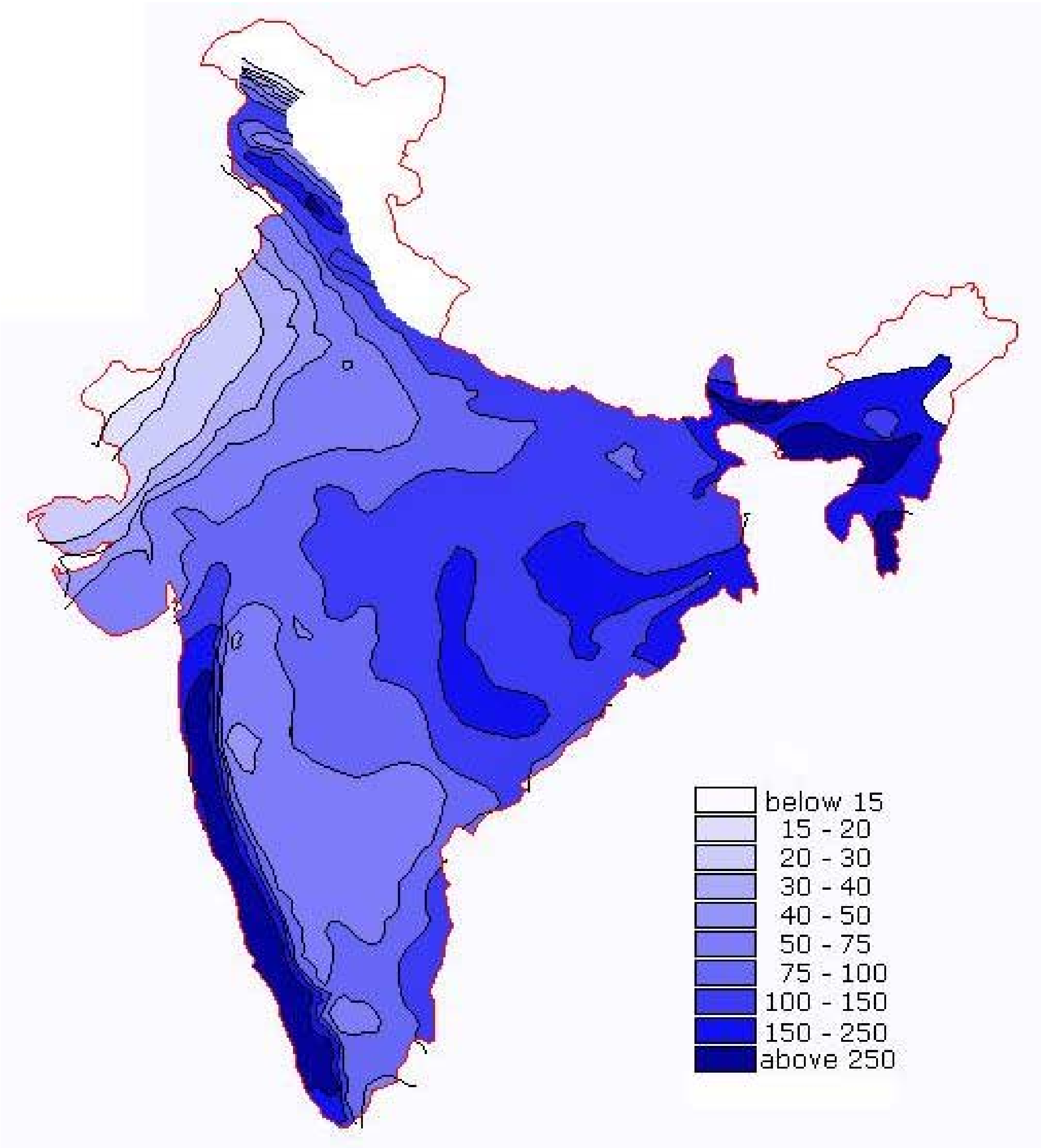
ANNEXURE 2.1

HYDROLOGICAL CYCLE



ANNEXURE 2.2

Rainfall Pattern (in cm)



ANNEXURE 2.3

River Basin wise Average Annual Water Availability

Unit: Billion Cubic Metre (BCM)

Sl. No.	River Basin	Average Annual Water Availability
1.	Indus	73.31
2.	Ganga-Brahmaputra-Barak	
	a. Ganga sub-basin	525.02
	b. Brahmaputra & Barak sub-basin	585.60
3.	Godavari	110.54
4.	Krishna	78.12
5.	Cauvery	21.36
6.	Pennar	6.32
7.	East Flowing Rivers between Mahanadi and Pennar	22.52
8.	East Flowing Rivers between Pennar and Kanyakumari	16.46
9.	Mahanadi	66.88
10.	Brahmani and Baitarni	28.48
11.	Subarnrekha	12.37
12.	Sabarmati	3.81
13.	Mahi	11.02
14.	West Flowing Rivers of Kutchh, Saurashtra including Luni	15.10
15.	Narmada	45.64
16.	Tapi	14.88
17.	West Flowing Rivers from Tapi to Tadri	87.41
18.	West Flowing Rivers from Tadri to Kanyakumari	113.53
19.	Area of Inland Drainage in Rajasthan Desert	Negl.
20.	Minor River Basins Draining into Bangladesh and Myanmar	31.00
	Total (National)	**1869.37**

ANNEXURE 2.4

BASIN-WISE UTILISABLE SURFACE WATER RESOURCES Unit-Billion Cubic Metre(BCM)		
Sl. No.	**Basin**	**Utilisable Surface Water Resources (BCM)**
1	Indus	46
2	Ganga-Brahmaputra-Meghna	
	(a) Ganga	250
	(b) Brahmaputra	24
	© Barak & Others	0
3	Godavari	76.3
4	Krishna	58
5	Cauvery	19
6	Subernarekha	6.8
7	Brahmani-Baitarani	18.3
8	Mahanadi	50
9	Pennar	6.9
10	Mahi	3.1
11	Sabarmati	1.9
12	Narmada	34.5
13	Tapi	14.5
14	West flowing rivers from Tapi to Tadri	11.9
15	West flowing rivers from Tadri to Kanyakumari	24.3
16	East flowing rivers between Mahanadi and Pennar	13.1
17	East flowing rivers between Pennar and Kanyakumari	16.5
18	West flowing rivers of Kutch & Saurashtra including Luni	15
19	Area of inland drainage in Rajasthan desert	
20	Minor rivers draining into Myanmar (Burma) and Bangladesh	0
	Total	690.1

3. GROUND WATER RESOURCES

3.1 Groundwater in India is the primary source of water supply for domestic and many industrial uses. More importantly, it is the single largest and most productive source of irrigation water. At present, 85% of the water supplies for domestic use in rural areas, 50% of water for urban and industrial uses and 55% of the irrigation water requirements are being met from groundwater. The total annual replenishable groundwater recharge in India is estimated at 432 BCM. The basin wise availability of this quantity is given in Annexure 3.1. After accounting for the natural system loss, the net availability is 361 BCM. The present net draft is 150 BCM. State-wise groundwater availability is given at Annexure 3.2. A map showing stage of groundwater development is at Annexure 3.3.

3.2 Several regions of the country are a good repository of groundwater which are yet to be tapped. The most significant is the Ganga-Brahmaputra basin which has about 50% of total potential of the country. Besides the dynamic resource, the basin has also a vast static or in-storage reserve. The quality of water in this region is generally good. The potential in other regions can be summarised as below.

Semi Arid & Arid Regions (Punjab, Haryana, Rajasthan, Gujarat, Parts of UP.	-	Declining groundwater levels due to over-exploitation. Saline water in predominant areas.
Great Indian Thar Desert	-	Insignificant recharge. Water level very deep going down to 130 m at places.
Coastal Aquifers	-	Uncontrolled development is leading to salinity hazards.
Peninsular India	-	Characterised by hard rock. Rocks have extreme heterogeneity and restricted storage capability.

Annexure 3.4 gives the major aquifer systems in India.

3.3 The groundwater development in the country is primarily sustained by the farmers themselves or by institutional finance. The public sector outlay is limited to groundwater surveys, construction of deep tubewells for community irrigation, services provided and grants to small and marginal farmers. The flow of institutional finance for groundwater development, mainly through NABARD, is about 60% of the total outlay for groundwater. Public outlay and private sources contribute 20% each. The investment on minor irrigation in the First Five Year Plan was just Rs.65.62 cr. with negligible contribution from institutional finance. This increased to Rs.8615 cr. in the Ninth Plan of which the institutional finance component was Rs.2659 cr. Share of investment in minor irrigation in the First Plan was 14.2% and this increased to 17.7 % in the Ninth Plan. The number of groundwater structures has increased from a mere 4 million in 1951 to 17 million in 1997. The irrigation potential created from groundwater, which was 6.5 m.ha. at the time of Independence, increased to 45 m.ha. by the end of the Ninth Plan.

3.4 The frenetic pace of groundwater development has not been without attendant deleterious effects. In our country, groundwater ownership is tied to the ownership of land. A person who owns the land also owns the groundwater resource below the land. This legal position, compounded with the fact that free or subsidised power to the agriculture sector is in vogue in many States, has led rapid decline in groundwater levels in many parts of the country. During the drought years, the tendency is to exploit groundwater, extensively and intensively, lead to rapid decline in water levels. The water level in 306 districts in 20 States has fallen by over 4 m during the period 1983-2003. Categorisation has also been done of the blocks/ taluks/ watersheds in the country as over exploited (where level of groundwater withdrawal exceeds the recharge) or dark (where the level is 85%-100% of the recharge). Of the 7928 blocks/ taluks/ watersheds in the country, 673 (8.49%) are over exploited while 425 (5.36%) are dark or critical. Annexure 3.5. gives the location of the over exploited and the dark blocks.

3.5 Another area of concern is groundwater quality. Arsenic has been detected in groundwater in 75 blocks in eight districts in West Bengal. 6 million people are living in this zone of risk. The problem is now being reported in parts of Bihar & U.P. also. While concentration of more than 0.05 mg/l of arsenic is injurious to health, concentrations upto 3.2 mg/lt have been detected in 24 Parganas in West Bengal. Another quality problem is presence of fluoride which causes skeletal fluorosis. 13 States are affected and half a million people suffer from fluoride effects. Iron in groundwater is found in north eastern states. Presence of nitrate indicates groundwater pollution. Out of the 14.2 lakh habitations in the country, nearly 2.18 lakh habitations have water quality problems in the water supply.

The Central Ground Water Board (CGWB)

3.6 The CGWB under the Ministry of Water Resources is the main organisation in the country dealing with the various facets of groundwater. The activities of the Board cover:

(i) groundwater surveys, exploration, investigation.
(ii) assistance to drought affected States with loan of drilling rigs.
(iii) monitoring of groundwater levels.
(iv) water quality studies.
(v) periodical assessment of the country's groundwater resources.
(vi) pilot studies for artificial recharge of groundwater.
(vii) conjunctive use studies.

3.7 Under the Environment Project Act 1986 a Central Ground Water Authority has been constituted in January 1987 to regulate, control, manage and develop groundwater in the country.

3.8 A Model Ground Water Bill has also been circulated by the Ministry of Water Resources to all the States in 1970 and again in 1992 and 1996. So far, only 5 States have enacted some form of legislation (Andhra Pradesh, Goa, Tamil Nadu, Lakshwadeep, Kerala). Gujarat, Maharashtra, West Bengal and Pondicherry have passed a Bill.

ANNEXURE 3.1

BASIN-WISE UTILISABLE GROUND WATER RESOURCES Unit-Billion Cubic Metre(BCM)		
Sl. No.	Basin	Replenishable Ground Water Resources (BCM)
1	Indus	26.5
2	Ganga-Brahmaputra-Meghna	
	(a) Ganga	171
	(b) Brahmaputra	26.55
	© Barak & Others	8.52
3	Godavari	40.6
4	Krishna	26.4
5	Cauvery	12.3
6	Subernarekha	1.8
7	Brahmani-Baitarani	4.05
8	Mahanadi	16.5
9	Pennar	4.93
10	Mahi	4.2
11	Sabarmati	3
12	Narmada	10.8
13	Tapi	8.27
14	West flowing rivers from Tapi to Tadri	8.7
15	West flowing rivers from Tadri to Kanyakumari	9
16	East flowing rivers between Mahanadi and Pennar	9
17	East flowing rivers between Pennar and Kanyakumari	9.2
18	West flowing rivers of Kutch & Saurashtra including Luni	11.2
19	Area of inland drainage in Rajasthan desert	0
20	Minor rivers draining into Myanmar (Burma) and Bangladesh	18.8
	Total	431.32

ANNEXURE 3.2

State wise Groundwater Resources and level of development

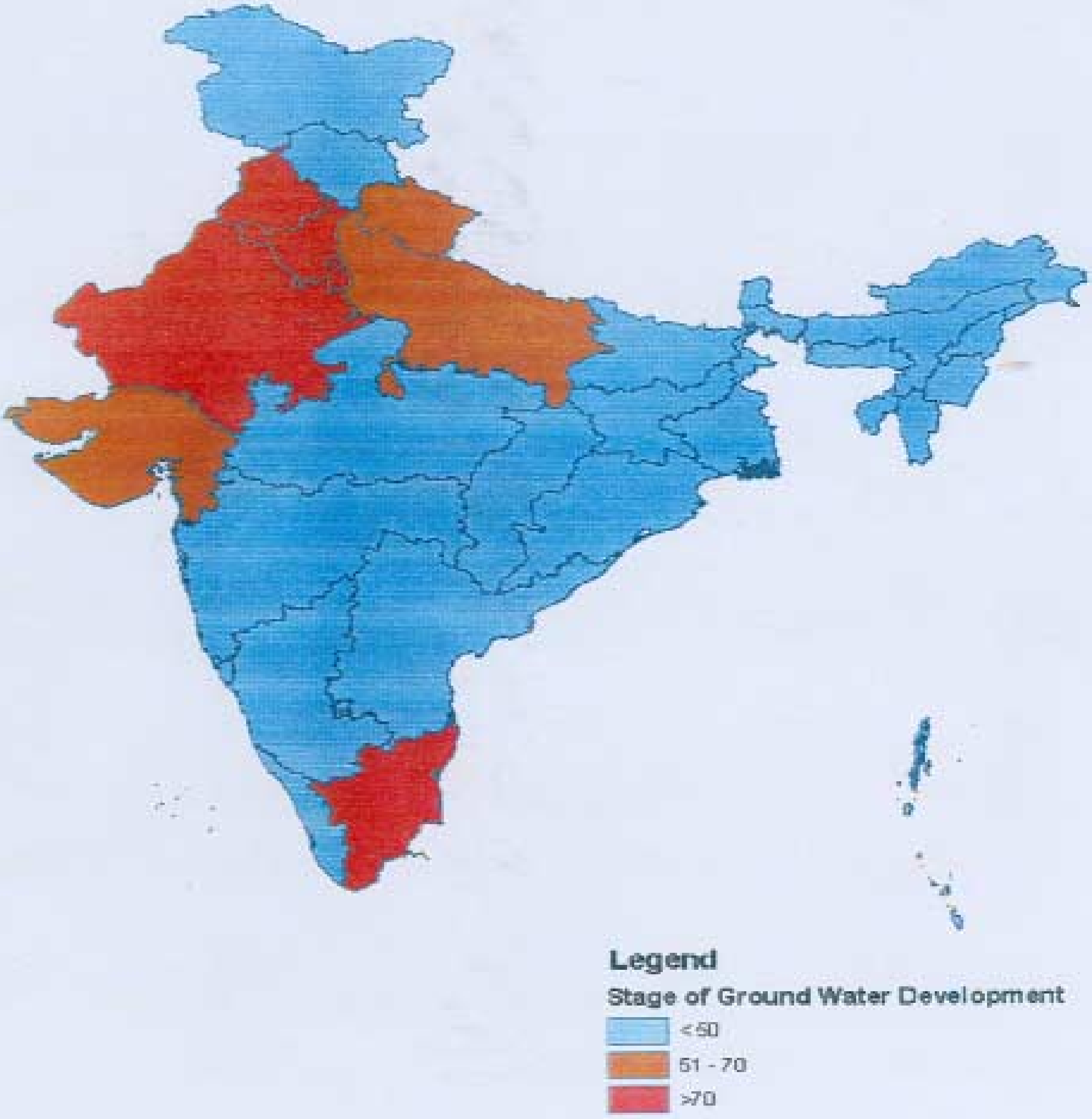
Sl. No.	States/UT's	Total Replenishable Groundwater Resource	Level of Groundwater Development
		BCM/yr	[%]
	States		
1	Andhra Pradesh	35.29	28.56
2	Arunachal Pradesh	1.44	Neg.
3	Assam	24.72	8.75
4	Bihar	26.99	46.33
5	Chattisgarh	16.07	5.93
6	Delhi	0.29	
7	Goa	0.22	8.30
8	Gujarat	20.38	55.16
9	Haryana	8.53	112.18
10	Himachal Pradesh	0.37	10.72
11	Jammu & Kashmir	4.43	0.81
12	Jharkhand	6.53	33.13
13	Karnataka	16.19	34.60
14	Kerala	7.90	22.17
15	Madhya Pradesh	34.82	27.09
16	Maharashtra	37.87	37.04
17	Manipur	3.15	Neg.
18	Meghalaya	0.54	3.97
19	Mizoram		
20	Nagaland	0.72	Neg.
21	Orissa	20.00	21.23
22	Punjab	18.66	97.66
23	Rajasthan	12.71	86.42
24	Sikkim		
25	Tamil Nadu	26.39	64.43
26	Tripura	0.66	33.43
27	Uttar Pradesh	81.12	46.89
28	Uttaranchal	2.70	35.78
29	West Bengal	23.09	38.19
	Total States	**431.77**	**41.53**
	Union Territories		
1	Andaman & Nicobar		
2	Chandigarh	0.030	
3	Dadar & Nagar Haveli	0.042	12.81
4	Daman & Diu	0.013	70.00
6	Lakshdweep	0.002	

Sl. No.	States/UT's	Total Replenishable Groundwater Resource	Level of Groundwater Development
		BCM/yr	**[%]**
7	Pondicherry	0.029	
	Total UTs	**0.116**	
	Grand Total	**431.88**	**41.57**

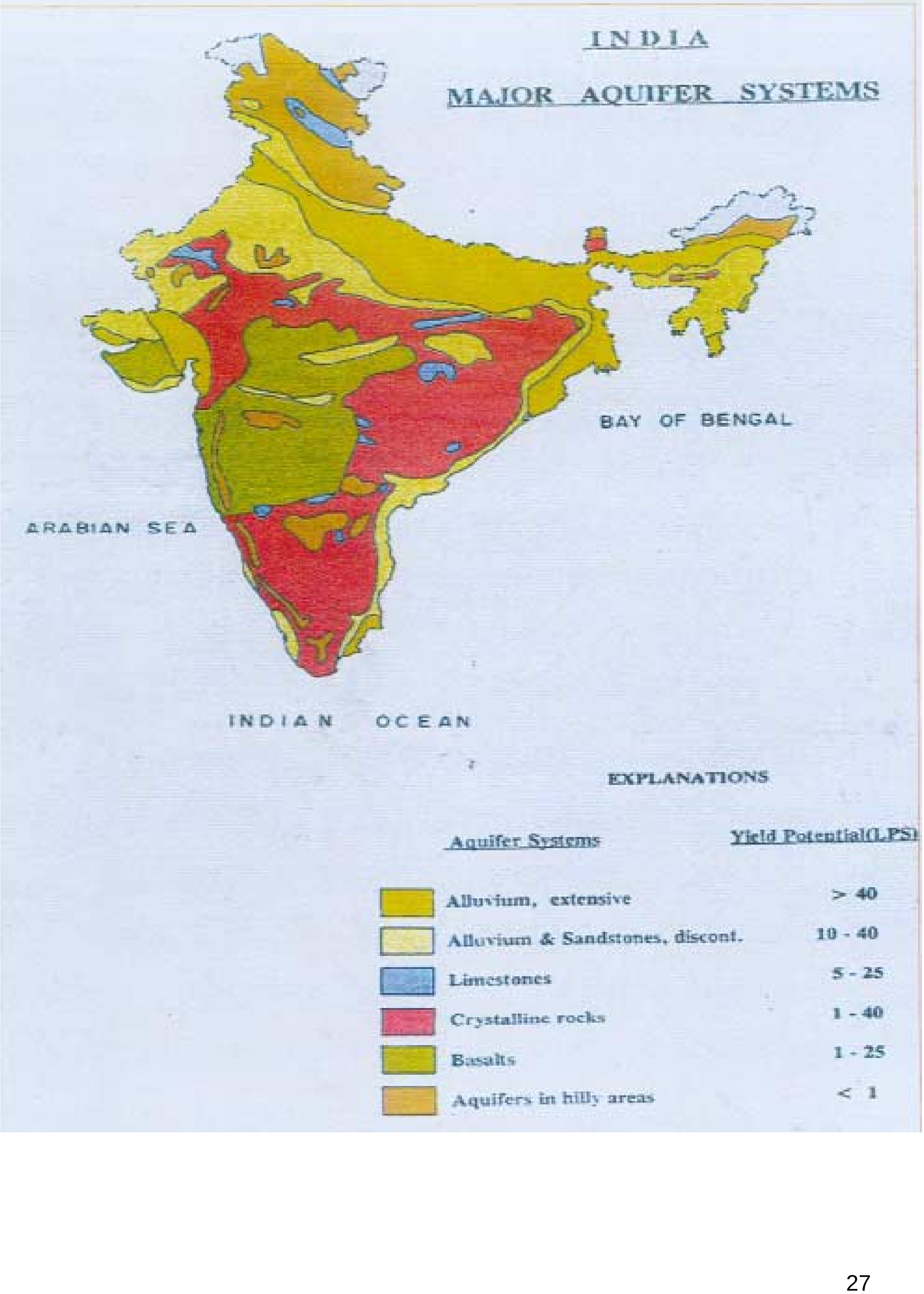
ANNEXURE 3.3

Government of India
Ministry of Water Resources
Central Ground Water Board

Map Showing Stage of Ground Water Devepoment

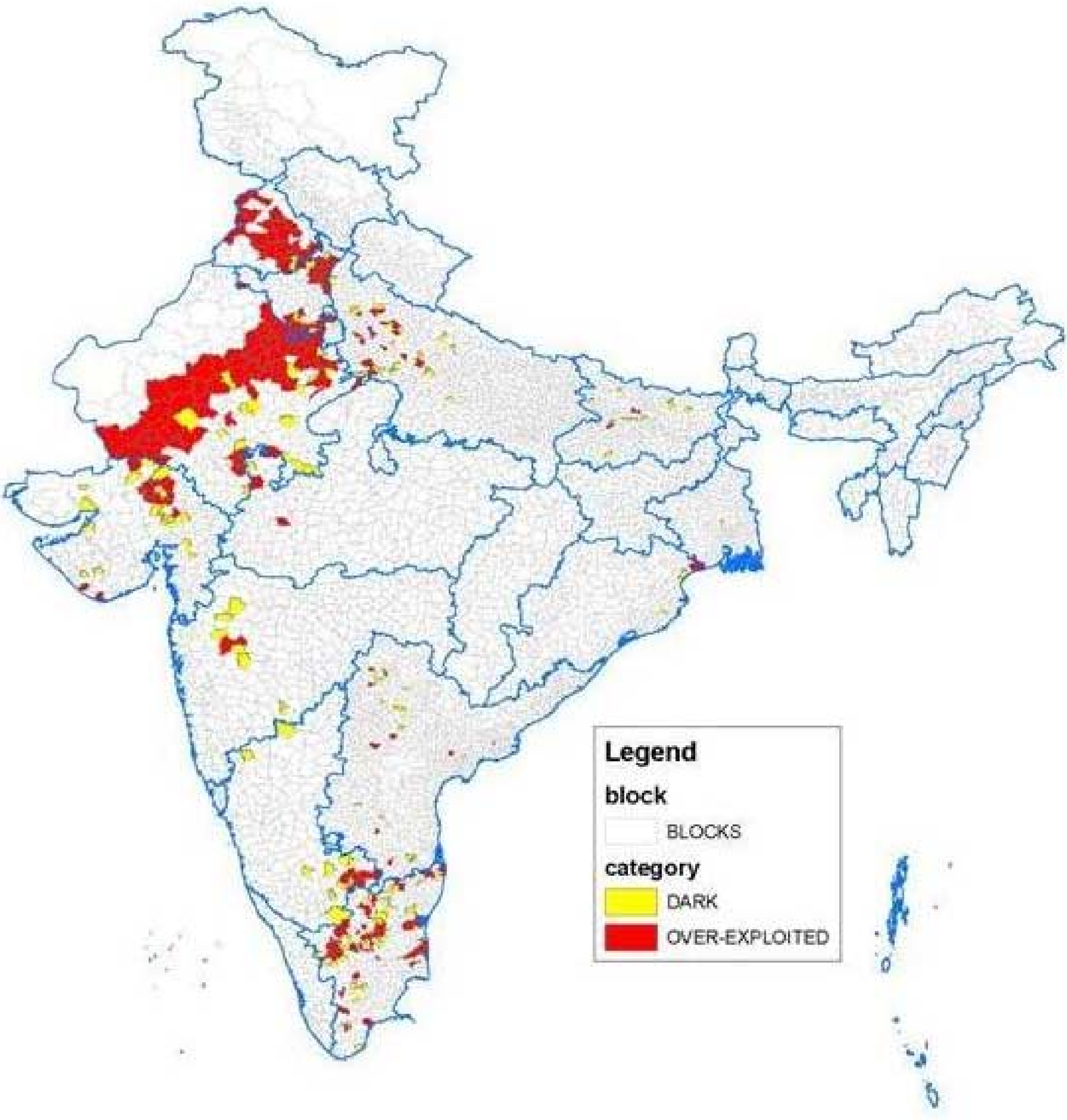


ANNEXURE 3.4


INDIA
MAJOR AQUIFER SYSTEMS
BAY OF BENGAL
ARABIAN SEA
INDIAN OCEAN
EXPLANATIONS
Aquifer Systems
Yield Potential(LPS)
Alluvium, extensive
> 40
Alluvium & Sandstones, discont.
10 - 40
Limestones
5 - 25
Crystalline rocks
1 - 40
Basalts
1 - 25
Aquifers in hilly areas
< 1

Annexure3.5

Map Showing Over Exploited& Dark (Critical) Blocks



4. AGROCLIMATIC ZONES, CROPPING PATTERN AND DIVERSIFICATION

4.1 Climate, soil and availability of water mainly determine the distribution of plants in a given geographical area. The country has been divided into 15 agro-climatic zones by the Planning Commission for sustainable agricultural planning. (Annexure 4.1). More recently, the National Bureau of Soil Survey and Land Use Planning has classified the country into 20 agro meteorological zones depending upon rainfall, soil, topography, length of growing period etc. Eco friendly promising crops and cropping systems that can yield optimum sustainable production have been identified for each agro-eco region and sub-regions. (Annexure 4.2). Through adoption of efficient cropping systems in different agro ecological zones, it is possible to achieve a quantum jump in food production with considerable improvement in economic well being of farming community.

4.2 It is, however, possible to grow crops in areas which are agro-ecologically non suitable for such crops. The notable example is rice in Punjab & Haryana. These kind of innovations no doubt increased food production significantly but at the same time threatens the natural resource base particularly soil, water and bio-diversity. Inefficient and indiscriminate use of fertilisers, irrigation water, pesticides and energy have deteriorated soil physico-chemical properties and groundwater resources. Excessive production of rice residues and their burning to facilitate wheat sowing has increased the load of green house gases in the environment. Indiscriminate use of chemical fertilisers has increased the cost of production over the years and deteriorated the economic condition of the farmers. Modelling experiments have predicted a climatic potential of 15t to 20t/ha/annum for the Indo-Gangetic alluvial plains but the actual potential achieved is only 10t/ha/annum. A paradigm shift is called for from less efficient and environmentally degrading farming practices towards efficient and environment conserving precision farming system targetted at optimising productivity, sustainability and profitability.

4.3 Table below gives suggested State-wise shifts in the cropping pattern for profitability and efficiency.

Suggested state-wise shifts in the cropping patterns for profitability and efficiency

State	Traditional crops grown	Proposed crop to be undertaken
1. Madhya Pradesh	Rice, wheat, jowar, maize, gram, rapseed/mustard, soyabean	Tur, gram, castor, barley, soybean, maize, durum, wheat, urd, moong, fruits
2. Jharkhand	Rice, niger, maize	Til, tur, green gram, durum, wheat, maize, vegetables, scented rice
3. Chhatisgarh	Rice, niger, linseed, small millets, gram	Niger, soybean, maize, scented rice, horticultural crops
4. Bihar	Rice, wheat, maize, lentil, gram, mustard	Scented rice, wheat, pulses, oilseeds, spices, banana, litchi, rabi tur, floriculture
5. Uttar Pradesh	Rice, wheat, maize, sugarcane, gram, tur, rapseed/mustard, millets	Scented/basmati rice, rabi, maize, pulses, soybean fruits, vegetable crops
6. Gujarat	Bajra, groundnut, tur, cotton, castor	Maize, til, castor, date palm, medicinal plants, spices and fodder crops
7. Andhra Pradesh	Rice, cotton, tur, groundnut, jowar, sugarcane	Castor, tur, soybean, maize, sunflower, til, green gram, blackgram, vegetables, coriander, horticultural crops
8. Karnataka	Groundnut, cotton, jowar, castor, soybean, maize, tur, sugarcane	Horticultural crops, spices, floriculture, gram, green gram, tur, coconut
9. West Bengal	Rice, jute, wheat, rapseed/mustard	Wheat, til, maize, mustard, lentil, vegetables, fruits, flowers, spices

State	Traditional crops grown	Proposed crop to be undertaken
10. Haryana	Rice, wheat, bajra, rapseed/mustard, cotton, sugarcane	Tur, gram, scented rice, moong, maize, cotton, fruits, vegetables
11. Punjab	Rice, wheat, cotton, sugarcane	Basmati/scented rice, maize, sunflower, green gram, black gram, barley, mustard, rabi, maize
12. Orissa	Rice, small millets, kharif pulses	Green gram, black gram, tur, groundnut, vegetables, horticultural crops
13. Tamil Nadu	Rice, jowar, groundnut, bajra, sugarcane	Groundnut, tur, green gram, black gram, fruits, vegetables
14. Maharashtra	Jowar, bajra, gram, tur, cotton, sugarcane, soybean	Groundnut, soybean, tur, green gram, black gram, horticultural crops, medicinal plants, floriculture
15. Rajasthan	Bajra, jowar, wheat, cotton, gram, maize, rapseed/mustard	Itur, green gram, black gram, mustard, green fodder crops, guar, moth, spices, horticultural crops

4.4 Evaluation of Cropping System: new Concept

Comparison of efficiency of cropping systems is generally determined based upon productivity and profits. However, unit value of each crop in terms of quality such as nutrient and energy values are seldom compared. Table shows changes in rate of return from different sequences when such values are considered.

Table: Evaluation of Cropping Systems (ICRISAT, Mean of 4 years)

Parameters	Cropping systems			
Ist Crop 2nd Crop	Sorghum Pigeonpea	Moong Sorghum	Maize Chickpea	Sorghum Safflower
Cropping period (days)	180	150	190	190
Yield (Mg/ha) Ist	2.88	0.65	2.44	3.34
2nd	0.94	2.07	1.31	0.79
Nutrient value/ha				
M. cals	11032	7956	10120	10765
Kg protein	508	371	494	453

Kg oil	71	48	157	271
Biomass (Mg/ha)	9510	6776	9363	9023
Energy (M. cals/ha)				
Seed yield + Biomass	41567	29821	41094	44287
Gross return (Rs/ha)	6227	4770	7490	6900
Rate of return (%)	320	173	240	182

Opportunities for Increasing Value in Cropping Systems

Ample opportunities exist for value addition in various cropping systems. Notable examples are:

Pigeonpea for *dal* in pigeonpea + groundnut cropping system
Safflower petals for economic value
Bee keeping in sunflower plots
Safflower+coriander in place of Safflower + chickpea
Hybrid rice and Golden rice cultivation instead of other rice types
High lysine wheat to fetch higher price
High methionine and oleic acid oilseed crops

Value addition in terms of improved nutritive value, profitability, processing and industrialization, employment generation, gender issues, preventing migration to urban areas, on-farm reliance and sufficiency are the issues that will continue to form an integral part of diversification research and promotion in future. Cultivation of quality protein maize should be encouraged for value addition.

4.5 Crop Diversification

In the past three decades, the productivity and cropping intensity have increased many fold through application of improved technology, changes in management practices, and input supply. Significant contribution of research has boosted the food grain production to the level of about 211 million tones during 2001-

2002. However, despite the success in attaining self-sufficiency in food grain production, it is important to note that average size of operational holdings declined at faster rate from 2.30 ha in 1970-71 to 1.57 ha in 1990-91. The land- man ratio has dropped to 0.18 ha in 1995-96 compared to 0.34 ha in 1950-51. The marginal and small farmers together account for 78.2% of the total operational holdings but cultivating only 32.5% of the land. Besides, thousand hectares of fertile soils are being used every year in other developmental purposes viz. roads, housing and industry. The unfavorable agro-climatic conditions such as drought and floods, pests and diseases, cold and heat waves are continuously threatening the future crop production in the country. Further, the gap in prosperity amongst the states and farming community, under employment, deterioration of natural resources and quality of environment are other serious concerns of the present agriculture. The situation calls for transformation of subsistence agriculture to viable industry which would take care of the above challenges by making the present agriculture profitable through introduction of high value and productive crops in the cropping pattern/cropping systems besides the integration of income generating enterprises with crop production. Increasing productivity of water, land, labour and energy through synergetic blending of various enterprises at the disposal of farmers is of current concern.

4.6 Pre-Requisites for Success in Crop Diversification

Changes in food habits, market forces, trade liberalization, domestic needs and other such reasons are encouraging diversification in different agro-ecological situations. However, it is not progressing at the desired level. Some pre-requisites which may help boosting diversification are listed below:

(i) Considering the resources available with different groups of farms, the package of diversification needs to be developed. The socio-economic conditions, domestic needs, market infrastructure and demand of the commodity must be kept in mind while developing such package.

(ii) The priority of crop diversification should be given in rainfed and dry farming situation where low value traditional and economically unviable crops are grown. In such regions pulses and oilseeds should be combined or intercropped with coarse cereals. The farmer's participation in developing the diversification programme is mandatory.

(iii) As export trend in recent past indicated relatively better prospects of processed and value added products over raw materials, it appears worthwhile to create and strengthen processing and value-addition industry in rural areas. This will provide employment to the rural youth and raise the living status of the farming community besides the export avenues.

(iv) The small and marginal farmers who are in majority, should be given additional care in crop diversification programme and they should be provided better loan facility to enable them to adopt crop diversification for raising their farm income and livelihood security.

(v) There is a need to develop multi-enterprise farming system model for small, marginal, medium and large farms both under irrigated and rainfed situations.

(vi) Development of mechanisms for assured purchase of diversified commodities/products at the pre-decided minimum support price will act as an engine for promotion of diversification.

4.7 Diversification Options

Cropping System Based Options

In spite of optimum application of critical inputs, the productivity of most dominant rice-wheat system is either stagnating or declining. Higher inputs use to maintain yield levels is not helping, rather results in problems of ground water contamination and environmental degradation. This is true for many other crops and cropping systems too. This calls for diversification towards other more remunerative cropping systems or resorting to other farm enterprises such as horticulture, agroforestry, animal husbandry, poultry, fish, high value medicinal and aromatic crops etc. Changing consumption and demand patterns and new trade opportunities are providing ample scope for venturing.

Scientists at the Project Directorate for Cropping Systems Research, Modipuram have identified alternate cropping patterns for the predominant rice-wheat system. Their five years data clearly shows that sugarcane-ratoon-wheat system followed by rice-potato-sunflower are much more remunerative than rice-wheat system. There are cropping options such as pigeonpea-wheat and maize-wheat which give almost similar net returns as are obtained from rice-wheat system but save on water approximately by 50 and 33%, respectively compared to rice-wheat system. However, such resource conserving systems are not as dear to the farmer as rice-wheat system. In mid nineties sunflower and winter maize were introduced as alternate crops to wheat during winter season. Both these crops were adopted by the farmers in Punjab, Haryana and western UP and a sizeable area was diverted from wheat towards these crops. However, area under sunflower declined gradually due to lack of availability of hybrid seeds and remunerative market price. Winter maize also met the same fate. The farmers are still persisting with rice-wheat because of assured marketing and price support.

Table: Comparative productivity in terms of wheat equivalent yield and net returns from different cropping systems (average of five years)

Cropping System	Mean yield (t/ha)	Net returns (Rs/ha)	Water requirement/ year (cm)	Employment generation (person days/year)
Rice-Wheat	8.74	26763	165	182
Rice-Berseem	9.37	18572	210	184
Rice-Potato-Wheat	16.40	39891	220	133
Rice-Potato-Sunflower	19.54	48136	205	263
Rice-Wheat-Green gram	10.61	30067	205	230
Sorghum (F)-Wheat	7.77	25300	100	96

Sorghum (F)-Toria-Wheat	8.80	24912	135	143
Pigeonpea-Wheat	8.81	33194	72	102
Maize-Wheat	8.61	25770	112	104
Sugarcane -Ratoon-Wheat	14.46	53151	350	207

F: Fodder

To promote adoption of such diversified cropping options, policy initiatives like assurance for procurement, fixing MSP, creation of post harvest and value addition opportunities for alternate system have become pre-requirements.

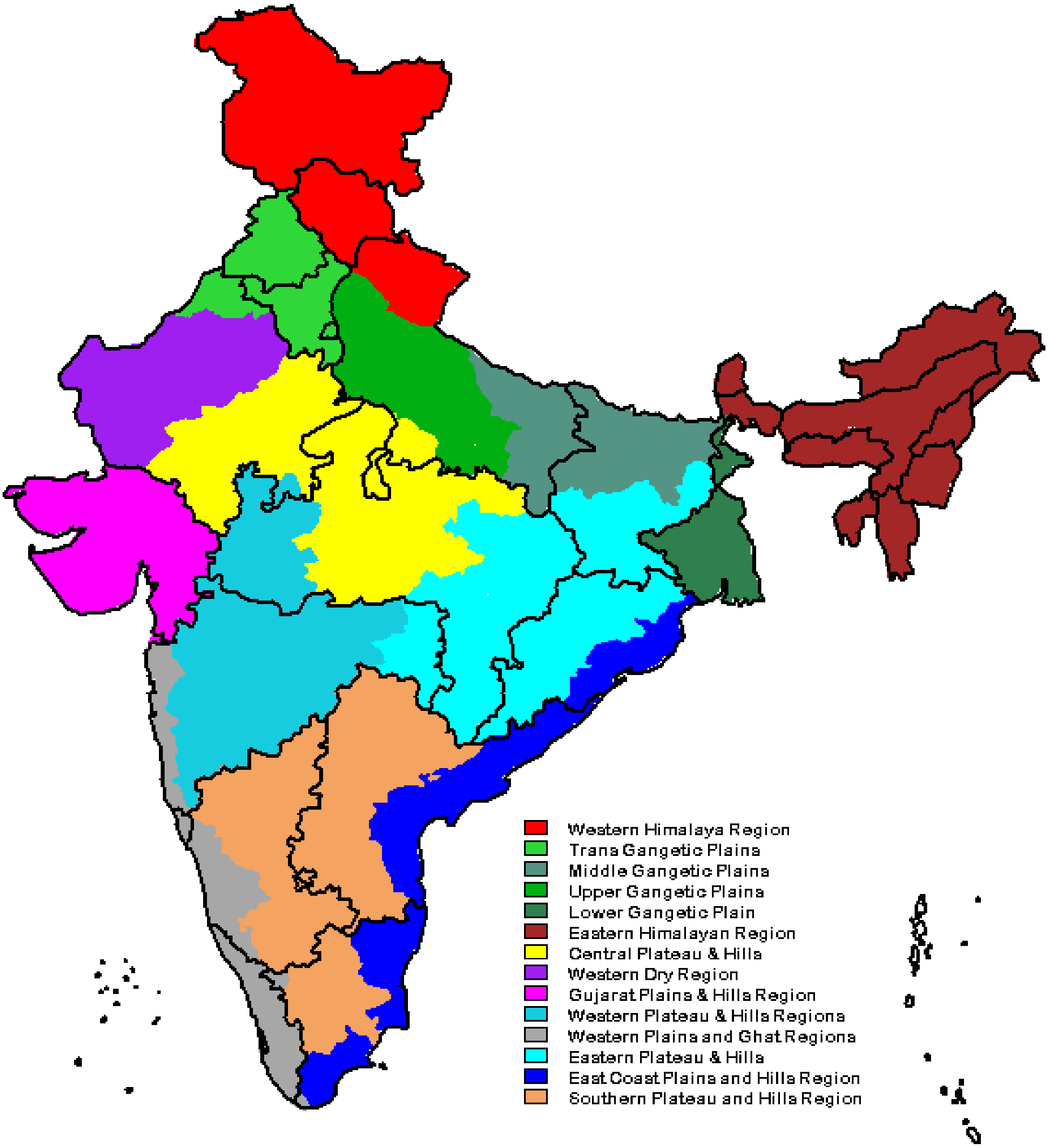
In diversification, the inclusion of legumes in cereal-cereal rotations increases the average productivity and farm income. Mixed cropping/inter cropping is also an important farming practice in rainfed areas to increase profits.

4.8 Agroforestry Options

A sizeable mass of land in the country faces severe degradation due to deforestation. The present area under forest cover is unable to support demand for tree based products. It has been estimated that pulp/plywood worth Rs. 5000 crores is imported annually to meet the demand of industry. Due to decreased forest area and cover density of reserve forests, there is build-up of green house gases (GHG) in the atmosphere. Fuel wood is the main source of energy in rural areas and rural inhabitants particularly landless mainly depend upon trees to meet this requirement. Further to maintain ecological balance, it is imperative that one-third of the total geographical area of a country should be under forest cover. These issues call for developing area specific agroforestry models not only to increase the forest cover but also as diversification and export generating venture. The Task Force on Agroforestry constituted by the Planning Commission in its report has also laid major emphasis to extend agroforestry both in irrigated and rainfed agro eco-regions.

ANNEXURE 4.1

INDIA AGRO CLIMATIC ZONES



Annexure 4.2

Table: Important Cropping Systems for 20 Agro-Eco-Zones

S. No.	Eco-Systems and Name	Soil Type	Growing Period (Days)	Important/Potential Cropping Systems
ARID ECO SYSTEM				
1	Western Himalayan	Shallow skeletal soils	<90	Maize-wheat-pea/cabbage-potato/ cauliflower-millets-red clover
2.	Western plain	Saline soils	<90	Cotton-onion/napier, pearlmillet hybrid/fodder sorghum/maize-wheat-cowpea(f), pearlmillet-potato-pearlmillet
3.	Deccan plateau having hot arid climate	Red & black soils	<90	Maize-gram, hybrid cotton-sunflower, pearlmillet/groundnut-sorghum-gram
SEMI-ARID ECOSYSTEM				
4.	Northern plains and central high lands	Alluvium derived soils	90-150	**For parts of Rajasthan** Bajra/maize-wheat,millet-wheat-mungbean, clusterbean-barley **For Punjab & Uttar Pradesh** Rice-wheat, rice-wheat-cowpea, sugarcane-wheat, rice-cotton, rice-maize **For part of Madhya Pradesh** Jowar-wheat
5.	Malwa highlands & Gujarat plains	Medium & deep black soils	90-150	Groundnut-wheat-greengram, soybean-wheat-greengram, soybean-wheat-fallow
6.	Deccan plateau having semi arid climate	Shallow & medium black soils	90-150	Sorghum-wheat, cotton-sorghum, greengram-*rabi* sorghum-wheat
7.	Telangana plateau and eastern Ghats	Red & black	90-150	Rice-rice, rice-groundnut, rice-blackgram/ greengram
8.	Eastern Ghats, Tamil Nadu uplands and Karnataka plateau	Red loam soils	90-150	Wetlands: Rice-rice-pulse Garden lands: Rice-groundnut-pulse
SUB-HUMID ECO-SYSTEM				
9.	Northern plains	Alluvium derived	150-180	Rice-wheat, rice-wheat-greengram/blackgram/ cowpea, rice-sunflower/*gobhi sarson*, sugarcane-wheat
10.	Central highlands (Malwa, Bundelkhand and Satpura)	Black and red	150-180	Cotton-wheat, soybean-wheat, sorghum-gram-fallow
11.	Eastern plateau	Red & yellow	100-80	Rice-gram, rice-wheat/blackgram/greengram
12.	Chotanagpur plateau and eastern ghats	Red & lateritic	150-180	Rice-wheat, arhar-groundnut/blackgram, rice-groundnut

13.	Eastern plain	Alluvium derived	180-210	Rice-wheat, rice-maize, rice-sugarcane + coriander/leafy vegetables, rice-potato/tobacco
14.	Western Himalayas with warm sub-humid climate	Brown forest & podzolic soils	180-210	Maize-wheat, rice-wheat, millets-potato/tomato/capsicum
HUMID-PER HUMID ECOSYSTEM				
15.	Bengal and Assam plains	Alluvium derived	>210	Rice-rice, rice-mustard-rice **In diara areas** Potato/rajma-rice, sweet potato-rice, rice-buck wheat/niger
16.	Eastern Himalayas	Brown and red hill soils	>210	Rice-sugarcane, rice-potato/sweet potato/mustard/sesame, maize-*rajma*
17.	North-eastern hills	Red & lateritic	>210	**In valley area** Rice-mustard/blackgram/greengram/lentil, jute-pulses/oilseeds **In hilly areas** Maize-potato, millet-pulses
COASTAL ECOSYSTEM				
18.	Eastern coastal plains	Alluvium derived	90-120	Rice-groundnut, rice-rice-blackgram, rice-vegetables (*bhindi*)/cowpea/cauliflower
19.	Western ghats and coastal plain	Lateritic & alluvium derived	>210	Rice (autumn)-rice (winter)-cowpea/greengram /blackgram//sesame/groundnut, rice-pulses
ISLAND ECOSYSTEM				
20.	Islands of A&N and Lakshadweep	Red loamy and sandy soils	>210	Rice-sesame/bhindi/cowpea, rice-rice-cowpea (f), rice-rice-blackgram/greengram, rice-tomato/ groundnut

5. WATER USE EFFICIENCY

5.1 Rapid industrialisation and urbanisation coupled with continuous decline in per capita water availability of water is putting a lot of pressure on the available water resources in the country. Some river basins like Pennar and Sabarmati are already water scarce. Some more basins will be similarly placed in the coming years. The demand for irrigation is expected to almost double from the present use level of about 541 BCM. which is 83% of the present total water use of about 634 BCM.

Irrigation Efficiency

5.2 Irrigation efficiency may be defined as the ratio of volume of water required for consumptive use by the crop for its growth to the volume of water delivered from the source. Irrigation efficiency accounts for losses of water incurred during conveyance, distribution and application to the field. Irrigation efficiency comprises conveyance efficiency and field application efficiency. Conveyance efficiency Ec can be described as:

$$E_c = \frac{\text{Volume of water delivered to the field}}{\text{Volume of water released at canal head.}}$$

Sometimes conveyance efficiency Ec is split up into E_{c1} and E_{c2} as under:

$$E_{c1} = \frac{\text{Volume of water made available at outlet head}}{\text{Volume of water released at canal head}}$$

$$E_{c2} = \frac{\text{Volume of water delivered at the field}}{\text{Volume of water made available at outlet head}}$$

Field application efficiency Ea takes into account losses which take place in the field like evaporation and run-off from the field.

$$Ea = \frac{\text{Volume of water delivered at the root zone}}{\text{Volume of water drawn at field head}}$$

Overall project efficiency Ep is defined as

$$Ep = \frac{\text{Volume of water delivered to the root zone}}{\text{Volume of released at the canal head}}$$

Ep is thus equal to $Ec_1 \times Ec_2 \times Ea$

Irrigation Efficiency in the country

5.3 For a gross irrigated area of about 80 m.ha., the water use is 541 BCM which gives a delta of 0.68 m per ha. of gross irrigated area. The average annual rainfall is 1170 mm (1.17m). Taking 70% of the rainfall as effective for crop consumptive use, the gross water use is about 1.45m (4.8 feet) per ha. of the gross irrigated area. This is very high as compared to water use in irrigation systems in say USA where water allocation is about 3 feet. This overuse in the country reflects as low irrigation efficiency of about 25% to 35% in most irrigation systems, with efficiency of 40% to 45% in a few exceptional cases. A basin wise study conducted by Dr. A. Vaidyanathan and K. Sivasubramaniam of the Madras Institute of Development Studies using potential evapotranspiration data and gross water withdrawals reports the overall irrigation efficiency in the country as 38%. The study reveals that the Krishna, Godavari, Cauvery and Mahanadi systems have a very low efficiency of around 27% while the Indus and Ganga systems are doing better with efficiencies in the range of 43%-47%. This is understandable as the peninsular rivers have large areas under irrigation in delta areas, where the water management practices are poor, while the rotational water supply ('warabandi') is practised in Indus and Ganga systems. However, this is only a macrolevel study. Project level data availability on irrigation efficiency unfortunately is minimal. It needs to be appreciated that 55% of the area irrigated is by groundwater sources where the efficiencies are quite high (70 to 80%) in view of absence of long conveyance systems. Consequently the efficiencies in surface irrigation systems must be much lower than the 38% average figure.

5.4 Reasons for Low Irrigation Efficiency

The reasons that contribute to low irrigation efficiency can be identified as follows:

(i) Completion of dam/ head works ahead of canals – There are many examples of dams/ head works being constructed much ahead of canals. Thus part of the command area gets developed in the head reaches where farmers over-use the available waters by either growing cash crops or applying larger-than-needed water doses to crops like paddy. This not only affects crop productivity but also leads to water-logging and soil salinity (5 to 6 m.ha of irrigated areas in major and medium irrigation commands is estimated to be water-logged). When the command area subsequently develops with extension of canals, the head reach farmers are reluctant to cut down on their water allowance which they have been traditionally enjoying. This leads to less supplies to tail-enders.

(ii) Dilapidated irrigation systems – it is estimated that 20 to 25 m.ha. of surface water irrigation systems need extensive repairs. This situation has arisen mainly due to their poor maintenance by State Governments resulting from inadequate allocation for Operation & Maintenance (O&M). Some of the common malaise in irrigation canals are accumulation of silt, growth of weeds, damage to structures, slip failure of canal banks and lining, rat holes etc.

(iii) Unlined Canal Systems – from cost considerations, canal systems were not lined in the past. This causes excessive seepage especially in sandy loamy soils. Ground water recharge is often cited as a benefit of canal seepage. While in diversion structures, such recharge could be beneficial for use in winter and summer seasons, in storage structures it would be economical to save on seepage and use stored supplies by gravity rather than spend on pumping.

(iv) Lack of field channels – Field channels are required for conveying water from outlet to each individual field. Lack of field channels leads to poor water management as flood irrigation has to be resorted to (as in delta irrigation systems). Field channels construction is taken up as a separate programme under Command Area Development (CAD). State Governments do not allocate enough funds for CAD as the priority is usually for dam and canal construction.

(v) Lack of canal communication network – Canal water gets wasted through canal escapes if there is sudden rainfall in command area when demand for irrigation water falls. An efficient canal telephone system will keep the head works control room promptly informed of the weather conditions so that water is not unnecessarily released into the canals. Most irrigation systems do not have desired communication facilities.

(vi) Lack of field drainage – while expansion of the irrigation system has received lot of attention in terms of funding, due attention has not been paid to drainage, especially field drainage. The main and intermediate drains, which have to carry off field drainage water, are mostly in a bad shape choked by weed growth.

(vii) improper field levelling – farmers apply excess water to ensure that water reaches plants situated on higher ground.

(viii) absence of volumetric supply – irrigation water charges are based practically in all states on the basis of area and type of crop and has no reference to the volume of water used. The irrigation water rates in most states not only do not convey the scarcity value of water but are also grossly inadequate to meet the O&M costs. A large portion of the O&M allocation gets consumed by the establishment component. The actual realisation of water charges as a percentage of the demand is also very low in most states due to a inefficient collection system, loop-holes in irrigation acts and remissions announced on account of drought.

Data collected by the Planning Commission for a few states for the year 1998-99 is very revealing in this regard.

(Rs. lakh)

State	Total O&M expenditure	Revenue realised through water charges	%	Percentage expenditure on Works establishment & Others	
Andhra Pradesh	12627	9316	73.8	13.4	86.6
Assam	565	0.4	0.07	0.8	99.2
Gujarat	3005	848	28.2	44.6	54.4
Haryana	15157	4016	26.5	6.9	93.1

(viii) Inadequate extension services – farmers need to be continuously educated on cropping pattern suited to soil and agro climatic conditions, periodicity of water application, fertiliser, weedicide, pesticide uses, etc. The extension services in most states are weak and do not cater to all the above areas.

5.5 Urban Water Use Efficiency

The present drinking water use in the country is only about 42 BCM. This is expected to increase to 102 BCM by 2050. Rural water supply needs are met mostly from groundwater through dugwell, borewell, shallow or deep tubewell. Water loss in rural water supply schemes is thus not significant as most of the people draw their supplies from public stand-posts. Urban water supply involves carrying water over long distances through pipe lines and thus there is ample scope for conveyance losses and pilferage. Such losses are usually termed as 'unaccounted for losses' and it is in the range of 30 to 40%. In Chennai city, a study conducted by National Environment Engineering Research Institute (NEERI), Nagpur in 1975 came up with 35 to 40% leakage losses. Even in a small city like Indore, Water & Power Consultancy Services (WAPCOS) study estimated 35 to 40% losses.

The main reasons for low urban water supply efficiency are:

(i) unauthorised connections and pilferage.

(ii) lack of adequate number of storage tanks leading to unequal distribution.

(iii) theft of taps from public standposts resulting in continuous flow of water.

(iv) very old distribution network causing leakages.

(v) low water tariff, not adequate revenue to maintain the system after meeting establishment and power costs.

(vi) unmetered supplies.

(vii) wastage of treated water for gardening, washing cars and courtyards.

5.6 The norms for water supply are 40 litres per capita per day (40 lcpd) for rural water supply, 70 lcpd for towns with piped water supply but without sewerage, 140 lcpd for cities with piped water supply where sewerage exists and 150 lcpd for metro/mega cities. The break down of these norms, use wise, is as under.

<table>
<tr><th>Use</th><th>40 lcpd</th><th>70 lcpd</th><th>140 lcpd</th></tr>
<tr><td>Drinking</td><td>3</td><td>3</td><td>5</td></tr>
<tr><td>Cooking</td><td>5</td><td>5</td><td>5</td></tr>
<tr><td>Bathing</td><td>15</td><td>20</td><td>55</td></tr>
<tr><td>Washing (utensils,house)</td><td>7</td><td>12</td><td>45</td></tr>
<tr><td>Ablution</td><td>10</td><td>15</td><td rowspan="2">30</td></tr>
<tr><td>Flushing</td><td>-</td><td>15</td></tr>
</table>

5.7 In the sewerage sub-sector, lot of water is wasted in the old large sized cisterns for flushing. While modern cisterns are of 5 lts. capacity, the older versions are 13 to 15 lts. capacity. In most cities, dual supply does not exist and hence treated water is used for all purposes whereas it is required only for drinking.

5.8 Most urban areas require augmentation to meet the demands of increased population but urban local bodies lack funds for new investments in infrastructure. Delhi Jal Board is one example where due to low water tariff, the Board is unable to meet even its expenditure on staff and power charges. To augment Delhi's water supply, large investments are required to be made by the Board in planned storages in Upper Yamuna basin for which it does not have the resources. Cities like Chennai are already facing a grave water crisis. Many other cities will follow suit unless urgent steps are taken to augment availability and cut down on losses.

6. RESEARCH AND DEVELOPMENT NEEDS

6.1 The modern concept of Integrated Water Resources Management considers two basic categories:

- the natural system, which is of critical importance for resource availability and quality, and

- the human system, which fundamentally determines the resource use, waste production and pollution of the resource. An integrated approach must balance consideration of both categories and their inter-dependence. In this context, some relevant issues that need the attention of researchers and water resources scientists are discussed.

6.2 Water quality aspect of irrigation returns flow

Portion of the irrigation water applied to crop fields is infiltrated into the soil and percolated down, and eventually joins the groundwater flow in the aquifer below. The rate of groundwater recharging due to irrigation (irrigation return flow) depends upon a number of factors including the quantum of water applied, soil characteristics and hydraulic parameters, etc. Detailed studies on the quantitative aspect of irrigation return flow is yet to be carried out for different cropping conditions/ patterns in different geographical regions of the country. Especially in regions where well irrigation is practiced along with canal irrigation, the return flow reaching the aquifer system is partly re-circulated to be used effectively again as irrigation water. Thus, the net percentage of irrigation water that is being utilised to replenish the aquifer system needs to be ascertained with more precision.

Further, the quality of water being recharged by irrigation return flow is obviously inferior to the irrigation canal/ well water due to application of fertilisers and pesticides in the agriculture field. The leaching of agrochemicals in the field can contaminate the aquifer and pollute the wells. Appropriate agricultural management practices and scientific methodologies need to be developed for ensuring a specified quality of irrigation return flow. Research input is required in developing technological solutions for treatment of aquifer system contaminated through leaching of farm wastes/ agrochemicals in the fields.

6.3 Improving water quality monitoring

Approaches to collecting water quality data need refining to ensure that the information gathered is relevant to management issues, as well as scientific understanding, and that its benefits clearly outweigh the costs of data collections. As the need to assess the water quality is increasing, it is appropriate to develop national standard for monitoring and assessment.

6.4 Minimum standards for water quality parameters in drinking water

The minimum standards for various water quality parameters are available for drinking water as per world/ national standards. The water purifying units manufactured by various companies may be following these norms in calibrating the purification systems.

However, even with the acceptable minimum limits, the intake of the amount of a toxic substance through drinking water can be different for different volumes of water consumption. Further, the human water consumption is varying with seasons as well as geographical locations indicating different intake of toxic substances even after adhering to the specified minimum limits by the water purifying systems. Investigations can be carried out into these aspects, to come out with new limits for water quality parameters by considering the total intake of water.

6.5 Effect of water quality on human health

Freshwater, both surface water and groundwater, is an important medium for the transport of toxins, viral and bacterial diseases and parasitic infections. Water quality impacts on human health are exacerbated in areas of high water stress, where the water withdrawn annually for human use is more than 40% of the water available. Thus R&D efforts are needed to understand better the relationships between water quality and quantity and their effects on human health.

6.6 Need for water quality based water budgeting system

In the traditional water budgeting method, the quantities of various components in the water balance equation are computed/ estimated. However, with a view to resource utilisation, the estimated quantities by this method will not always be available as a result of quality deterioration by water pollution or naturally unusable water quality in certain regions. Therefore, it may be desirable to devise ways and means to incorporate the water quality parameters while estimating the water budget so that utilizable estimates of various components of the water balance may be obtained. Methodologies have to be formulated and standards need to be redefined in a holistic manner to achieve this.

6.7 Water resources assessment and management in hard rock terrains

More than two-third area of the country falls under the hard-rock terrain. The unique hydrogeology of the hard-rock terrain makes the process of water resources planning, development and management complex. Coupled with scanty rainfall conditions in the semi-arid regions of the hard-rock terrain, the development and utilization of groundwater takes predominance. However, prospecting and development of groundwater resources in the hard rock terrain still remains to be unscientific, and a blind-task in many cases. The recharge issues in such terrain are complicated due to the complex hydrogeology. Technical solutions based on Darcy's law may not be applicable in these aquifer systems due to secondary porosities caused by faults/ fissures/ joints etc. Conceptualization of hard rock aquifer systems by delineating fractures and flow boundaries is still a challenge to be engaged. Estimation of aquifer parameters in hard rock regions is also important in terms of resources evaluation and improved methodologies need to be developed.

6.8 Tools for better management of water resources

The implementation of water resource schemes are time, money and energy intensive. Improvement in success rate of these schemes can be increased by developing Decision Support Systems (DSS) through which alternate water management scenarios could be simulated. There is need to develop more efficient and user-friendly methods to derive the physically based distributed model input parameters for further improving the efficiency of the models used in development of DSSs. Suitable models for different agro-climatological zones should be developed, calibrated and propagated.

6.9 Coordination of R&D activities in different water user sectors

An integrated approach in water resources management is expected to bring about better water user efficiency. For example, the tailrace of a hydroelectric project can cater to the downstream requirements of drinking water, irrigation and inland navigation. Though there are several sector wise R&D efforts going on in the stakeholder departments/agencies, integration of these efforts is not effectively taking place to strengthen the capacity of implementing ministries/agencies. This leads to reduction in water use efficiency, especially where consumptive and non-consumptive uses are involved. Moreover, within a sector, different components of the hydrologic cycle are overlooked, while managing the system. For example, in irrigation systems, often, return flows, conjunctive use of surface and groundwater sources, etc are not taken into account. This leads to considerable reduction in water use efficiency. DST and MoWR may coordinate the R&D efforts in different sectors and take up new R&D works to fill up the gaps.

7. ACTION PLAN

A multi pronged action plan encompassing both supply side augmentation and demand side management is called for, covering completion of ongoing storage projects taking up new storage works, inter-linking of rivers, modernisation of existing irrigation systems, restoration of water bodies, bridging gap between potential created and potential utilised, participatory irrigation management, bench marking, ex-post facto evaluation of completed projects, development of groundwater in potential areas, artificial recharge of groundwater, prevention of overuse of groundwater, promotion of conjunctive use, tapping of the dynamic groundwater resources, on farm water management, change in farming practices, micro irrigation especially for horticulture crops, strengthening of extension activities, S&T inputs, mass awareness, water audit in urban areas, institutional strengthening and setting up of an incentive fund. These are discussed below in detail. The fund requirements for the Priority Action Plan have been worked out and are at Annexure 7.1.

PRIORITY ACTION PLAN

7.1 Completion of Irrigation Projects

There are about 388 major and medium irrigation projects which have spilled over into the Tenth Plan with a completion liability of Rs.91000 cr. (as on April, 2004) Many of these projects were started in the pre-Fifth and Fifth Plan periods. Completion of these projects will provide another 76 BCM of storage and bring about 13 m.ha. additional area under irrigation. The main reasons for such a large backlog of projects are:

(i) water being a State subject, States have been taking up too many irrigation projects on the plea of correcting regional imbalances or in order to quickly utilise allocations made by Tribunals on inter-State rivers. Investment clearance of projects by the Centre is not a statutory requirement.

(ii) the investments in the State Plan for the irrigation sector have been declining over the successive Plans. (From 23.25% in the Fifth Plan to 16.5% in the Ninth Plan).

iii) there have been time and cost over runs for practically every project due to inadequate annual allocation, delays in resettlement of project affected families, land acquisition and so on.

The Accelerated Irrigation Benefits Programme (AIBP) was launched in 1996-97 to assist the States in completion of 'last mile' projects. Although about Rs.14000 cr. has been released under the programme, only 32 projects could be completed out of 136 projects being assisted. The programme suffers from several infirmities as has been pointed out in a recent CAG report also. The pace of potential creation under the programme has also been slow. Projects need to be identified with low balance cost per ha. of balance potential so that maximum returns are assured for every rupee spent. Modern tools like remote sensing should be used to monitor potential creation. Since one of the observations of the CAG is that States delay release of AIBP funds to project authorities, the Centre could consider placing of AIBP funds directly with banks from where project authorities could draw as per requirement without depending on State Finance Dept.

The National Commission for Integrated Water Resources Development, in its Report of September 1999, has strongly advocated prioritisation of projects by States based on twelve attributes and allocation of funds to higher priority projects for their early completion. All States must be directed to adopt this methodology for allocation of funds to projects from 2005-06 onwards. The AIBP could be linked to such an exercise so that higher priority projects can be benefit from this funding.

A large number of the on-going major projects are unapproved mainly for want of environment and forest clearance. Such projects are thus ineligible for various assistances like AIBP and external aid. To speed up environmental clearance, MoE&F could consider some more relaxations like raising the cost limit for major projects needing environment clearance from present Rs.100 cr. to Rs.250 cr. and exempt major projects from need for environmental impact assessment for culturable command area up to 25000 ha. from the present 10,000 ha. (medium projects only) if adequate provision for drainage and conjunctive use has been made.

7.2 Modernisation of Irrigation System

It is estimated that about 20 to 25 m.ha. of irrigation systems in the country need rehabilitation & modernisation. With an average investment per ha. of about Rs.8000, the total requirement is Rs.16000 cr. to Rs.20,000 cr. The main components of modernisation would be desilting of canals, weed removal, repairs to banks and lining, selective new lining in vulnerable reaches, repairs to structures, provision of off-line storages and communication system. It is estimated that even a 10% improvement in efficiency can make available about 50 BCM additional water. System improvement can lead to other benefits, besides water savings, like equity in supplies, reduction in water logging and improvement in crop productivity. There is no scheme with the Centre to assist the States in this area. A National Irrigation System Modernisation Project needs to be launched linking to reforms like raising of water charges and participatory irrigation management for sustainability of assets repaired. Canal automation has not been successful in our country due to maintenance problems.

7.3 Restoration of Water Bodies

There are 5 lakh tanks in the country. Most of them have silted up. It is estimated that about 2 m.ha. potential has been lost due to this. A pilot project for restoration of such water bodies is already being launched to be followed by a National Project. Funding from external sources needs to be tied up for the larger national project.

7.4 Development of Groundwater

Out of the 64 m.ha. of groundwater potential only 45 m.ha. has been developed. Potential exists in certain States like West Bengal, Orissa, eastern UP, Andhra Pradesh, Assam, Chattisgarh for further development. The Ministry of Water Resources have already formulated a scheme for groundwater development in 19 States where the stage of groundwater development is less than 70%. The scheme assisting Rs.15300 cr. will bring additional area under irrigation of 5.2 m.ha. 40% is planned as Central subsidy while 50% will be loan and 10% beneficiary contribution. Such back-ended subsidy schemes have been successful in Assam and in Bihar. If a second green revolution is to be ushered in, groundwater development will be an important input.

7.5 Artificial Recharge of Groundwater

The declining groundwater levels in the country are a matter of concern. Artificial recharge of groundwater with rainwater is an important strategy to arrest this trend. The CGWB have already prepared a master plan to recharge 36 BCM of rainwater into the groundwater at a cost of Rs.24500 cr. Except for pilot projects in the Eighth & Ninth Plans, no serious effort has been made to implement this on a mission mode. In urban areas, many cities have by-laws making rainwater harvesting compulsory for new buildings. However in rural areas there is no such programme. The master plan needs to be implemented in phases. The CGWB have already proposed a Rs.3000 cr. project in the Tenth Plan. However, the existing level of funding permits only a Rs.175 cr. demonstration project.

7.6 On farm Water Management

On farm water management covers a gamut of areas like field channels, field drains, land levelling and irrigation scheduling with the objective of reducing field application losses. The works below the outlet are traditionally taken as command area development works and not included as a part of the scope of the irrigation project which stops at the outlet. Out of an investment of Rs.1,48,000 crores in major, medium and minor irrigation till the Ninth Plan, the investment in command area development works has been only Rs.6800 cr. or 4.6% . This is an important contributory factor to poor on-farm water management viz. low application efficiency and shortage in supplies to tail enders. Since stepping up of CAD allocations by States will be difficult, one measure that could be taken is to include all CAD works as a part of the project itself so that infrastructure required for irrigation water to reach every field is implemented alongwith the dam. This, together with conjunctive use, will no doubt hike project cost but since compartmentalised approach has not succeeded, an integrated approach will have to be seriously considered.

7.7 Micro Irrigation

Micro irrigation, comprising drip and sprinkler, has emerged as a tool for effective management of resources which saves water, fertiliser and also electricity and distributes benefits evenly unlike other irrigation systems. Drip irrigation is ideally suited for horticulture crops like pomegranate, grapes, mango, banana, guava, coconut, 'amla' and cash crops like sugarcane. Drip irrigation saves 25 to 60% water and upto 60% increase in yield can be obtained. Sprinklers are useful in undulating land with cereals crops and save 25 to 33% of water. Out of the 69 m.ha. net irrigated area in the country, only 0.5 m.ha. under drip and 0.7 million ha. under sprinkler has been achieved. Maharashtra has 46% of the area under drip in the country. Karnataka, Tamil Nadu and Andhra Pradesh follow with percentage area of 21%, 14% and 12% respectively. Drip irrigation methods range from simple bucket kit systems for small farms to automated systems linking release of water to soil moisture conditions measured continuously by tensiometers.

The Govt. of India constituted a Task Force on Micro Irrigation under the Chairmanship of Shri N. Chandrababu Naidu, former Chief Minister of Andhra Pradesh. The Task Force in its report of January 2004 has recommended increasing the area under micro irrigation by 3 m.ha. in the Tenth Plan and 14 m.ha. in the Eleventh Plan with investments of Rs.10,500 cr. and Rs.51,000 cr. respectively. The Task Force has suggested levying of import cess of 5% on items like pulses, oilseeds and horticultural products, allocation of 10% of funds on irrigation projects and making available credit to farmers at 6% interest step for raising required resources. The Task Force has suggested a combination of Central funding, external aid, NABARD loan and beneficiary contribution for implementing the scheme. The group has also suggested other fiscal and tax incentives to promote micro irrigation.

It is suggested that while sanctioning new irrigation projects, it would be made obligatory for project authorities to implement micro irrigation in at least 10% of the command area. The various suggestions of the Task Group also need to be taken note of as micro irrigation has the potential to transform Indian agriculture.

OTHER ACTION POINTS

7.8 Bridging gap between potential created and utilised

As per data compiled in the Planning Commission based on feed back from States, there was a gap of 14 m.ha. between potential created (about 94 m.ha.) and potential utilised (80 m.ha.) at the end of the Ninth Plan. The reasons for this are many – change in cropping pattern from that envisaged at project design stage, silting of reservoirs, lack of field channels, poor condition of canals are the important ones. There is a need to make a project-wise reassessment by States of potential created and potential utilised based on actual performance. The figures of potential created and potential utilised would thus undergo revision and would be realistic; hopefully the gap will considerably narrow down. This exercise needs to be jointly coordinated by the Ministry of Water Resources and the Dept. of Agriculture. If this exercise starts now, it could be completed by the end of the Tenth Plan. The major projects could be first taken up as they constitute bulk of the potential.

7.9 Benchmarking of Irrigation Systems

In simple terms, benchmarking is an introspection, a continuous process of measuring one's own performance and practices against the best competitiors and is a sequential exercise of learning from other's experience. Opportunities for improvement get accordingly identified and the cycle of improvement continues. In the irrigation sector this would mean more productive and efficient use of the water i.e. more 'crop per drop'. The Ministry of Water Resources have already identified some projects for carrying out benchmarking. This needs to be extended to at least all the major projects in the country.

7.10 Performance Evaluation

Project-wise efficiency data is very scanty in the country. Improvement can be planned only if we know where we stand today. Performance evaluation of all irrigation projects must be made mandatory not only to cover actual efficiency measurement but also to evaluate the actual hydrology, cropping pattern, crop productivity etc. to compare it with design assumptions. The diagnostics to remedy the situation can then easily be planned.

7.11 Promotion of Conjunctive Use

Conjunctive use of surface and groundwater is practised on a large scale in Haryana and Punjab making irrigation intensities of 180% to 190% possible. However, the level of conjunctive use in most irrigated areas leaves much to be desired. There is immense scope for such use in delta areas of Krishna and Godavari. Conjunctive use reduces the pressure on surface water and is also an insurance against water logging. During planning of irrigation projects, a token provision is made for groundwater development but no serious attempt is made to integrate this in project planning. A diagnostic analysis of all projects will reveal areas where potentialities exist. For all new projects, conjunctive use should be made obligatory and its development cost included as a part of the project.

7.12 Prevention of Overuse of Groundwater

Legislative measures to curb the overuse of groundwater have failed. Only few States have enacted legislation and where enacted, enforcement has been weak. Perhaps the time has come to review the whole issue of groundwater ownership. Attachment of groundwater ownership to land rights has been the root cause of over exploitation. Unorganised water markets in groundwater are reportedly thriving. A review of the ownership issue could mean either attaching the shallow part of the aquifer to the land and transferring the deeper parts ownership to the community or limiting the ownership of the land owner only to the quantum required to meet his needs. With community ownership, perhaps the indiscriminate exploitation of groundwater can be curbed to a large extent. A public debate on this issue needs to be started to mobilise opinion before legislative measures are considered.

7.13 Tapping Static Groundwater Reserves

In addition to the dynamic replenishable groundwater resources, the country is blessed with an enormous groundwater resource below the lowest level of groundwater fluctuation termed as in-storage resource. Preliminary estimates reveal that about 10800 BCM is available upto 450 m. depth in alluvial aquifers including 180 BCM upto 150 m. depth in hard rock aquifers. The availability in off-shore aquifers is still to be estimated. Serious efforts need to be undertaken to correctly assess this availability, aquiferwise, and draw up plans for its exploitation to augment the dynamic availability.

7.14 Drainage

Drainage should be made an integral part of the project. Bio-drainage technology i.e. establishment of trees with high transpiration capacity along canals/water courses needs to be promoted to use the seepage for biomass production and checking rising salinity in command areas.

7.15 Water Rates

For most States raising water charges for irrigation and water supply is politically sensitive and thus they keep putting off the decision. The result is low revenue recovery not adequate to meet even the O&M costs.

On the analogy of electricity, where State Electricity Regulators have been set up, if States set up Water Regulators who can periodically review the water charges and recommend appropriate revision, it may be easier for State Govts. to accept these recommendations. The Govt. of Maharashtra is setting up the Maharashtra Water Resources Regulatory Authority not only to regulate the water tariff system and water charges but also to ensure integrated development of water resources, protect water quality and to decide criteria for water trading. This should serve as a model for other States and the MoWR and Planning Commission should pursue all States to set up such Regulators.

7.16 Urban Water Audit

Urban water wastage occurs both in pipelines and in the houses. All urban water supply agencies must carry out leak detection studies and take remedial measures thereafter. In Chennai, based on such a study, several rectification works were undertaken to reduce leakage from 35% to 15% resulting in improved water supply to individual houses. At the domestic level, significant water saving can be achieved by discouraging use of multi-spout showers and washing of cars, watering of plants with hose pipe etc. Such measures will go a long way in easing water stress in urban areas. Intensive information campaign by municipalities/ water boards is called for.

In domestic flushing, there is lot is scope to save water by reducing cistern size. While the smaller sized cisterns of 5-6 lts capacity should be made compulsory in all new buildings, change of cisterns in existing government buildings and quarters will be a costly proposition. A Senior Railway Officer (now retired) has devised a simple technique of drilling a 12.6 mm hole in the bell dome of the conventional flushing cistern. The leakage of air through the hole drilled in the bell dome disrupts the syphon action at the appropriate time and thus saves upto 3.5 lts water in each flushing action. About 500 flushing cisterns are reported modified in Central Railway of Mumbai which led to a saving of 32 million litres in a 5 year period. Such innovative techniques need to be promoted and encouraged.

Railway stations have the potential for a lot of water saving as standposts are usually heavily leaking, filling of water in rail compartment tanks is done inefficiently resulting in wastage and overflow and a lot of water is consumed for flushing of railway tracks. The Railways must conduct a station-wise study to come up with water saving measures.

The concept of recycling and reuse of domestic and industrial water supply is at a nascent stage in our country. Residential colonies offer immense scope for dual water supply (untreated water is supplied for other purposes while treated water is only for dinking and cooking), low cost sewage treatment and recycling of domestic water. Incentives should be offered to such colonies by way of rebate in house tax and water tariff to encourage them to take up such water saving measures.

7.17 Integrated Use of Poor and Good Quality Water

When canal-water supplies are either unassured or in short supply, such that the farmers are forced to pump saline ground or drainage waters to meet the crop-water requirements, these waters from the two sources can be applied either separately or mixed.

The management practices to be followed for optimal crop production with saline irrigation must aim at preventing the build-up of salinity, sodicity and toxic ions in the root zone to levels that limit the productivity of soils, control the salt balances in soil-water system as well as minimize the damaging effects of salinity on crop growth.

Crops differ considerably in their ability to tolerate salinity/sodicity. These intergenic differences can be exploited for selecting the crop that gives satisfactory yields under a given root-zone salinity. for successful irrigation with saline waters in specific agro-climatic zone, selection of crops should be such as to suit the salinity of the water because it may not be possible to change the quality of irrigation water. The cultivation of high-water-requiring crops like sugarcane and rice should be avoided with brackish waters, as these aggravate the salinity problems. Rice-wheat system is usually not recommended for alkali water irrigation, Late-sown crops, for example wheat, can tolerate only lower levels of ECiw than timely seeded crops.

Further, crops do not tolerate salinity equally at different stages of their growth. In most crops germination and aeration in scarcely seeding establishment are the most critical stages. Therefore, to increase the plant stands, strategies for minimizing the salinity of the seeding zone should be followed. Saline waters should be avoided at some of the sensitive stages to minimize the damage. Under saline conditions, irrigation should meet both water requirements of crops and leaching requirements to maintain a favourable salt balance in the root zone.

7.18. Cropping Pattern for Treated Sewage water

Increasingly higher quantity of domestic and industrial effluents will be available for irrigation in the near future. After treatment these waters can be used for growing crops. Crops which can be raised with treated sewage water are given in Table.

Table: Suggested cropping pattern for irrigation with treated sewage

Treatment Level	Suggested crops in order of preference
Primary treated	Cash crops (cotton, jute, sugarcane, tobacco) Essential oil crops (citronella, mentha, lemon grass) Cereals and pulses (wheat, rice, green gram, black gram, sorghum, pearl millet) Oilseeds (linseed, sesame, castor, sunflower, soybean, groundnut) Fruit crops (coconut, banana, citrus, sapota, guava, grapes, papaya, mango) Vegetables (brinjal or eggplant, beans, lady's finger, etc.)- these should be cooked before eating
Secondary treated	All crops listed above. All crops including vegetables near the soil surface, but consumed after cooking
Secondary treated and disinfected	All crop without restriction

7.19 Farming Practices

i) Zero Tillage: It is a technique in which wheat is cultivated without ploughing the field after rice harvesting. It helps in early sowing of wheat crop particularly when rice is harvested late. Zero tilled wheat gives almost similar yield that is obtained by the traditional method of wheat sowing. Further, it saves on water, diesel and labour and thus help in reducing the cost of cultivation. The left-over rice stubles are recycled in the field to raise organic carbon level. The infestation of grassy weeds particularly P*halaris minor* in zero wheat is much less as compared to traditional wheat sowing. At present, more than 1 million hectare area in the country is under zero tilled wheat. This resource conservation technology needs further promotion.

ii) Furrow Irrigated Raised Bed Planting (FIRB System): This is a system of wheat cultivation wherein the crop is sown on ridges and irrigation is applied through the trenches/channels. This practice saves on irrigation water by more than 20% without compromising with wheat productivity. In some cases higher wheat yield is also obtained as compared to flat sowing method. This practice also helps in better management of weeds such as *Phalaris minor*. The method is gaining popularity with the farmers.

iii) Direct Seeded Rice: The most common practices for rice cultivation in the irrigated areas is through transplanting of seedlings. The nursery is raised more than a month in advance with keeping water stagnated almost daily for a month during May/June when the transpiration rates are also very high. Alternatively direct seeding of rice is being popularized to save on water by moving away from raising nursery and thus reducing cultivation period of rice by almost a month. The productivity of direct seeded rice is reported near to the productivity of the transplanted paddy but the overall profits are reported higher because of saving in water and labour. The only problem in direct seeded rice is the management of weeds. This can be overcome by the use of weedicides.

iv) Laser Land Leveller: The experiments have shown that irrigation efficiency at the field level can be increased by about 10% by laser land levelling. It also increases the crop yields by 5 to

10%. With the introduction of precision land levelling machines, this practice is gaining popularity in India.

Average cotton yields and water application in different methods

Particulars	Irrigation methods			
	Flooding	Furrow	Sprinkler	Drip
Lint yield, Kg/ha	1257	1350	1300	1890
Water applied, cm	203	165	106	81
Yield to water use ratio, Kg/cm	6.19	8.18	11.3	23.3

Effect of furrow Irrigation on yield and water use of maize and cotton

Particulars	Irrigation in each furrow	Irrigation in alternate furrow
Maize		
Saving of water (%)	---	03.0
Yield (q/ha)	41.3	40.6
Cotton		
Saving of water (%)	---	27.1
Yield (q/ha)	20.5	19.8

Relative efficiencies of various methods of Irrigation

Method of Irrigation	Yield (q/ha)	Water use efficiency (kg/ha-cm)
	Groundnut	
Border	23.2	25.85
Check basin	23.8	26.45
Sprinkler	28.9	46.80
	Chilli	
Furrow	18.87	45.03
Sprinkler	24.23	81.57

Deficit irrigation i.e.providing a pre-determined less quantity of water than the total required by a particular crop is another method which can be adopted where water availability is low so that even with marginal reduction in yield per unit area, the total yield and profits will be higher as larger area can be covered.

7.20 S&T Inputs / Solutions to Water Sector

There are several areas in water sector, where there is a scope to improve upon or to introduce innovative techniques, structures, products, etc leading to water use efficiency. Starting from simple design of water taps, it may go up to the design of large water control structures in dams and conveyance systems. There is also considerable scope to look into the conveyance systems with a view to improve their performance and prevent wastage of water. For example, the materials to be used for lining a canal, methods of lining, optimum length to be lined and benefits of lining etc may be further investigated to achieve water use efficiency. Another area deals with evolving standard designs and construction procedures for hydraulic structures, especially on farm structures. Since MOWR and ICAR are looking into many of these aspects, it is felt that the DST should play a major role in organizing the Spatial and Non-spatial data in the water resources sector and making the water resources related information available to the implementing agency for better water use efficiency. In this context, some of the solutions suggested are as follows:

Establishing Hydrologic Data Bank

For hydrologic research aiming at water resources development, data collected from the field over a period of time is essential. This has been highlighted by the International Association of Hydrologic Sciences (IAHS), and the World Meteorological Organization (WMO). Though considerable data on hydrologic and other related parameters are collected by different departments/agencies, there is limited coordination and networking among these agencies, and this adversely affects the uniformity and reliability of data collected at great expense. These data should also be accessible to different departments/agencies and academic and research institutions. Data compilation and mapping form an integral part of the Natural Resources Data Management System (NRDMS) Division of DST, Central Water Commission (CWC) and Central Groundwater Authority (CGWA). In collaboration of these organisations a Data Bank for hydrologic and other related parameters should be established.

The data to be collected, stored and retrieved in the Data Bank may include the following:

Hydro meteorological	Process parameters	Physical parameters
Precipitation (daily & continuous)	Infiltration (seasonal)	Land surface
Radiation (continuous)	Crop water (seasonal)	Geologic type
Temperature (daily)	Evapotranspiration (monthly)	Soil type
Wind velocity (daily)	Soil moisture (seasonal)	Land use
Humidity (twice daily)	Hydrographs (UHG & daily)	Channel details
River stage (daily & continuous)	Groundwater flow (seasonal)	Elevation zones

Stream flow (daily & continuous)	Suspended sediments (bi-monthly)
Ground water level (bi-monthly)	Erosion rate (estimation)

It is important to find out the minimum data requirement at each level of hydrological unit. The experience of "Hydrology of Small Watershed" programme implemented by the DST shows that small watershed level precipitation, evapotranspiration and stream flow are the minimum parameters to be measured for estimating water balance.

Mapping and Spatial Data Framework

Several new integrated approaches are being propounded to achieve the goal of sustainable development of freshwater sources, one such approach being 'ecosystem' approach or watershed approach. The concept of a 'holistic approach' is relatively easy to preach but difficult to practice, mainly because it encompasses not only the domains of physical and natural sciences but also that of social sciences. To achieve success in natural resources management for sustainability, it is necessary to carefully plan for bringing together the two important components, namely (i) the complex web of interactions in nature, and (ii) still more complex web of interrelationships among human needs, expectations and value systems. In such an approach, sustainability calls for due consideration of economic, social, environmental and institutional aspects.

Geographical Information System (GIS) is one of the tools which can considerably help in integrated river basin management.

Advancements in GIS-Remote Sensing techniques can be effectively used in increasing water efficiency in crop production and water supply. Refined data inputs on land use, evapotranspiration, leaf area index, transplanting periods, crop water requirements etc. can be derived using remote sensing techniques. GIS tools can be used to create various thematic layers on boundary, DEM, soil, spatial distribution of rainfall and evapotranspiration, watershed delineation, drainage etc. The spatial data derived using these techniques are highly useful to obtain more refined and dependable results from hydraulic and hydrological modelling of the watersheds/ commands.

The integration of hydrologic models with GIS can help in coming out with Decision Support Systems. The Hydrologic Data Bank proposed to be established along with the RS data will be greatly useful in establishing spatial data platforms useful for integrated river basin management, which in turn will help in achieving better water user efficiency. Through networking different institutions involved in the application GIS, it will be possible to cover several of the river basins in the country. The procedures need to be standardized as a part of this exercise so that uniformity can be achieved in the application of GIS for water resources management.

Need for Water Resources Information Infrastructure

The incoherence between micro level water related schemes and micro level scheme is one of the main reasons for lower water use efficiency. The absence of a mechanism for information flow between micro level watershed and macro level basin calls for an integrated framework. The development of Geo-Spatial technologies and Geo-Informatics has laid to the concept of Spatial Data Infrastructure (SDI). SDI is a combination of technological and policy issues to provide information support to multi level users. Adoption of this concept could surely help in overcoming the problem of incoherence at different level of water management.

Water Quality Information System

On-going developments in tracers, remote sensing and other technologies will provide new tools with which to advance our scientific understanding of the natural and anthropogenic factors influencing water quality, and also to improve our ability to manage and control this aspect of water resources.

Though the Central Pollution Control Board (CPCB) and MoEF are involved in several efforts to investigate and control water quality deterioration through different means, there is no single agency in the country responsible for water quality monitoring and data management. Pollution dispersion also has to be studied in detail with regard to surface water and groundwater sources to avoid further deterioration of the quality of the freshwater sources of the country. A networking with different departments/agencies and academic and R&D institutions can help in this task of establishing a Water Quality Information System. The gaps in knowledge may be identified and future works initiated by DST.

Clearing House For Water Related Information

Electronic clearing house is the mechanism through which the data sets and metadata, which is the data about data stored with different water related organizations are made available. The basic idea is that each orgnisation should have their own data server and through networking and user interface the data could be accessed through a central server.

7.21 Inter Departmental Coordination

The subject of water is presently being dealt at the Centre by many Ministries/Depts.

Ministry of Water Resources	-	Major, medium, minor irrigation, flood control, CAD, groundwater, model study, consultancy.
Ministry of Power	-	Hydropower
Dept. of Land Resources	-	Watershed Programmes
Dept. of Agriculture	-	Soil conservation, watershed in rainfed areas, drought management
Ministry of Shipping	-	Navigation
Dept. of Science & Technology	-	R&D
Dept. of Atomic Energy	-	Desalination.
Dept. of Drinking Water	-	Rural water supply & sanitation
Ministry of Urban Development & Poverty Alleviation	-	Urban water supply and urban sanitation.
Ministry of Environment & Forests	-	Environment clearance for river valley projects.
Planning Commission	-	Investment clearance, allocation of funds.

Though it would be difficult to transfer all the above subjects to one Ministry, better inter departmental coordination is called for. The Tenth Plan Document envisaged setting up a Coordination Committee under Member, Planning Commission with Secretaries of the above Ministries/Depts. as members. Such a body with

Ministry of Water Resources serving as the Secretariat would be useful.

No member of the Task Group has suggested any institutional strngthening of the Ministry/Dept. to better handle water-related issues. However, more coordination seems to be called for in the following areas.

Areas		Ministries/Organisation concerned
Major Irrigation & CAD	-	DAC, MoWR
Rural Drinking water	-	CGWB, DoDWS
Urban Water supply	-	MoUD, MoWR
Water Quality	-	MoEF/CPCB,CWC/MoWR, DST
Farm Practices	-	DAC, ICAR, MoWR
Hydro Power	-	MoWR, MoP
Navigation	-	MoS, MoWR
Watershed	-	DST, MoRD, DAC, MoWR

Each Ministry dealing with water should allocate a small percentage of their budget for information, education, communication, activities to propagate need for water saving. An Incentive Fund at the Centre could also be considered to reward States who undertake and demonstrate water saving measures.