Planning Commission
(S&T Division)

Strategy Paper

on

"S&T Intervention for post-disaster reconstruction efforts in Uttarakhand"

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Executive Summary:

Uttarakhand is home to rich natural resources and wildlife habitats. It is a land of natural beauty, comprising of 93% mountainous and 64% forest cover. Its geographical location, the climate and the vegetation on the region are vary greatly with the elevation and is an eco-sensitive zone. With a very fragile terrain that is prone to natural disasters, the state of Uttarakhand falls within Zone IV and Zone V of seismicity. The state of Uttarakhand is also prone to massive natural calamities, such as rains, cloudbursts, flash floods, landslides, floods, hailstorms and water logging events.

The recent disaster that struck Uttarakhand in June 2013 while was largely due to natural causes such as peculiar monsoon and melting of the glaciers due to climate change, but was also aggravated due to the unplanned development in the region. Various developmental activities pursue over the years could not meet the requirements of the ecology and topology of the region. The huge deforestation, high intensity blasting across the hills, unregulated haphazard construction of houses even in the river terrace region, have led to the destruction of the natural ecosystem and distressed the ecosystem, endangering the local ecology and human life.

Himalaya is one of the least observed regions on the globe. As a result, there is a corresponding knowledge gap in our understanding of this extensive domain of unusually high gradients in topography, temperature, precipitation, biota and the radiative balance. Focused observations on meteorology, snow, ice and glaciers are required to understand the interaction of cryosphere with atmosphere and geosphere. This understanding is a prerequisite for the development of the capabilities to forecast the extreme weather events, and to understand the changes in the mass balance of glaciers. More importantly, monitoring of glaciers is integral to observing and understanding both the climate change and its attendant implications for water security. The role of ecosystem in the Himalayan region on the present and future regional climate needs to be examined such that the capabilities for now casting for expeditions, pilgrimage, tourism, etc. can be developed.

While the relief in terms of food grain and financial assistance were meant for most immediate requirement, Reconstruction, Rehabilitation and restoration of normal life have become major challenges before the state government. This is not only requires help and collaborative efforts from various national and international agencies, but more importantly it calls for scientifically sound planning so that the vulnerabilities to natural hazards are reduced to minimum and developmental activities are sustainable in long term.

Although, rebuilding of Uttarakhand has begun and the efforts would further accelerate in due course of time, however the challenge is to recreate its original form, similar to that before the unplanned developments with ecological and topological structures available. The S&T intervention can play a significant role in this endeavour.

In view of the above, there is a need to develop short term, medium term and long term strategy for reconstruction, rehabilitation and developmental activities of Uttarakhand. This include: Damage assessment, geographical mapping of hazard zonation, reconstruction of damage houses, roads and communication infrastructure, enhance livelihood opportunities for rural people, strengthening of communication systems for early warning and emergency response, strengthening institutional capacity and linkages, main streamlining remote sensing and GIS technology in developmental planning, strengthening of scientific observational network, monitoring and evaluation of developmental activities and capacity building for sustainable management of natural resources.

1. <u>S&T vision, mission and objectives for reconstruction</u>

1.1: Vision

- Provide sustainable development plan for post disaster reconstruction and rehabilitation of Uttarakhand through scientifically designed programmes and build a disaster resilient community in the State.

1.2: Mission

- To carry out damage assessment, identify multi-hazards risk elements, augment observing system, identify new communication technologies; strengthen Information systems, leverage GIS technology, establishment of critical infrastructure, set up a proper consultative mechanism and build human and knowledge capacities etc.
- To integrate the hazard mitigation processes with sustainable practices along with developing strong early warning systems and preparedness strategies.

1.3: Objectives

- Map the neighbourhood of Uttarakhand
- Map fragile and disaster prone areas of Uttarakhand
- Use Geographical System (GIS) to map critical resources and geographical data of the state.
- Prepare spatial databases on different themes, viz. land use/ land cover, land degradation, geomorphology, ground water prospects and biodiversity characterization using satellite imagery
- Focus observations on meteorology, snow, ice and glaciers to understand interaction of cryosphere with atmosphere and geosphere which is prerequisite for the development of capabilities to forecast the extreme weather events
- Network existing institutions in the region for coordinating technical knowhow for developing infrastructure in a sustainable manner in the Himalayan hill region
- Identify a set of reliable, new and effective technologies to cater to the situations created in a disaster
- Provide knowledge base in diverse areas and unique S&T interventions in rebuilding of Uttarakhand
- Establish viable models of rural bio-resource complexes / hubs and rural technological innovation & application centre
- Support R&D component for refinement and validation of technology for addressing the problems of affected groups
- Apart from national mission projects and pilot projects, undertake training & education and research programmes
- Promote use of biotechnological processes and tools for Socio economic up-liftment of affected community in Uttarakhand

- Preservation of food and agro products by radiation processing and address the water quality issues using indigenously developed technologies
- Create entrepreneurship development among the youths
- Provide information on post-disaster relief and support.
- Implement large scale initiative for disaster management proper support in terms of infrastructure like data centre, last mile networking till sub-district level.

2. <u>Assessment of current situation:</u>

2.1: Quantitative impact of disaster

The disaster occurred on the June 15th in upper reaches of Uttarakhand. This was predicated due to the results of global warming and unprecedented 72 hours rain across the Himalayas. The worst hit zone was Rudraprayag district (Kedarnath Valley) of Uttarakhand. Official records revealed that more than 5000 pilgrims and locals lost their lives. Besides, many villages almost washed away, many bridges collapsed, building and huts also succumbed to damage. Due to the worst disaster loss of property and lives are amounting to billions. About 20000 hectares of agricultural land have also been washed away.

2.1: Expectations of Stakeholders

During a disaster, the requirement includes quick assessment of the ground situation on the extent and magnitude of the disaster. The Government authorities need information to take steps to mitigate the risks. Though the State machinery has resources to deploy the rescue operations, they should know where to act, and how much resources have to be allocated. The State & District administrators expect information in an understandable format rather than huge sets of data. Towards this the data from various sources are to be converted into information for decision making and provided to the administrators. The following are the expectations from the stake holders:

- The local level administrators and the common people expect clear directions from the State.
- Laid down policies and Standard Operating procedures on the responsibilities of the stake holders will be useful in ensuring the inter-agency coordination and fast response.
- Construction and renovation of their houses and farm land.
- Reconstruction of roads and bridges
- Necessary infrastructure facility for electrification, sanitation, health care and education etc.
- Regaining loss of livelihood and new avenues as an alternative livelihood
- Create opportunities for self-employment and reduce migration

3. S&T Strategy for Reconstruction

3.1: Short-term strategy

Multi-hazard risk zoning: The state being prone to multi-hazards, reconstruction must be based on scientifically sound planning to prevent/reduce recurrence of disaster losses in future. Spatial zoning based on multi-hazards risks using the scientific data and methods is therefore an immediate requirement for regulating the construction activities. While doing this, all risk elements including dynamic occupants in the building, vehicular traffic etc. need to be considered. Flash-floods, landslides and forest fires being the common recurrent hazards affecting the mankind and ecosystem must be given priority for multi-hazard risk zoning. Additionally, reserve forests/ parks, high biological richness areas, wildlife corridors and other protected areas should also be considered for avoiding (as far as possible) the human interference.

Initial zoning to delineate hot spots for natural hazards can be carried out based on existing scientific datasets on various aspects through a multi-institutional effort. Construction activities in the high and very high risk zones identified through this process need to be regulated through legislation by the government. However, such zones can still be used for other land use practices based on land suitability. Legislation based on such a scientific approach will bring a lot of advantage not only in safeguarding the people and infrastructure from exposure to natural hazards but also conserving the natural environment. These zones can be subject to revision at some regular intervals based on additional scientific data and knowledge.

Detailed geomorphological mapping along major river valleys: In the recent Uttarakhand disaster, major river basins such as Mandakini, Alaknanda, Yamuna, Bhagirathi, Pindar and Kali river basins and many minor basins have undergone significant geomorphic changes in terms of shifting of active channel, bank erosion, toe cutting, increase of river width, appearance and disappearance of channel bar and terrace deposits. Therefore, it is very important to map such new features, which would be extremely useful in planning reconstruction activities. Further, identification and mapping of the highest flood levels of various rivers in the recent past vis-a-vis location of settlements will also be vital to mark unsafe settlements and infrastructure for reconstruction and rehabilitation. ISRO/DOS and GSI have taken-up a collaborative project on nation-wide geomorphological and lineament mapping at 1:50,000 scale. In case of Uttarakhand, mapping for most of the state is already completed. These maps should be revisited in the light of current disaster using latest high resolution satellite imagery.

Landslide inventory: During the recent disaster, many new landslides have taken places and many of the old landslides have been reactivated. Therefore, landslide mapping is needed immediate using the latest (post-disaster) satellite images. NRSC has used post-disaster images to map landslides using a semi-automated method in parts of Char-Dham and Pindar valley; the work is in progress in the remaining part. However, ground truthing of these landslides is needed for detailed characterisation. Geological Survey of India (GSI) has been entrusted with the responsibility of carrying out detailed inventory of landslides. The MANU initiative will also help in this endeavour.

Identifying safer zones for reconstruction: Uttarakhand is prone to frequent natural and man-made/induced hazards which have the potential to cause extensive damage to life, property, infrastructure and natural resources. The common and potential hazards of immediate concern to human kind living in this region are flash-floods, landslides, forest fires, earthquakes, Glacial Lake Outburst Flood (GLOF) and avalanche. Land degradation processes, particularly soil erosion, are other major concern as they have adverse impact on the productivity and environment in the long-term.

Climate change with accompanied environmental degradation poses further threat as it will potentially increase the vulnerability of the society to natural hazards in future. Therefore, relatively safe places for human settlements, new tourist sites, and infrastructure should be identified based on scientific analysis of available spatial and non-spatial data. The multi-hazard risk zoning and land suitability analysis form the key for reconstruction activities and optimal land use planning. Geographical Information System (GIS), rainfall-runoff and flash flood modelling, debris flow modelling, are some of the approaches that could be used for comprehensive risk assessment and identifying safer and environmentally sustainable zones for reconstruction.

The tourist sites and supporting infrastructure including the camping sites (which are often located at the banks of the rivers) need to be evaluated for multi-hazard risks. Wherever needed/feasible, they may be relocated at safer places based on scientific planning. The tourist influx to famous places (particularly Char-Dham) needs to be regulated based on the carrying capacity. Early warning systems and the infrastructure to disseminate the warnings to the tourists needs to be strengthened.

Reconstruction of houses, roads & communication infrastructure: Reconstruction of damaged houses and public buildings, and road and communication infrastructure is one of the top-priorities where the aim should be to reduce the vulnerability to different kinds of hazards (especially earthquake, flood, landslides and forest fires) and restore access to basic amenities and services of governance. Any reconstruction activity of houses and public buildings should be taken up only at safer and environmentally suitable places and as far as possible close to the original locations.

3.2: Medium-term strategy

*Optimal land use planning***:** Land use planning around the new and old settlements should be based on land suitability and the local knowledge/ wisdom for optimum returns.

Strengthening emergency communication systems: Communication plays a vital role in early warning and emergency response. As most part of Uttarakhand is characterised with rugged and inaccessible terrain, a strong network of space-based communication system needs to be established to ensure the availability of communication link even during the disaster. ISRO/DOS has developed Satcom-based early warning and emergency communication systems, such as portable satellite phones (MSS Type-D terminals), DTH-based system, Satellite based Virtual Private Network (DMS-VPN), etc. which can be deployed in critical areas of the state to make satellite communication an integral part of the disaster management. During the recent disaster, ISRO has deployed satellite phones and DMS-VPN user nodes through extended C band 1.8m VSAT antennas in disaster-affected areas which were very useful in supporting rescue and relief operations when the terrestrial links failed.

*Strict scrutiny and implementation mechanism for EIA and EMP***:** Environmental impact assessment (EIA) carried out for hydropower, industrial and other infrastructure projects must be based on scientifically sound data and methods and should be subject to strict scrutiny before granting clearances. Further, effective implementation of environmental management plans (EMP) in developmental projects must be enforced through a monitoring and regulatory mechanism.

Tourism sector: The vulnerable tourist sites/ places and supporting infrastructure need to be relocated to safer places based on scientific planning. New sites should be identified and developed.

Enhancing Livelihood Opportunities for Rural Population: Migration of people from rural areas to towns/ cities in search of employment is a serious issue in the state. The main reason for this is small and scattered land-holdings coupled with low agricultural productivity. New ways to enhance the income of farmers need to be promoted to enhance the livelihood opportunities. These could be: improvement in productivity by adopting high-yield varieties of seed, crop diversification, change from conventional crops to high-value crops, providing marketing support, promoting the self-employment generating schemes, involving people in national schemes like MNREGS and IWMP, etc.

Establish few viable models of Rural Bio-resource Complexes / hubs in the flood affected regions, which can sustain regular livelihood for the community by adoption of integrated model of farming system including agriculture, animal husbandry, horticulture, post-harvest and value addition. This would involve the participation of large number of farming community to provide them tangible benefits with creation of rural entrepreneurship among the youth, SHGs and cooperatives. The models would also have technology driven with the establishment of resource centre and village knowledge centre to promote rural innovation according to the need of hour.

3.3: Long-term strategy

Conservation of Natural Resources and Environment: About 6.6% area of the state is constituted by culturable wasteland and permanent fallow lands. About 11.6% area of the state comes under degraded land, most part of this constituted by the wastelands and permanent fallow lands. Although about 61% of the geographical area is under forest but a considerable portion of it is under degraded forest cover. Similarly, although there is a large potential of water resources but water crisis prevails across the hilly region. These facts point out that there is a lot of scope for conservation of the natural resources and enhance the productivity by adopting scientific, technically viable and environmentally sustainable methods and approaches that are also acceptable to local people.

The sectors which need the attention include: (1) forest and biodiversity; (2) soil and agriculture; and (3) water, including hydropower. The spatial databases on forest types, biodiversity and biological richness, geomorphology, soil (some parts), groundwater, glaciers, land degradation, land use/ land cover, etc. prepared by ISRO/DOS in association with State Remote Sensing Centres and other institutions using satellite imagery with limited field checks can be used for this purpose.

There is a strong need to involve the local people and use indigenous knowledge in protection and conservation of natural resources. Community-based land and water resource development plan and governance need to be formulated and implemented to sustain the developmental programmes and schemes of the government. The concept of generating the assets inventory and other baseline information through community including school/ college level students should also be promoted using the latest tools and technologies.

Strengthening scientific observational network: Himalayan region is data scarce and, therefore, a strong network of instrumented observatories is required to improve the quality and availability of scientific data on land, water and air. These data are needed essentially for two purposes: (1) early warning for natural hazards, and (2) monitoring and evaluating (before, during and after) the developmental activities, projects and programmes and even the disasters.

Cloudburst and associated flash floods, and landslides which are generally triggered by heavy rain are recurring events in the Himalayan region. This warrants a strong network of meteorological instruments, *viz.* automatic weather stations (AWS), rain gauges, radars including Doppler weather radar (DWR), etc. for improving the weather forecasts through numerical weather prediction (NWP) models that will be extremely useful in early warning of meteorology related hazards. Many organisations such as IMD, ISRO, dam authorities, Central Water Commission (CWC), universities, research organisations and state government departments have installed AWS, automated rain gauges (ARG), and traditional rain gauges at various locations. Attempt should be made to integrate all such systems and share the data for various purposes. Based on the inventory of such systems, additional instruments must be installed in gap areas as the accurate meteorological data are necessary in flood modelling/ forecasts and also early warning of landslides. As the cost of AWS/ARGs instruments are low and there is an improved GSM network in the State, attempts should be made to install such instruments and collect data at a centralised server for faster dissemination and usage related to modelling, prediction/ forecast and decision making. However, in view of paucity of instrumental precipitation data, satellite-based precipitation data available from different sources (*e.g.* TRMM, NOAA CPC) also need to be analysed in addition to ground-based measurements to assess precipitation pattern in spatio-temporal domain.

Recently, TROPMET-2012 Symposium on "Frontiers of Meteorology with Special Reference to the Himalaya" held at IIRS, Dehradun in November 2012 has strongly recommended strengthening the meteorological observation network realising the fact that the research, observations and operational requirements in the Himalayan region are quite different from the rest of the country. It has even recommended the need for a dedicated institute for Himalayan Meteorology by the Govt. of India. The observational datasets will also help understanding the climate variability and change in the Himalayan region and its impact on different sectors, *viz.* water resources, agriculture, biodiversity, etc.

River flow discharge is one of the most important parameters for developing flood forecast models. There should be a mechanism to share the information being collected by various dam authorities as well as CWC. Such data should be collected on priority at all places where higher order tributaries meet the main river, such as Mandakini, Alkananda, Yamuna, Bhagirathi, Pindar, Kali and other major rivers.

The region being prone to seismicity, the existing network of seismograph and GNSS-CORS (G*lobal Navigation Satellite System - Continuously Operating Reference Stations*) needs to be strengthened in the gap areas. These measurements can also be supported with satellite-based measurements.

Apart from above, measurements on land, water and other air quality parameters are also critical in understanding the changes not only at specific places but also as a network across the state and even the Himalayan region, so that preventive/ mitigation measures can be taken in time.

*Strengthening institutional capacity and linkage***:** An efficient emergency response and planning process depends on the timeliness of many actions based on real-time, simulated as well as ancillary spatial and non-spatial information. There is an urgent need to strengthen the institutional capacity of the state government departments (e.g. State Emergency Operation Centre (SEOC), Disaster Mitigation and Management Centre (DMMC), Uttarakhand Space Application Centre (USAC), Uttarakhand Council of Science & Technology (UCOST), Geology and Mining Unit) in terms of technical expertise (including number of staff) and facility augmentation. State needs to invest heavily in S&T to enable it effectively analyse and utilise scientific inputs coming from various agencies. Suitable scientific staff with research background (PhDs) well versed with ground realities, domain expertise and well versed with modern tools such as remote sensing and GIS should be recruited. Technical expertise is prerequisite for synthesis of various spatial and non-spatial inputs which keep flowing prior to disaster during golden hours of disaster management from various agencies and field workers/first responders. A policy framework for appropriate utilisation of remote sensing and GIS data may also be needed.

Indian Institute of Remote Sensing (IIRS), a capacity building institute of ISRO/DOS, can support in providing short-term/ customised and long-term training to the manpower of the stakeholder departments.
The linkage among the state government departments must be strengthened to share the data and exchange of the technical expertise. The linkage between state and central government departments and centres of excellence also needs to be strengthened.

Capacity building of community and local bodies of governance: Generating awareness amongst the people and capacity building of Panchayati Raj Institutions are of paramount importance in conserving and optimal utilisation of the natural resources in a sustainable manner. Watershed management, awareness of the technological advancements and innovation for increasing the agricultural and livestock productivity, use of local products for income generation, understanding of the disaster risks and safe construction for building disaster resilience community are some of the priority sectors for human capacity development. Young generation, especially students/ children, should be the focus for generating awareness so that sustainable management of natural resources becomes a culture in long run and vulnerabilities to natural and man-made/induced hazards are minimised while adaptive capacity of the society is enhanced.

The long term prospective will be to realize the affected problems and to give emphasis on R&D to address various environmental and ecological issues to take measures from future calamities. The development should be promoted by considering the environmental issues. Establishment of bio-clusters with end to end approach on farm to market concept by actively involving the Local Community, Government Institutions, Private Partners including Social Agencies through PPP mode.

3.4: S&T intervention in building knowledge capabilities:

- Local R&D institutions and their knowledge dissemination centres would be linked with the Science communicators for propagating awareness on technological know-how on biotechnological interventions.
- Create Farm Science Centre and Village Knowledge Centre to get updation on technology front and adoption of sustainable models by the community

- Introduce a technology popularization magazine in a local language for the benefit of the local community and for the school going students and youths.

4 Detailed Implementation Plan of Central S&T Ministry/ Departments:

4.1 Department of Science & Technology

Department of Science & Technology has developed a comprehensive scientific plan for 8-10 month time. During this period, the action plan for mapping damage to National wealth will be drawn. The whole programme of DST designated as "Map the Neighbourhood in Uttarakhand (MANU)". Under this programme, financial support will be provided to R&D projects submitted by the following Universities and R&D organization to undertake detailed data collection and analysis to draw a sound scientific action plan.

SOI will undertake Air-borne Photographic Data acquisition for 8000 sq km area for Uttarakhand which will cover all the Char Dham areas which got maximum damaged. The output of this project would be in the form of High Resolution Digital Elevation Model with 20cm accuracy and generation of 1:10K scale maps which will be utilized as base map for integration of all the data to be collected by different groups and it will help in drawing a comprehensive scientific reconstruction and relocation plan in the State.

Garwal University, Srinagar will carry out the damage assessment mapping of Alaknanda and Mandakini valley in Uttarakhand and give the details of the infrastructure damaged during the high floods and suggest alternative development plan.

Department of Geography, Kumaon University, Nainital will focus on preparing the damaged assessment maps of the Pinder Valley in Kumaun Himalaya and also collect data on the objects which got damaged during the event and draw a comprehensive scientific plan for reconstruction and relocation of infrastructure.

University of Kashmir, Srinagar will focus on Assessment of Glacial Lake outburst in Kedarnath valley and draw a comprehensive, quantified action plan for monitoring the Glacial Lake which would be important for further planning. Another project of the University is to synthesize and integrate all the data sets being collected by all participating agencies. It would draw a comprehensive and scientific action plan for reconstruction and relocation of infrastructure facilities in Uttarakhand.

Wadia Institute of Himalayan Geology (WIHG), Dehradun will carry out damaged assessment mapping of Baghirathi and Yamunotri valleys in Uttarakhand and draw a comprehensive action plan for reconstruction and relocation of the infrastructure facilities which got damaged during the event.

Deptt. of Geology, Delhi University will focus on the study of two highly vulnerable landslide sites in Char Dham area and collect the data and related information about the causes of landslide and based on the detailed analysis, develop a suitable scientific preventive measures to restore the unstable areas.

IIRS, Dehradun will concentrate on imparting training to the students and train them for collection of data and use the data for analysis and draw a comprehensive scientific reconstruction and relocation plan using advance technologies like GPS and Mobile Mapping etc. Further, all the information collected will be uploaded at Bhuvan portal for wider use by the scientific community as well as other concerned stakeholders.

4.2 Department of Biotechnology

Department of Biotechnology will promote use of biotechnological processes and tools for Socio economic upliftment of affected community in Uttarakhand, establish viable models of rural bio-resource complexes / hubs and rural technological innovation & application centre, Support R&D component for refinement and validation of technology which can be housed from any other source in Uttarakhand for addressing the problems of affected groups and create entrepreneurship development among the youths.

In the short term, DBT will support State Educational Institutions including Agriculture Universities and labs for undertaking projects in various disciplines of biotechnology. These projects can be supported with inter-disciplinary and inter-institutional mechanism involving autonomous institutions, Government Departments and social mobilizing agencies with end to end approach. Support will also be provided for interventions for livelihood generation, health, environment and sanitation, value addition and post-harvest processing including marketing using proven and field tested technologies. This activity can be supported as an income and employment generation programme for a period of 1-3 years.

In Medium Term, few viable models of Rural Bio-resource Complexes / hubs in the flood affected regions, which can sustain regular livelihood for the community by adoption of integrated model of farming system including agriculture, animal husbandry, horticulture, post-harvest and value addition. This would involve the participation of large number of farming community to provide them tangible benefits with creation of rural entrepreneurship among the youth, SHGs and cooperatives will be established. The models would also have technology driven with the establishment of resource centre and village knowledge centre to promote rural innovation according to the need of hour.

To realize the affected problems, DBT, in Long Term, will give emphasis on R&D to address various environmental and ecological issues to take measures from future calamities. Further, bio-clusters with end to end approach on farm to market concept by actively involving the Local Community, Government Institutions, Private Partners including Social Agencies through PPP mode will be established.

In order to build knowledge capabilities, local R&D institutions and their knowledge dissemination centres would be linked with the Science communicators for propagating awareness on technological know-how on biotechnological interventions. Farm Science Centre and Village Knowledge Centre will be created to get updation on technology front and adoption of sustainable models by the community and also introduce a technology popularization magazine in a local language for the benefit of the local community and for the school going students and youths.

Department of Biotechnology has been supporting a Biotechnology Information System Network to bridge the gap between bio-informaticians and experimental biologist by bringing their expertise together through inter-disciplinary project and creating a newer generation of Scientist and researchers. This facility is also supports to handle massive data bases on various bio-resources and the scientific research aspects which can be extended to Uttarakhand in implementation of various R&D and extension nature of projects.

Biotechnology Information System Network of DBT will be extended to Uttarakhand to handle massive data bases on various bio-resources and the scientific research aspects which can be in implementation of various R&D and extension nature of projects.

4.3 Ministry of Earth Sciences

Focused observations on meteorology, snow, ice and glaciers are required to understand the interaction of cryosphere with atmosphere and geosphere. There is therefore a need to enhance the base of essential observing systems so as to assimilate more and more local scale observations in to our meso-scale forecast models. MoES has taken up an initiative to augment the observing and forecast systems in a phased manner covering hilly regions and particularly the Char Dham Yatra Route in Uttarakhand and other routes of religious/tourism importance in adjoining states of Himachal Pradesh and Jammu & Kashmir with state-of-the-art infrastructure. At the same time, investment in human resource is highly essential with the due sanction of additional scientific posts on a continuous basis with annually staggered recruitments.

MoES has proposed an augmentation of Observing System over Uttarakhand which includes: 3 Nos. of Doppler Weather Radars (DWRs) at Mussorrie/Dehradun; Uttarkashi and Nainital, 4 Nos. of Compact Severe Weather Detection DWRs at Chamoli; Rudraprayag; Bageshwar; Almorah, 5 Nos. of Micro-Rain Radars (MRRs) at Kedarnath; Badrinath; Dehradun; Paudi; Pithoragarh, 3 Nos. of Heliport Aviation Weather Observing Systems at Kedarnath; Badrinath; Phata, 2 GPS based Upper Air Meteorological Data observing stations and 75 Nos. of Additional Automatic Weather Stations (AWS)/ Automatic Rain Gauges (ARG)/ Snow Gauges (SG) [46 AWS and ARG stations are functional currently]

4.4 Department of Space

The vision and Mission of Department of Space are to harness the advancement of Science and Technology in building a disaster resilient community in the State of Uttarakhand and develop a model that can be replicated in other disaster prone areas in the country and rebuild Uttarakhand State sustainably, so that the further impact of disasters on people and livelihood is minimal.

An accurate assessment of impact in disaster-affected areas, especially Char-Dham and Pindar valley areas, is of paramount importance to take up the reconstruction activities in Uttarakhand. This can be done in three stages: (1) analysis of post-disaster high resolution satellite images taking the pre-disaster images as reference; (2) ground truthing in the damaged areas mapped through satellite imagery; and (3) collating the satellite imagery and field data to assess the extent and spatial pattern of damage. National Remote Sensing Centre (NRSC) has carried out damage assessment in and around Kedarnath and in upper reaches of Mandakini and Alaknanda valleys using satellite images and the results are available in ISRO's Bhuvan geoportal. Towards ground truthing for detailed assessment of extent of damage, a multi-institutional initiative on “Map the Neighbourhood in Uttarakhand” (MANU) has been initiated by DST, Govt. of India. In this initiative, field data will be collected through crowdsourcing by the students and teacher community of the universities/ institutes located in the state. Indian Institute of Remote Sensing (IIRS) in association with NRSC and Survey of India (SOI) has trained 149 students and teachers/ scientists from HNB Garhwal University, Kumaun University, and Wadia Institute of Himalayan Geology (WIHG), on using the latest geospatial tools and technologies for field data collection and uploading the same on Bhuvan geoportal in near real-time using GPS-enabled mobile application, GAGAN SBAS receiver and other field instruments. The field data collection process is envisaged to be completed in about two months’ time (October and November 2013). Then the satellite image results and field data along with ancillary data can be collated to assess the extent of damage and also to understand the spatial pattern of damage. This assessment and understanding will be vital in carrying out risk zonation to natural hazards in the area.

It is very important to assess the vulnerability of biologically rich areas to natural hazards and interference due to development. Environmental monitoring and protection of biological richness should be one of the top priorities and remote sensing and GIS can help in this direction.

The baseline data/information on different aspects of the natural resources, environment and biodiversity captured through satellite imagery or field-based instrumental measurements prior to, during and after the project can be used for this purpose. The spatial databases at medium (*e.g.* 1:50,000) and large (*e.g.* 1:10,000) scales prepared/ being prepared by ISRO/DOS in collaboration with State Remote Sensing Centre and other institutions using the satellite imagery under different national

mapping missions, or that available from any other organisations/ line departments, can be used as the base data.
The biological richness maps prepared by Indian Institute of remote Sensing (IIRS) /ISRO will be of great value while undertaking any developmental activities related to reconstruction and rehabilitation and also for environmental monitoring. The instrumental data collected by conventional means form the other important sources of data. While it is obvious that satellite imagery can play a great role in monitoring and evaluating the developmental activities and even for post-disaster damage/ impact assessment, a strong network of instrumented scientific measurement observatories is also necessary for not only validating the satellite-based observations but also for making the measurements which are not yet operational through space inputs.

It has been reported that there are about 127 glacier lakes in Yamuna, Bhagirathi, Alkananda and Kali valley. The Chorabari glacier lake breach during the recent Kedarnath tragedy has highlighted the fact that all glacial lakes and potential sites of snow melt accumulation zones need to be mapped and monitored to assess their breaching probability and downstream flooding.

ISRO/DOS is engaged in monitoring of areal extent of the snow covered region; glaciers and associated geomorphological features and retreat/advance of glaciers and glacier mass balance studies as part of climate change studies. At the behest of Central water Commission (CWC), ISRO is carrying out inventory of glacial lakes/water bodies of spatial extent greater than 10ha in the Himalayan region of Indian River basins using satellite data. Monitoring the spatial extent changes of the lakes/water bodies of more than 50ha is also being carried out on monthly basis during June to October months. Satellite-based monitoring aided by aerial and ground survey will aid in the assessment of such lakes. Glacial Lake Outburst Flood (GLOF) and flash flood modelling are required for estimating peak discharge/ flood levels, inundation areas in the downstream, etc. It can also help in scenario generation to generate awareness among stakeholders.

4.5 Council of Scientific and Industrial Research (CSIR)

Council of Scientific and Industrial Research (CSIR), known for its cutting edge R&D knowledgebase in diverse S&T areas can contribute significantly to the efforts in rebuilding the state of Uttarakhand. CSIR-Indian Institute of Petroleum (CSIR-IIP) situated in Dehradun, Uttarakhand can be a nodal laboratory for facilitating the required collaboration of the following sister CSIR laboratories towards development and deployment of the desired S&T interventions for rebuilding of Uttarakhand.

S. No.	Name of the Institute	Knowledgebase
1.	CSIR-CBRI (CSIR-Central Building Research Institute), Roorkee	• Infrastructure Engineering • Construction and Building materials Technology • Disaster mitigation including Fire related hazards

2.	CSIR-CRRI (CSIR-Central Road Research Institute), New Delhi	• Bridges and Structures • Road and Pavement Engineering and Materials • Geotechnical Engineering • Road Development Planning & Management • Traffic and Transportation Planning & Safety
3.	CSIR-CFTRI (CSIR-Central Food Technological Research Institute), Mysore	• Food science and food technology for optimal conservation and utilisation of the nation's food resources • Integration of scientific and technological knowledge into conventional and traditional systems and practices, and local and regional realities • Aid and promote the development of food industry through inter-disciplinary, innovative and state-of-the-art solutions
4.	CSIR-IHBT (CSIR-Institute of Himalayan Bioresource Technology), Palampur	• Bioresource Mapping • Biodiversity Conservation • Bioprospective-Plants & Microbes • Proteomics & Metabolomics • Plant Viruses
5.	CSIR-CIMAP (CSIR-Central Institute of Medicinal & Aromatic Plants), Lucknow	• Conservation, evaluation and cataloguing of selected high value medicinal and aromatic plants (MAPs) • Metabolic pathway studies in selected MAPs • Genetic enhancement of obligate asexual and sexual medicinal and aromatic plants, • Process and synthetic chemistry, technology for phytomolecules and plant products • Prospecting bioresources of commercial potential
6.	CSIR-IIIM (CSIR-Indian Institute of Integrative Medicine), Jammu	• Drug from natural products • Natural products chemistry • Medicinal chemistry • Pharmacology • Biotechnology & Microbiology
7.	CSIR-NBRI (CSIR-National Botanical Research Institute), Lucknow	• Biodiversity • Biomass Biology • Conservation Biology • Ethnopharmacology

		• Floriculture • Genetics & Plant Breeding • Molecular Biology & Genetic Engineering
8.	CSIR-NEERI (CSIR-National Environmental Engineering Research Institute), Nagpur	• Environmental science and engineering • Pollution studies and mitigation technologies • Waste water and Solid waste management
9.	CSIR-CSIO (CSIR-Central Scientific Instruments Organisation), Chandigarh	• Optics & Opto-Electronics • Medical Instrumentation • Geo-Scientific Instrumentation19 • Analytical Instrumentation • Agri-Electronic Instrumentation • Biomolecular Electronics
10.	CSIR-IMMT (CSIR-Institute of Minerals and Materials Technology), Bhubaneswar	• Mineral/bio-mineral processing • Metal extraction and materials characterization • Mineral process engineering • Marine and forest products development • Appropriate technologies for societal development

4.6 Department of Electronics and Information Technology

DEitY has the following plan for post disaster construction of Uttarakhand.

New Communication Technologies: One of the prime concerns during disasters is failure of communication channels which acts as a major impediment in delivery of relief and support and in dissemination of critical information to the citizens. Even mobile networks are rendered dysfunctional and thus ineffective. As a result, in the current scenario, authorities had to resort to technologies like Satellite phones and VSATs. This has necessitated the need to identify a set of reliable, new and effective technologies which would cater to the situations created in a disaster and further compounded by difficult terrains in a state like Uttarakhand.

Information Systems: It is understood that NIC Uttarakhand, as a part of reconstruction measures, has designed and implemented a portal to provide information on post-disaster relief and support. Although failure of mobile networks during a disaster may render mobile phones to be of limited help for a short period, it can play a substantial role in disseminating information especially early warnings and alerts to citizens and rescue related details to the relatives. Mobile solutions based on SMS – push and pull, IVRS, mobile applications, USSD etc. can play a vital role. NDMA and DeitY are already engaged in discussions on how to leverage Mobile Seva for providing advance warning/alerts and other services related to disaster management through mobile. Mobile enablement of its services available on the portal can also be undertaken as a part of enhancing the information systems. Also emphasis should be made on dedicated modules to manage the entire supply chain of relief and support measures as they throw huge challenges in managing donations, civic supplies, efficient and timely delivery of the supplies, storage of the supplies accounting etc.

Leveraging GIS Technology: Utilization of Geographic Information System (GIS) to map critical resources and geographical date of the state in a manner which is suitable to identify disaster prone areas, mitigate disasters in these areas, reduce the impact and manage post-disaster activities by proper resource mobilization. NIC has undertaken GIS development at the national level which can be refined and customized for implementation in Uttarakhand in the medium/long –term. Currently, NIC's GIS is at 50,000 scale and work is under progress to make it to 10,000 scale.

While implementing GIS, few issues of importance are integration of GIS with MIS, addressing the challenges in collection of data sets from various sources, standardization of these data sets etc. This will necessitate a close interaction with various state agencies and DeitY would like to hold such consultations in near future.

Support infrastructure: Implementation of a large scale initiative for disaster management proper support in terms of infrastructure like data centres, last mile networking till sub-district level is required. While establishment of such a critical infrastructure has already been initiated under NeGP, it would require strengthening after undertaking necessary requirement analysis.

Building-in-Sustainability into the System: Any initiative for disaster management tends to fade away with time and reusability of the capacity built during a disaster is very limited. This also leads to reinventing the wheel with each disaster. As a measure to make the efforts sustainable, it would be essential that the disaster management solutions and the infrastructure created be included in the workflow of the regular solutions of the administration with a capability to scale up during contingencies. Moreover, the solutions need to be replicable at both national level and by other states.

Prioritizing efforts in Fragile and Disaster prone Areas: In the short-term, priority could be given to the upper hilly areas of Uttarakhand like the districts of Chamoli, Uttarkashi and Rudra Prayag which are fragile and more prone to disasters. These areas have been under a recurrent wrath of disasters and majority of the disasters in Uttarakhand happen in these areas. Even while implementing GIS technologies these areas should be mapped first.

Stakeholder consultation: Developing a strategy for reconstruction as well as managing the disasters in future in a scientific and sustainable manner require involvement of multiple stakeholders and setting up of a proper consultative mechanism. All state agencies concerned need to be engaged in a dialogue in the near future and should be starting point of development of such strategy.

In addition, Department of Telecom suggested providing more than 100 satellite phones to the sites to facilitate rescue and relief operations. All district magistrates and Superintendent of Police may be provided portable satellite phones on regular basis in Uttarakhand with the permission of MHA. The cost towards this may be borne by State Government or the NDMA. Further, the provision of VSAT may be made to provide alternate redundant backhaul and establishment of an early warning system through SMS from mobile tower. The cost of such VSAT connectivity is Rs. 2.00 lakh per mobile tower may be borne by service provider, in addition to the usage cost.

4.7 Department of Atomic Energy

Department of Atomic Energy has developed techniques for radiation aided mutant crops which is helpful in enhancing the yield and quality of certain crops and/or their resistance to salinity or drought and diseases and in dealing with biotic and abiotic stresses affecting agriculture; Radiation processing of various foods and food-products for killing pathogens and insect lavae or for decelerating delaying the biochemical processes that lead of sprouting or ripening and thus enhancing shelf-life of the (radiation) treated food products, Water Purification Technologies such as Nuclear Desalination, online domestic water purifier technology using spiral membrane elements and this has already been commercially exploited, Indigenous development and production of the required quality of membranes for Water purification cartridge systems for removal of fluoride, iron, arsenic as well as uranium contaminants from water and Isotopic techniques which are useful in water resources management particularly for identifying sources of ground water salinization, ground water recharge, inter-connection between water bodies, seepage in dams and reservoirs etc.

Department of Atomic Energy will provide technical inputs and expertise to the specific request of the State Government on the above techniques developed by the department.

5. Identification and Management of Cross-Cutting Technology Issues

As hazard, vulnerability and risk assessment requires several spatial inputs, remote sensing and GIS can play a very important role. Many of the IT application deployments, including GIS and other information systems are dependent on and make use of diverse technologies and products, each of which is emerging and evolving at a rapid pace. Attempt should be made to use GIS system as a decision making system that will allow assessing all information related to disasters and also helping to prioritise reconstruction activities and manage overall implementation and progress. In this scenario, many crosscutting technology issues are bound to surface and it is necessary to identify and manage them for effective utilization and exploitation of benefits offered by the technology advances.

5.1. GIS Technology and Information Systems: GIS technology and its usage represents a combination and integration of multiple technologies, right from space-based/ aerial-based remote sensing data analysis, computing systems hardware & software, input & output peripheral devices & GPS to server-based/ web-based GIS and geospatial functionalities based on algorithms contributed from computer science & domain-specific research efforts.

In terms of systems infrastructure, GIS technology has long since moved from powerful, expensive multi-user monolithic workstations to client-server & web technology based deployments. GIS desktop client softwares are now invariably deployed on commodity desktop PC systems. However, server-based softwares supporting Enterprise GIS, Web GIS and Map servers have become mainstream requirements and have become realizable due to the technology advances happening in the field of server & storage consolidation in data centres. These data centres house the requisite high-end load balanced servers/ server farms, network & security devices, network mass storage systems (SAN/ NAS), RDBMS engines, web applications & services, etc. Some of the major influencing factors for developments in GIS technology are:

Sl.No	Technology elements	Influencing factor
1	Computer desktops/ clients	Increased processor cores & power, memory, disk capacities help faster execution of analysis tasks with larger data sizes handling
2	Local network (LAN)	Gigabit Ethernet network speeds up access to shared network resources; 10GbE uplinks help in efficient access to network storage systems
3	Internet access	Key contributor to using latest applications designed for online access. Continuous improvements happening in terms of last mile connectivity/ reach, bandwidth/ speeds, always-on availability

4	Server systems	Increased processor cores & power, scalability, load balancing, reliability & availability features, tuned for 24x7 always-on availability/ operations, centralized management
5	Parallel computing	Leveraging multi-core systems for complex GIS analysis operations and batch processing tasks on clients as well as servers; expected to play more significant role in near future
6	Network security	To secure the GIS services and applications made available online to closed user groups or general public
7	Web technologies	Widespread adoption and reach of Internet & Web browser access promotes development of numerous new applications leveraging Web technologies; Bhuvan geo-visualization portal is one example
8	Network storage	To resolve the local storage capacity limitations and provide data consolidation, security, protection, maintenance and management
9	GPS	Widespread availability and use of GPS devices resulting GIS databases enrichment; Recent development is use of GAGAN SBAS devices for more accurate location information
10	Cellular networks	Cellular networks support for data services (GPRS, 2G, 3G) is an important facilitator for near real time data transfer and data access
11	Mobile devices/ smart phones	The current smart phones with GPS, GPRS/ 2G/ 3G, camera, powerful OS, etc. greatly contribute to the implementation of useful & innovative GIS applications like field data collection, vehicle tracking, etc., besides access to GIS portal (Bhuvan) access
12	Open source technologies & products	This is a significant contributor in steering the developments in GIS. Increased use of open source tools is evident, which promises cost effective solutions deployment.
13	Cloud computing	This represents a major adoption and use of proven recent technologies like virtualization, service orientation, distributed computing, distributed file

		systems, etc. It emphasizes reduction of capital costs, dynamic resources allocation, centralized management, accounting, etc. Cloud based GIS applications implementation is on the increase

Some of the GIS-centric applications developed and deployed at NRSC and which encompass a wide range of technologies discussed above are described below:

5.1.1 BHUVAN Geoportal: Bhuvan (Sanskrit for Earth) is a Geoportal of ISRO (http://bhuvan.nrsc.gov.in), allowing host of services covering visualization, free data download, thematic map display and analysis, timely information on disaster and project specific GIS applications since August 2009 and available in English, Hindi, Tamil and Telugu. More than 17 TB data consisting of multi-resolution, temporal, sensor raster data, multi-thematic data of various scales and Point of Interest data along with user added content are organized as 'Land Services, Weather Services, Ocean Services, Disaster Services and Collaboration Services' and served with standard cartographic representation towards societal good.

Bhuvan is also offering a platform to create, visualize, share, analyze Geospatial data products and services as Spatial Mashups for various user agencies. Thus users can visualise the High resolution datasets (2.5m) uniformly across the country in 2D and 3D domain. This ortho-corrected products with online shape file creation utility enables the users to map/ delineate the feature in their area of interest even with multi-temporal data for various resources mapping ranging from small scale to large scale which nullifies the data cost and software cost for processing the satellite data and creation of both spatial (vector & raster) and non-spatial data.

Current development environment for Bhuvan is mainly on open source (PHP, Mapserver and Geoserver, Postgre/ PostGIS, and Apache) and having the flexibility to customize and meet the user requirements as per the demands of the project. Thus the initial cost of procuring the software and annual maintenance of the software is also nullified.

5.1.2 Online processing: A wide variety of thematic datasets organized in central server enable the user to consume these services as OGC Web Services on their system for further usage towards interoperability. This nullifies the redundant or duplicate efforts in creating datasets and in focusing the users towards integrated geospatial information management. Query shells present in the thematic datasets provide on-the-fly generation of statistics of any area of interest or administrative boundary with graphical display besides having provision to run the query and get the output based on SQL, along with print option.

5.1.3 Crowd sourcing: Crowd sourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community. Bhuvan enables crowd sourcing/ collaborative mapping from different methods like add point of interest data, sharing GIS layers, mobile applications, creating spatial datasets etc. towards enriching location based services. It will also provide the facility to overlay the imagery / vector / ground data including photographs from the user system to value add to the existing layers in Bhuvan to derive better plans. Mapping the Neighbourhood in Uttarakhand (MANU) programme is the best example of crowd sourcing.

With the prevalence of feature-rich smart phones, a comprehensive application has been developed for field data collection, transfer, organization and management. The developed solution facilitates (a) collecting field data with location information, photographs and application-specific parameters, (b) transmitting the collected data to the server in near-real-time or deferred mode, (c) organizing the received data in central database on Bhuvan servers (d) querying and visualizing the data using Bhuvan viewer applications.

The configurable design allows numerous application-specific field data collection solutions to be quickly configured and deployed on a variety of devices as well as uniformly handled on Bhuvan servers by appropriate database schemas and server programs. All the server-side databases and programs are integrated, deployed and maintained on Bhuvan servers in operational mode.

The application has been customized, configured and implemented to support the reconstruction and rehabilitation needs contemplated under the Map the Neighbourhood in Uttarakhand (MANU) project. The application enables collection of various categories of field data - damage to buildings, roads, bridges/ culverts & other infrastructures, landslide, river bank erosion and land cover & natural resources. The application is also facilitates collection of Points of Interest (POI) data.

5.1.4 Free / Open EO Data: NRSC/ ISRO has taken new initiative to provide the free/ open Earth Observation (EO) data and products coarser than 24 m through Bhuvan-NOEDA (which nullify the data cost) to the public through Bhuvan to facilitate the students/ researchers/ users for various engineering applications, natural resources mapping and management. More than 160000 downloads have been recorded in last 2 years.

6 Financial Requirements

6.1 Proposal of Uttarakhand Government

- Rs. 50 crore for establishment of Science Research Centre.
  (The financial requirement for the Research centre would be met from the proposal of Department of Science & Technology on establishment of National Centre for Himalayan Glaciers (NCHG) with estimated cost Rs. 211.06 Cr supported by Planning Commission)
- 11 hill states need to earmark 2% of their Annual budget for rehabilitation, post disasters like land slide which will be funded through Central Sector.

6.2 Additional Financial requirements

All the S&T Departments may provide separate line entry in the budget of 2014-15 & 2015-16 for "Disaster management support" on the similar lines of Department of Space

Sl. No	Ministry/Deptts.	Additional requirement during 12th Plan period
1.	Ministry of Earth Sciences	Rs. 110 crore
2.	Department of Biotechnology	Rs. 5 crore
3.	Department of Science & Technology	To be met from annual budget of existing schemes
4.	Department of Space	To be met from annual budget of existing schemes
5.	Department of Atomic Energy	To be met from annual budget of existing schemes
6.	Department of Scientific & Industrial Research inclu. CSIR	To be met from annual budget of existing schemes
7.	Department of Electronics & Information Technology	To be met from annual budget of existing schemes
	Total	**Rs. 115 crore**

7.0: Monitoring and Review mechanism:

Various developmental projects and programmes taken up at the institution and community level ought to be monitored and evaluated to find out whether the objectives envisaged at the time of conceptualisation and beginning of the project are met or not; (2) to carry out EIA; (3) to evaluate if EMP is effectively implemented, etc.

The monitoring of the progress of the projects to be implemented by DST will be carried out through an Expert Committee already constituted by the DST under the Chairmanship of Dr. Y.S. Rajan. DST would share the outputs of the project as and when those are ready to all stakeholders. Outcomes of programmes to be implemented by various S&T ministry/Departments will be monitored by the existing mechanism of the concerned departments.

7.1 Monitorable deliverables:

- Mapping of the affected and vulnerable region of Uttarakhand in 1:10000 scale
- Establishment of an early warning system through SMS from mobile tower
- Establishment of National Centre for Himalayan Glaciers
- Establishment of Rural Bio-resource Complexes / hubs in the flood affected regions
- Extend Biotechnology Information System Network of DBT to Uttarakhand to handle massive data bases on various bio-resources
- Study Reports,
- Human Resource Development,
- Augmentation of observational system,
- Realisation of Geo Imaging Satellite (GISAT) for Disaster Management Support.