VISION DOCUMENT

NATURAL RESOURCE DATA MANAGEMENT SYSTEM

(NRDMS)

Introduction

In the quest evolving a model of planning, India adopted the practice the micro level resource planning. The approach did not produce the desired result, as the inequities amongst people and disparities between regions persisted, while the environmental condition continued to degrade leading to severe stress on land and water resources. To ensure integrated and sustainable development of the area, conceptual change in the practice

of planning was brought in around late 70s, by adopting the micro or local level planning process.

The objectives of decentralized planning are:-

- Increase the productivity of land
- Poverty alleviation
- Increase scope for employment with focus on asset generation.
- Providing of minimum amenities and infrastructure facilities.

To implement this strategy, institutional changes were brought about through the 73rd and 74th Constitutional Amendment acts (1992 & 1993). As per this, the State Governments were empowered to form the institutions of local self-governance right from the village level up to the district level and within the municipal jurisdiction *i.e. panchayats* and *nagarpalikas* in the context of rural & urban development respectively. The Eleventh and Twelfth schedules (Annexure 1-2) of the Constitution while specifying the sectors for the *panchayats* and the *nagarpalikas*, have also defined the role for the multi-level institutions of governance in planning and implementing

the integrated developmental schemes. The State Governments have accordingly constituted such local level bodies with definite mandates to collect revenues, draw up and implement integrated development schemes. This needs capacity building at institutions of local self-governance to prepare and implement locale- specific integrated development schemes by assessing and utilizing the available resources.

1.1 Context

Preparing and implementing development schemes is an information intensive task. But, the data management system that exists at the district or lower level is not fully geared to address the information needs of integrated developmental planning. The conventional methods of data collection/ collation, storage are not amenable for quick updating, retrieval and holistic analysis and several problems that we encounter in this system are,

(i) Incompatible and non- standard datasets inhibiting integration

(ii) Inefficient inter-sectoral data flow

(iii) Lack of information on quality, completeness and lineage of data.

The process of integrated approach to planning requires a detailed knowledge of the interrelations and interdependencies between various sectors to resolve often-conflicting demands. This leads to a requirement for appropriate data management and analyzing tools and techniques and a large matrix of sectoral data, in digital format, on natural resources, demography, socio-economy, and calls for specific scientific interventions in –

(i) Need-based data creation,
(ii) Development and improvement in data handling and analysis tools,
(iii) Efficient distribution of the data & information to the user community.

1.2 National Initiatives

Taking note of the above requirements and the developments in the areas of Information and Communication Technology (ICT) and Geo-spatial Data

Management and Analysis Techniques like, remote sensing and Geographical Information Systems (GIS), certain initiatives had been taken at the national level to create awareness on the usefulness of these technologies amongst planners and decision-makers. The Natural Resources Data Management System (NRDMS) programme of Department of Science and Technology was one such pioneering effort, the others being :

I. National (Natural) Resources Information System (NRIS) of the Department of Space,
II. Integrated Mission for Sustainable Development (IMSD) programme of Department of Space,
III. Geographical Information System (GISNIC) and District Information System (DISNIC) of the National Informatics Center

Details of the above programmes, their mandate and objectives are provided in **Annexure – 3**.

2.0 NRDMS: THE PROGRAMME

The **NRDMS** (Natural Resources Data Management system), one of the flagship programmes of Department of Science and Technology, Government of India, started over two decades ago, was aimed at generating computerized spatial and non-spatial data bases on :

(i) natural resources (minerals, water, agriculture, forest and bio mass, land use etc),
(ii) physical and infrastructural resources (health, education , irrigation, water supply, communication, transport, power etc), and
(iii) human resources (demography, population etc)using GIS technology for various developmental planning.

Duly witnessing the phenomenal virtues of GIS/Geospatial technology, the horizon of NRDMS programmes was vastly expanded in multiple fronts in the later years using multi-level and multi-resolution spatial and non-spatial data for (i) various geological explorations, (ii) modeling of surface and ground water resources including the hydrology of small watersheds, revival of ponds etc, (iii) geospatial modeling of

mountainous and coastal ecosystems and coastal wet lands, (iv) landslides, floods and tsunami disasters mapping, mitigation and management, (v) initiation of studies for developing forewarning systems for landslides, floods and tsunamis through international collaborations, (vi) villages or cadastral level spatial data bases on various resources, (vii) hyper spectral remote sensing, (viii) SAR interferometry studies, and (ix) geo visualization and restructuring of heritages etc.

India has possibly the longest known tradition of systematically collecting spatial data through various organizations at national level. Also, there is a strong tradition of non-spatial data collection at district level by different line departments. In order to utilize this plethora for efficient local level planning, Hanumanth Rao (1984) committee emphasized on management of these data. Understanding the above requirements Natural Resources Data Management System (NRDMS) programme was mooted by DST in 1982 is a multi-disciplinary and multi-institutional R & D initiative with vision to provide appropriate scientific and technological inputs for

operationalising the concept of decentralized planning. The goal was to develop scientific data base approach to support the local level planning. At the end of the first decade of the programme, 73rd and 74th constitutional amendments came into being and with the entry of computers at district level and GIS in India during late 1980's the goals of NRDMS programme were evolved to develop spatial data management technologies for integrated rural development planning and demonstrate it in the local level decision making. In the context of NRDMS, any natural resource, which is important for local area development, is relevant for study. NRDMS is supporting several academic and R&D institutions through grant-in-aid projects. The focus under NRDMS has always been on technological and institutional capacity building in a multi-level framework, so that people can plan their own development, utilizing the local resources. In this respect, NRDMS develops and provides tools and techniques for assessing local level natural resources endowment, their utilization potential and generating alternative scenarios for development. NRDMS operates through District database centers as its hubs. 45 Pilot district centers are located in Karnataka, Andhra Pradesh, Orissa, West Bengal, Bihar,

Uttar Pradesh, Uttaranchal, Haryana, Gujarat and North East Region.

2.1 Highlights of the achievements

The achievements made under the programme after two decades of its operation are highlighted below:

Over the past two decades, 45 district GIS centres have been set up spread over the country, with the approval of the respective state governments on fund sharing basis. The activities of these centres are:

i. Gain insight into the data requirements at the district level
ii. Development user specified applications and tests the tools and technologies developed through R&D institutions.
iii. Demonstrate the efficacy of the database approach for drawing up integrated area development plans.

Development of WINDOWS based GIS software Geo Referenced Area Management ++ (GRAM++) with the support of United Nations Development Program (UNDP).

Module like GRAMNET and GEO_SQL developed to facilitate resource network analysis and spatial querying.

A user-friendly module- VEC VIEWER developed to support viewing of geo-referenced layers with collateral attribute information with querying facility.

GRAM – Drishti a prototype application, using GRAM controls was developed and tested in collaboration with Madhya Pradesh government. MP government markets this product.

GRAM – based Decision Support Modules developed in water management, land use planning, energy budgeting and facility location / allocation. Supporting Co-ordinated programmes on :

i. Hydrology of small watersheds
ii. Bio-Geo Database and Ecological modelling of the Himalaya

Supporting Sub-programmes on

i. Landslides,
ii. Coastal Resource Management and conservation

iii. Groundwater Modelling

Promotion of modern spatial data capturing technologies like **Microwave Remote Sensing & Synthetic Aperture Radar (SAR) interferometry, Airborne Laser Terrain Mapping, Global Positioning System.**

Adoption of multi-pronged strategy in technology transfer through Sensitization workshops, training workshops, hands-on training, awareness workshops and national level seminars

Taking pro-active role in the establishment of NRDMS node of National **Spatial Data Infrastructure (NSDI).**

2.2 NRDMS Renewed Approach

In spite of the national efforts, spanning two decades large segment of end-users are yet to explore the full potential of the system and use it in most of their planning activities due to lack of technical, organisational and institutional capacity. To reduce the impediments in the widespread use of the technologies and make it an effective tool in the process of local level integrated planning,

NRDMS is focusing its research on simplifying the methods and techniques of data capture, organisation and analysis, devise suitable strategy to transfer the techniques for adoption by the end user in their planning activities.

Considering the recent trends in the development of spatial data technologies, the emerging changes in the system of governance planning, polices, institutionalization of National Spatial Data Infrastructure (NSDI), meet the aspirations of the users and in support of the overall transformation in the concept of information sharing, the need was felt for refocusing the R&D thrusts of the programme :

1. Spatial Data Management and Analysis Technologies

2. Advanced Technology Applications in large scale spatial data gathering

3. Land & Water Management

4. Technology Transfer and Capacity Building

The Expert Committee had constituted sub-committees for preparation of 'Thrust Area Document' and the reports submitted by each sub-group was integrated later. In the following sections the identified research areas have been documented.

3- VISION, GOALS AND OBJECTIVE OF THE NRDMS PROGRAMME

3.1 Vision

Enabling people, communities and Institutions of self-governance, with Spatial Data Technologies, for informed participation in Decision-making for Integrated Development of local areas.

3.2 Goals

- To strengthen the S&T inputs for integrated resource management through development of appropriate tools and techniques in data collection, organization and analysis.

– Technical capacity building at various levels of administration for enabling the adoption of the technologies developed in integrated development planning.

3.3 Objectives

Demonstrate and promote the use of Spatial Data Technologies for micro level planning under diverse terrain conditions:

- Provide software support for data management, modeling and operation research
- Promote R & D in spatial data technology
- Technology Transfer & Capacity Building of potential users
- Forge linkages with the users at different levels
- Provide S&T inputs for framing Policies related to Spatial Data Technologies
- Develop & Demonstrate pilot scale spatial infrastructure and provide research support to National Spatial Data Infrastructure.
- Documentation and dissemination

4.0 TECGNOLOGY TRENDS & THRUST AREAS

4.1 back ground

The various thematic maps on the earth resources , ecosystems, land cover ,the man made physical resources etc form the major inputs for such NRDMS programmes / studies. Though these information were provided by the black and white panchromatic aerial photographs in 1940s and 50s , it is only the polar orbiting , sun synchronous earth observing satellites have made the revolution by providing multi- spectral digital images of the earth which could be processed and color coded using the computer software for enhancing the earth surface features and mapping the various resources. Such satellite based space programme was started with the launching of the **SPUTNIK** by the **USSR** in 1957 and **EXPLORER -1** satellite by **NASA/USA** in 1958.Following these super powers , many countries like **India, France**, a **few European countries** independently and jointly under the European Space Agency**(ESA),Japan,**

Korea, Taiwan, Thailand and also private agencies like **Digital Globe** entered into the fray of space technology. Amongst these ,the countries like USA**(with LANDSAT series of satellites),** India**(IRS series)** , France**(SPOT series)** and ESA**(ERS series)** are the front line countries in the world and during the last 30-40 years or so and they kept on sending remote sensing satellites to the space and collecting the data on the earth's geospheric, hydrospheric and biospheric dynamics , ecosystems and the resources. All these countries in the initial stages sent the satellites with coarser spectral, spatial and temporal resolutions and gradually kept on narrowing down the spectral, spatial and temporal resolutions and also launched satellites with innovations and for the special purpose mapping of the earth resources.

4.2.NASA'S remote sensing missions

The NASA/USA has so far launched eight satellites (LANDSAT-1 to 8) in between 1972 and 2013 at regular intervals starting with coarser resolutions and gradually narrowed them down along with innovative additions in the data type and the mode of data collection . The

Landsat 1 and 2 were the twin satellites launched in 1972 and 1975 with Multi Spectral Scanner(MSS) having four bands in Visible and Near Infra-Red (VNIR) ranges(green-0,5-0.6µm,red-0.6-0.7µm,Infra-Red 0.7 - 0.8µm and IR 0.8-1.1µm) with spatial resolution of 79 m^2 and the revisit capability(temporal resolution) of 18 days .Whereas in the Landsat 4 launched in 1982 and Landsat 5 launched in 1984 , the number of spectral bands were increased to 7 with 4 bands under MSS in between 0.45 and 0.9 µm in VNIR range ,3 bands under Thematic Mapper(TM) payload with two bands in Shortwave Infra-Red region 1-3 µm (SWIR) and one band in Thermal Infra-red (TIR) region(10.4-12.5 µm).While the MSS and the SWIR bands had 30 m^2, the TIR band was with 120 m^2 spatial resolutions. While the MSS bands had the credentials to discriminate and map the water bodies, vegetation , rocks and minerals etc , the TM bands provided additional information on the biomass and the TIR on the earth surface temperature , volcanoes etc.

In between Landsat 6&7 , while 6 failed immediately , the Landsat 7 launched in 1999 had 8 bands with one

panchromatic band in VNIR region(0.5–0.9 μm) and seven bands under Enhanced Thematic Mapper (ETM) with bands 1–4 in VNIR region(0.45–0.90 μm),bands 5&7in parts of SWIR region(1.55–2.35 μm) and band 6 in parts of TIR region (10.04–12.5 μm).While the VNIR , and SWIR bands had 30 m^2 spatial resolution, the TIR band had 120 m^2.The panchromatic and the ETM bands had discrete capabilities in discriminating the various earth surface features and the phenomenon with (i)band 1(0.45–52 μm) showing tank bathimetry, chlorophyll absobtion and discrimination of deciduous and coniferous forests, (ii) band 2 (0.52–0.60 μm) the healthy vegetation and the plant vigor,(iii)band 3(0.60–0.69 μm) the chlorophyll absorbtion and the plant species discrimination,(iv)band 4 (0.76–0.90 μm) the plant cell structure, plant vigor, and the land – water boundary(v) band 5 (1.55–1.75 μm) the soil moisture content and the soil discrimination (vi)band 7(2.08–2.35 μm) the hydroxyl ion absorbtion and geology and (vii) the band 6 (10.4–12.5 μm) earth surface temperature, soil moisture, plant heat stress etc .Whereas the Landsat 8 launched in 2013 had 9 spectral bands with 5 in VNIR, 3

in SWIR (both with 30m^2 spatial resolution) and 1 panchromatic band with 15m^2 spatial resolution.

In between the Landsat series of satellites , the NASA/USA has also kept on launching satellites for specialized applications .Some of them are (i) TERRA mission in 1999 with ASTER payload for hyper spectral remote sensing meant for discriminating and mapping the subtle variations on the earth surface including the minerals and the alteration zones and MODIS for cloud and flood related studies, (ii)SRTM(Shuttle Radar Topographic Mission) ,a 11 day mission in 2000, for collecting the data on the topographic variations of the earth surface and which collected valuable data for various applications including contouring , DEM creation, shaded relief mapping for tectonic appraisals etc,(iii)AQUA mission in 2002 for ocean related studies,(iv) GRACE satellite in 2002, for five years, to precisely map the earth mysterious and uneven gravity fields, gravity variations due to coastal deep currents ,ice exchange amongst glaciers, ice sheets , ocean etc.,(v)AQUARIS in 2011 for ocean salinity variations due to snow melt , river discharge, reduction in salinity due

to rainfall etc . (vi) Hyperion satellite for hyper spectral remote sensing etc. Again SEASAT launched in 1978, though was in the orbit only for a few days, has collected very valuable data on the oceanographic parameters.

4.3. INDIAN remote sensing missions

India is the leading country in space Technology. The space program in India was started in 1962 with INCOSPAR under the Chairmanship of Dr. Vikram Sarabhai, followed by SITE program in 1975 ,STEP program during 1977-79 ,launching of a series of Polar satellite launch vehicles(PSLV) and Geosynchronous satellite launch vehicles (GSLV) during 1960s and 1970s, the first satellite ARYABHATA in 1975,ROHINI in 1980,APPLE in 1981 and a series of communication satellites .After such a series of experiments first and the second experimental remote sensing satellites BHASKARA 1 &2 were respectively launched in 1979 and 1982. Following these, India has started its operational remote sensing satellites namely the IRS series and IRS P series, the special purpose satellites , with IRS 1A(in 1988),IRS 1B(1991),IRS-P2(1994),IRS 1C(1995),IRS-P3(1996),IRS 1D(1997),IRS P4 Oceansat

(1999),IRS P6 Resource sat(2003),IRS P5 Cartosat-1(2005),IRS P7 Cartosat-2(2007), Cartosat - 2 A (2008), Oceansat-2 (2009), Cartosat - 2B(2010),Resource sat-2 (2011), Risat-1(2012), Saral (2013) etc and thus India is one of the few leading countries in space programme. Similar to Landsat series of satellites , the IRS 1A/1B had the coarser spatial resolution of 36.25(LISS-I) and 72.5m^2(LISS-II),spectral resolution of four spectral bands in between 0.45 &0.86µm and temporal resolution of 22 days for vegetation and other resources mapping .Whereas the subsequent satellites had gradually the finer resolutions and additional options and innovations for earth resources mapping. For example, IRS 1C &1D had 7 spectral bands , 1 band in panchromatic, 3 bands in VNIR, 1 band in SWIR and 2 bands WIFS sensor(1 red band and one NIR region) with panchromatic band having spatial resolution of 5.8m^2,VNIR bands with 23.5m^2,SWIR band with 70.5m^2 and WIFS bands with 188m^2 for varied applications. Similarly, the IRS- P3 spectral bands had varying resolutions with WIFS for littoral currents mapping, MOS -A for land- water boundaries mapping, MOS-B for Bio mass and chlorophyll and MOS-C for oceanographic applications. In the same way while IRS-P

5 Cartosat-1 had 2 panchromatic bands and dedicated for topographic mapping , DEM generation and relief based applications, the IRS-P 6, Resource sat-1 had 12 bands in VNIR and SWIR regions with 4 bands in LISS-III with 23.5m^2spatial resolution for vegetation and crop cover mapping, same 4 bands in LISS-IV with 5.8m^2 for species diversity mapping and again same 4 bands of AWIFS with 70m^2 spatial resolution for land - water boundary related applications. Again India's Oceansat -2 was dedicated to oceanographic applications and RISAT was the first India's micro wave satellite to collect data of the earth under all weather conditions. Further ,India has launched SARAL satellite for ocean related studies, GAGAN for GPS based navigations and Chandrayan for Lunar exploration. Indian missions had the capability of collecting stereo imageries also.

4.4. space programme of France

France has come out with its commercial mission **SPOT** with over six satellites launched in that series in between 1990 and 2012.The SPOT entered into the space arena with many innovations like first simultaneous

panchromatic and multi spectral images, 10 to 20 m^2spatial resolutions , first stereo imaging technology, satellite invitation possibilities, to the regions of need etc in SPOT 1 . Now the SPOT 6 has the efficiency of collecting data with 1.5m^2 spatial resolutions .

4.5. ESA space programme

The ESA(European Space Agency) , the consortium of European countries has entered into the space program by launching the first micro wave series of satellites **ERS 1 &2** in 1991 and 1995 , then entered into ENVISAT series, PROBA series, and now the Sentinel series and all them provided potential information on various land , water, ocean , bio mass and environment related applications.

4.6. Space programmes of Russia and China and other countries

Russia and China are again pioneers in space programmme. Though the Soviet union was the first country to launch SPUTNIK to space and also animal and man to the space, after it's fragmentation into a number of countries , it's space program had many setbacks and

further most of its missions were defense related . So much so with China.

Countries like Thailand, Brazil, Korea, Japan Taiwan etc have also started launching their own satellites .

4.7 Space missions of private agencies

The entry of private agencies like Digital Globe has lead to the launching of a series of satellites like Geo eye, IKONOS , Quick bird World view series etc which had advanced credentials in the aspects of resolutions amongst which the temporal resolution of 3 to 1.1 days is a great boon in disasters related situations.

5.0. INPUT OF REMOTE SENSING TO NRDMS PROGRAMMES :

Thus the polar orbiting sun synchronous hyper altitude satellite technology has exhaustive vistas in exploring the earth in general and the highly demand driven purpose oriented NRDMS programmes in particular. So, it can provide vital information in the following areas and hence needs to be capitalized.

(i) Inventory of mineral deposits using hyper spectral remote sensing and GIS based 3D modeling of deep seated mineral deposits.

(ii) Integration of multi bas geological, deep geophysical, borehole, geochemical, hyperspectral derived vegetation anomalies for detecting the deep seated possible oil /gas bearing structures in frontier basins of India.

(iii) Water resources modeling including the surface water quantity forecasting using satellite IR data, quality monitoring & siltation studies using green band satellite data, rejuvenation of defunct of water bodies duly identifying the reasons using multi-dated satellite data, patio-linear modeling of the fractured aquifer systems, 3D visualization of aquifer systems using remote sensing and GIS, artificial recharge, water shed wise water budgeting, identification of water surplus and water deficit water sheds and inter water shed water transfer and re

organization of drainages and inter linking of rivers etc.

(iv) GIS/GPS based modeling of deforming Indian plate and its consequences.

(v) Study of life history of Indian river systems for the water resources assessment, Environment, flood dynamics and disaster vulnerability, building up models on the recent geological history etc.

(vi) Modeling of land-ocean interactive dynamics, coastal evolution models, coastal ecosystem dynamics, visualization of sea level rise.

(vii) Geospatial modeling of desertification processes.

(viii) Modeling of glacial movements glacial ecosystems, ice exchange amongst glaciers, ice sheets, ocean etc using GRACE and other satellites.

(ix) Mapping and modeling of marine water quality, salinity changes etc using AQUARIS and other satellite data.

(x) Studies on building up of signatures of global warming using multi dated multi-

spectral, SWIR and Thermal Infra Red data and climate change studies.

(xi) Biomass mapping and carbon budgeting,

(xii) Various natural disaster mapping, mitigation, management and fore warning system development.

(xiii) Propagation of NRDMS data base for the whole country and G – Governance etc.

The following section briefly specifies the research goals that require being taken-up in each of the above-mentioned thematic sub-groups in the areas of a) Data infrastructure Development, b) Technology development and c) Technology Transfer.

5.1 Spatial Data Technologies (SDT)

The operational activities of the NRDMS District Centers are supported by an intensive research back up in spatial data management and analysis technologies in which leading academic and research institutions of the country are participating. At the core of the technologies developed under NRDMS is Geographic Information Science,

the basic research field that seeks to redefine geographic concepts, re-examining some of the traditional spatially – oriented fields, such as geography, cartography, geodesy, sociology, demography and incorporating recent developments in computer science, mathematical science. As the field of geographic information science is vast, areas of research and development having relevance to the understanding of the geo-spatial concepts have been focused on. It will help in the refinement of appropriate tools & techniques relevant to Geographic Information Science. The research issues identified are listed below:

I. Ontology – Concerned with defining concepts, relationships, and operations pertinent to geo-spatial domain

Standards (metadata, vocabulary, functionality, interoperability)

Representations (physical, conceptual, and user level)

Data Sharing

Space-scale relationship

Data quality & Uncertainty

II. System Issues – for efficient representation of spatial data analysis and management techniques

Role of advanced technologies

– Distributed & high performance computing

– Data processing using high performance software and hardware

– Dissemination of data to remote clients

– Data clearing house development.

– Security

User interface

– Touch screen

– Web based

– Indian language support

– Voice based interaction

Query optimization / storage structures

Open / public domain implementation of GIS

Object-oriented database design and management

III. Functionality – to enhance the capability of SDT Spatial data mining and knowledge discovery

– Data Warehousing

Object oriented image analysis

Content based image retrieval

Visualization

Spatial analysis

– Spatial models to represent real world interactions

– Spatial statistics

– Network analysis

– Time series analysis

– Simulation

– Predictive spatial interactive models

– O-R models

IV. Applications– innovative solutions to location specific problems using SDT

Decision support systems in different sectors.

Application specific models – development of new models, adaptation of existing models, development of model base management systems

V. Policies and socio-legal issues

IPR issues

Information policies at Government level

Economics of data

Access to Government data

Role and benefits for local users

Security and ownership

Assessment of impact of SDT on society

VI. Capacity building – training manpower, deployment of technologies developed, distance education, development of educational content for different levels of users

5.2 Advanced Technology Application in High Resolution Spatial Data Gathering

The advancements in computers, electronics, space and allied technologies, have given way to several new gadgets, techniques and methods of spatial data gathering. The primary goal of such technological innovations is to leverage existing abilities to do more things, to do things better and faster. Nevertheless, not every innovation that looks like a productivity-enhancing tool eventually plays that role. Therefore, if not carefully introduced, it may run counter to natural modes of expectations, thereby leading to rejection of the technology.

Any information based planning activities at local level requires high resolution data (spatial and non-spatial) which are currently not available on a routine basis from national, state or even district data generating agencies. The greatest constraint in large-scale data capture is the limitations of currently available technologies. In view of this, there is a need for giving special thrust to explore the application potential of some of the technologies, either independently or in combination, for effectively capturing the high-resolution geo-spatial information. The following

are the technology development and training initiatives required for its wide application in spatial data capture.

5.2.1 Remote Sensing Technologies

a. Hyper spectral Imaging –

I. Development of appropriate indices, band combinations etc. for information extraction

ii. Employment of hyperspectral data in applications relating to Agriculture, Land use classification, Mineral targeting, Forestry, Ecology and other related areas.

b. Microwave Remote Sensing including SAR Interferometry

I. Refinement of soil moisture estimation technique using Microwave Remote Sensing methods

ii. Development and improvement of microwave probes / sensors for ground measurements of soil moisture

iii. Development of indigenous SAR Interferometric data processing tools

iv. Improve techniques of high resolution topographic information generation by employing SAR Interferometry

v. Application of SAR Interferometry in estimation of water flow from glacial melt, land subsidence, landslides and in watershed management

vi. Create state of the art facilities spread over research and academic institutions in the country to provide opportunities to the scientists to understand and explore the capabilities of SAR Interferometr

c. Airborne Laser Terrain Mapping

I. Explore the technical & economics of ALTM technology in gathering height information in different physiographic setups through pilot scale projects

ii. Organize awareness workshops to disseminate the research findings

d. High Resolution Satellite images

I. Promote R&D in application of high-resolution satellite images in construction and updating of spatial information for block and village level planning.

ii. Support training programmes and workshops in image interpretation and information extraction

e. Use of thermal remote sensing

I. Support application studies in the use of thermal images in resource estimation

5.2.2 Adaptation of new technologies

f. Application of Global Positioning System

I. Development of easy interfaces with GPS for deployment in the field for data collection using the local level manpower.

ii. Organize Training programmes on the concepts and application of GPS in spatial data gathering

iii. Support R&D studies in the application of GPS technology in spatial planning

g. Use of Ground Penetration Radar

I. Application in specific studies relating to agriculture, town planning etc. to be supported.

5.3 Land & Water Management at local level

Water and land management requires democratization and decentralization of decisions and accountability and encourages the integration of traditional knowledge with innovative science to promote fair and efficient management strategies. The Watershed approach is a well-accepted coordinating framework for planning & development. The integrated nature of activities and information involved in water and land management calls for collation and generation of data relating to geological, biological and ecological resources for different eco-systems. In order to focus the research initiatives in this sector, five sub-programmes are being supported under NRDMS viz.

1. Landslide Studies
2. Hydrology of Small Watersheds

3. Bio-Geo Database & Ecological Modeling for the Himalayas

4. Coastal Resource Management & Conservation

5. Groundwater Modeling Studies

Details about the sub-programmes are available in Annexure 4 – 8. Research issues identified are:

5.3.1 Data infrastructure Development

1. Research on standardization of data collection, and data density

2. R & D in object-oriented database design and management (SDT)

3. Building of knowledge bases in relation to local preferences

4. Risk assessment relating to extreme events

5. Assessing data needs at the watershed level for different agro-climatic regions to provide information for watershed management and planning.

6. Standard national codification of natural resources (like watersheds up to micro and mini level, flora, fauna etc.).

5.3.2 Technology development

1. Development and improvement of models for local area planning including urban area for which can integrate the hydrological, ecological, economic, social, institutional and legal aspects of land & water issues for developing multi-objective DSS and SDSSs for different ecosystems.
2. Environmental Impact Assessment
3. Performance Evaluation
4. Improved Water management practices – Salinity ingress prevention, pollution abetment, recycling and reuse of water, Geo-thermal water, irrigation methods, wetland management, vector harvesting groundwater recharge etc.
5. Improved land management practices including land related problem studies.
6. Assessment of water quality.

7. Ecological modeling – Dynamics of Biodiversity
8. Coastal zone management technologies

5.3.3 Technology transfer

Technology transfer & technological capacity building at local level through:

1. Training in Land & water management technologies relevant for local area/watershed planning

2. Development of web-based tools and technologies for better land and water management

3. Education curricula on locally relevant sustainable water management

4. Training at village, in water resources identification, quality assessment and control of pollution and adoption of water harvesting techniques.

5.4 Technology Transfer and Capacity Building

Capacity building is the process by which individuals, groups, organizations and institutions

strengthen their ability to carry out their functions and achieve desired results over time. In the current era of accelerating technological and institutional changes, strengthening the capabilities of individuals, organization and institutions is essential to ensure the sustainability of developmental efforts.

Under the NRDMS Programme, several geo-spatial tools and techniques for data management and analysis have been developed. District level GIS databases have been developed for the pilot districts and demonstrated to the Decision-makers at various levels. Availability of concept champions at some of the districts, core research teams on spatial data analysis and management technologies at National level have created congenial environment for implementing Technology Transfer to the appropriate user groups.

5.4.1 Technology Transfer Infrastructure

i. Setting up of multi-tier training infrastructure in NRDMS technologies at national, regional/ state, and local levels to cater to the training needs of de-centralized planning

ii. Setting up of pilot NRDMS center at least in one district of uncovered states.

iii. Setting up of model information hubs at selected block / Village *Panchayats* or micro-watersheds in various NRDMS districts in already-covered states by linking them up to the district NRDMS centers to facilitate easy access to resource information.

iv. Setting up of similar networks in each of the uncovered states for subsequent expansion and maintenance by the State Governments, District Administration, Local Communities, and NGOs.

v. Coverage of urban areas to facilitate capacity building of *nagarpalikas* in relevant themes by setting up similar Networks in wards

5.4.2 Training

i. Development of different training kits, modules, e-tutors for different target groups in a. spatial database development, up gradation, and maintenance b. map making, map use; c.

information retrieval relevant to local level planning

ii. Customization of GIS tools for different target groups and dissemination of the tools with packaged area-specific data sets for their immediate use

iii. Training of at community level people in Map reading & large-scale map preparation. iv. Preparation of GIS-based digital atlases for schools/colleges for the training of students on spatial data retrieval using GIS techniques on pilot basis.

5.4.3 Technology transfer & Capacity Building

i. Dissemination of spatial data Sets, products and technologies (GRAM++ and GRAM++ based technologies) to local self-governance institutions, NGOs, schools, colleges, Line Departments etc.

ii. Popularization of customized GIS tools to cater to the specific needs of development schemes/ programmes in operation at the districts or below.

iii. Building up of technical and institutional capacities of local institutions of self-governance, government officials, NGOs and individuals as well as local technical institutions for absorption of NRDMS technologies and tools at different levels.

6.0 SET GOALS FOR THE NEXT 5 YEARS IN REALISING THE VISION

Promote research aimed at local area natural resources management in different ecological setups.

Promote R&D to aid spatial planning at village level.

Drive research to empower the community with knowledge-based decision-making.

Create natural user interfaces for GIS packages.

Capacity building & Transfer of Technology.

Testing the concept of community participation in neighborhood information generation & proactively upscale the concepts proved.

7.0 NEW VISION

Considering the changing scenario, quantum jump in technology and nature of spatial data on natural resources, it has been felt that there should be serious consideration to have an introspection of the activities of NRDMS. This Division of DST should adopt a new role in nation building. Priorities have been changing but technologies are also available to handle the critical areas of application. Sometime technologies are developing faster than we can use it for different application. On the other hand, trained manpower is required to empower people of the country with geospatial technologies. Hence, it is the right time to consider a new vision for NRDMS.

DST, with the help of NRDMS Division, has been involved in forming a task force for developing a methodology for mapping on 1:10k scale using high-resolution stereo-satellite imagery for the high-resolution satellite images and development in GPS and GIS technologies.

Nevertheless, new vision is also required taking following priorities into considerations:

- With increasing population, there has been a tremendous pressure on natural resources of the country.
- The per capita availability of land, water, forests, fuel and biotic resources is reducing substantially.
- Recently, land, the finite natural resource, has become extremely sensitive.
- Further, the problems are aggravated due to the lop-sided distribution of population and resources.
- Hence, a sound and scientific basis for the management of natural resources is required.
- This would only be possible if the relevant data is generated from all the possible options available at our disposal.

The government has taken cognizance of the situation and made significant changes in terms of policies, availability of remote sensing data and

technology, some of which have been mentioned above. Hence, this is an occasion for introspection particularly to work out a new vision regarding the management of the natural resources of the country. Obviously, the new vision has to consider the compulsions, options and the opportunities available to us. Considering all the above issues, the proposed NEW VISION is as follows:

"The Natural Resource Data Management System or NRDMS should adopt a pivotal role in the country for promoting geospatial technology by formulating policies; supporting activities and projects on education and capacity building; demonstration of viable solutions, entrepreneurship, and in exchanging experience and expertise. It should also become a hub for developing linkages between the geospatial stake holders within the country and abroad."

NRDMS Division of DST has already taken a few steps in this direction. But, such initiatives

have to be strengthened by adopting the proposed new vision. Based on the above vision, new Missions are to be worked out as well. Some priority areas are as follows:

- Development of geospatial data policy.
- Identification of new applications areas using geospatial technologies : Web based services, village information system, management of natural resources
- 3D modeling, visualization, Spatial data mining, DSS,
- GIS Software development
- Generation of primary geospatial data : AWS, Lazar mapping/ALTM
- Development of geospatial curriculum and capacity building at various levels

The above vision and missions will help in redefining new role of NRDMS in the country.

8.0 CONCLUSION

In order to implement, at least some of the enlisted activities to realize the vision of NRDMS, support from a large segment of scientists, NGOs and entrepreneurs are required. The areas mentioned in this document is expected to stimulate the imagination of the research community to relate specific problems in their area of interest and evolve suitable research proposal to pursue the line of investigation to arrive at meaningful solutions to the problems as well as in advancing the existing knowledge in certain spheres of activity thereby aiding the overall development of the country.

ANNEXURE – 1

73RD CONSTITUTIONAL AMENDMENT (ELEVENTH SCHEDULE)

Agriculture, including agricultural extension.

Land improvement, implementation of land reforms, land consolidation and soil conservation

Minor irrigation, water management watershed development

Animal husbandry, dairying and poultry.

Fisheries

Social forestry and farm forestry

Minor forest produce

Small scale industries, including food processing industries

Khadi, village and cottage industries.

Rural housing

Drinking water.

Fuel and fodder

Roads, culverts, bridges, ferries, waterways, and other means of communication.

Rural electrification including distribution of electricity.

Non-conventional energy sources

Poverty alleviation programme.

Education, including primary and secondary schools.

Technical training and vocational education.

Adult and non-formal education.

Libraries.

Cultural activities

Markets and fairs.

Health and sanitation, including hospitals, primary health centers and dispensaries.

Family welfare.

Woman and child development

Social welfare including welfare of the handicapped and mentally retarded.

Welfare of the weaker sections, and in particular, of the scheduled castes and the Scheduled Tribes.

Public distribution system.

Maintenance of Community assets.

Note: Highlighted in annexure -1 is issues relevant to NRDMS programme.

ANNEXURE – 2

74TH CONSTITUTIONAL AMENDMENT (TWELFTH SCHEDULE)

The 12th Schedule of the 74th Constitutional Amendment Act of India, defines 18 new tasks in the functional domain of the Urban Local Bodies, as follows:

1. Urban Planning including town planning
2. Regulation of land use and construction of buildings
3. Planning for economic and social development
4. Roads and bridges
5. Water supply for domestic, industrial and commercial purposes
6. Public health, sanitation conservancy and solid waste management
7. Fire services
8. Urban forestry, protection of the environment and promotion of ecological aspects
9. Safeguarding the interests of weaker sections of society, including the handicapped and mentally retarded

10. Slum improvement and upgradation

11. Urban poverty alleviation

12. Promotion of cultural, educational and aesthetic aspects

Note: Highlighted in annexure –2 are issues relevant to NRDMS programme.

ANNEXURE – 3

BRIEF OVERVIEW OF NATIONAL PROGRAMMES PURSUED BY OTHER MINISTRIES ON APPLICATION OF SPATIAL DATA TECHNOLOGY FOR SUSTAINABLE RESOURCE MANAGEMENT

National (Natural) Resource Information System

NRIS is the major programme of National Natural Resource Management System of Department of Space. The programme seeks to provide an integrated database for the use of remotely sensed data and collateral information in the framework of a spatial information system for optimal management of the nation's natural resources and support

environmentally benign sustainable development. Through NRIS the NNRMS aims to make available the inventory of natural resources of the nation in a spatial format with proper linkages to other socio-economic data within a framework of a smart information system to enable customized retrieval and analysis for specific needs. The whole programme is visualized to be a network of GIS based nodes covering districts, aggregated through states to eventually cover the entire country. Presently 30 district nodes (1:50,000 scale) and 4 state nodes (1:250,000 scale) covering 17 states of the country have been established through the state remote sensing agencies. NRIS has also worked out the content and design standard of certain data sets that is to be hosted in each node.

Integrated Mission for Sustainable Development (IMSD)

In the year1987, the Department of Space had launched a technology demonstration-cum-exploration programme to counter recurring droughts and called it Integrated Mission for Sustainable Development (IMSD). National Remote Sensing Agency was identified to implement this programme in collaboration with Regional

Remote Sensing Service Centres and State Remote Sensing Centres. The programme aims at generating site specific "Action Plan" for optimal management of land and water resources using remote sensing technology, contemporary field data and socio-economic profile of the district.

During the demonstrative stage, 21 drought prone districts in the country had been covered. In the next four years, the programme was extended to 174 districts, spreading across 25 states of the country. In addition, 92 drought prone blocks had been taken-up for special study upon specific request from the Ministry of Rural Areas and Employment.

GIS Programme of NIC

NICNET, DISNIC and GISNIC are the three major programmes of the National Informatics Centre (NIC) with the objective of developing and operationalising Management Information Systems for better coordination and administration of developmental schemes. Under the GISNIC Programme, GIS-based information systems are being developed for the monitoring of the schemes at the

district level. As a part of this effort, GIS software package has been developed to support this exercise.

ANNEXURE – 4

LANDSLIDE STUDIES

Landslides have wide-ranging impact on the people of the affected area in terms of the devastation caused to material and human resources. The magnitude of destruction depends on the location of the landslide area. In the context of India it is a painful truth that most, if not all, the areas susceptible to landslide hazards are inhabited by the economically weaker section of the population who have neither the resources nor the expertise to organize rehabilitation measures out of their own. Necessarily, therefore, administrative assistance is called for to organize remedial measures – both short term and long term. Such administrative action is to be controlled and managed by appropriate technological support if optimum benefit is to be derived out of the efforts put in all front. There are two significant aspects of this. First, it is necessary to have a hazard zonation map of the area so that the local area management can take pre-emptive action to meet an

impending challenge rather than to wait for the disaster to happen. Secondly, the relief and long-term rehabilitation measures are to be worked out once the disaster has struck – whatever be its magnitude.

The natural instabilities in the Himalayan regions are accentuated by the human activities if the development schemes are not properly planned and implemented. Considering importance of this problem in development planning at local level especially in the Himalayan states, the following thrust areas have been evolved:

Developing data infrastructure

1) Preparation of nation-wide Inventory of existing landslides

2) Landslide Hazard Zonation and Assessment:

   – Regional specifically for planning (1:50,000 – 1:25,000) district level planning (1:15,000 –1, 10,000) and for site-specific micro zonation (1:5,000-1:2,000)

Technology development

3) Field validated zonation methodologies for long term and short term developmental planning.

4) Landslide Hazard Risk Analysis

5) Monitoring and Analysis of typical Landslides

6) Development of Early Warning System for landslides mitigation

7) Control Measures: a) Scientific & Technological measures, b) Validation of new technologies as successful landslide control measures and c) Legislative and regulatory measures

Technology Transfer

8) Dissemination of knowledge on landslide hazard mitigation and prevention.

ANNEXURE – 5

HYDROLOGY OF SMALL WATERSHEDS

Planning and development of small watersheds calls for rigorous understanding about the occurrence and movement of water in the surface and sub-surface systems along with soil and nutrient losses in a small watershed.

Realizing the importance of the problem and gaps in understanding small watershed hydrology in Indian catchments due to paucity of data, the coordinated program on **"Hydrology of small watershed"** has been launched by Department of Science and Technology, Government of India.

The main objectives of the program are:

1. To generate data on hydro-meteorological, soil, nutrients and process related parameters at small watershed level in different agro-ecological zones of the country through instrumentation.

2. To carry out modeling studies on watershed hydrology.

3. To develop SDSS for land and water management at small watershed scale.

4. To assess the impact of on-site and off-site management structures for soil and water conservation.

Under the program a pair of treated and untreated small watersheds (about 10 sq. km.) has been selected in the following regions

1) Dudhi and Bewas watersheds of Tawa basin in Raisen district of Madhya Pradesh.

2) Pundlu and Madpuriya watersheds of Siyara catchment in Jodhpur district of Rajasthan.

3) Chandrabhaga Garh and Danda watersheds in Garhwal district of Uttar Pradesh (Now Uttaranchal).

4) Paykkara watershed in Attapady region of Palghat district of Kerala and Rampatna watershed in Kolar district of Karnataka.

5) Waikhulok and Awang Khujailok I watersheds in the Loktak lake basin of Manipur.

Criteria for selecting these watersheds are as follows:

a) Small watersheds as defined by the Department of Agriculture, Govt. of India varying in size from 500-5000 ha.

b) It should be accessible and must have sites for water resources development.

c) The watershed should have some agricultural activities in it.

d) Those contiguous to another watershed, which has already been developed under some governmental programme.

e) The watershed should represent the pre-dominant land use system of the agro-ecological region.

Project proposals are invited for other Agro-ecological regions under the programme. DST assistance in the projects comes mainly in the form of supplying hydro-meteorological instruments, hardware, software and manpower.

Outputs expected out of these programme are:

1. Database for land and water management at small watershed level for different Agro-climatic regions.

2. Standardized methodology for

i) Hydrologic monitoring of small watersheds

ii) Procedure for data analysis

iii) Methodology for land and water management plan preparation

3. Bio-physical indicators for small watershed monitoring

4. Spatial Decision Support Systems (SDSS) for watershed management.

5. Tools for regionalization to other small watersheds of the same agro-ecological region.

ANNEXURE – 6

BIO-GEO DATABASE & ECOLOGICAL MODELING FOR HIMALAYA

Realizing the strategic importance of the fragile Himalayan eco-system and the need to develop spatial methodologies for the conservation of its natural environment, the coordinated programme on "Bio-Geo Database & Ecological Modeling for Himalayas" has been initiated by NRDMS division of the Department of Science & Technology. The emphasis of the

programme is to assess the potentiality of various sectors of natural resources for selected micro-watersheds in project mode and thereafter building up of application oriented scenarios for the decision makers.

Objectives of the Programme

1. Development of micro scale resource databases at watershed level along the altitudinal transects of Himalayan eco-system appropriate for the district level planning.
2. Formulation of a Database Management System and decision support systems using GIS and modelling tools to facilitate preparation of sustainable developmental plans.
3. Dissemination of the information/application strategies to the user community through appropriate reports, training programmes etc.

Approach for Implementation

For the identified watersheds in the Himalayan eco-system, a holistic multi-disciplinary scientific approach with special reference to natural resources and bio-diversity have been taken up in a coordinated manner covering the following sectors.

Land (soil & land use)

Water (surface & ground)

Biological diversity (plants, agriculture, horticulture and fauna)

Agro & Socio-economic aspects

Data Integration & capacity building

Ecological Modeling & Analysis

Expected Outcomes

Integrated database of natural resources at the micro-watershed level

i) Decision Support System tools for sectors like hydrology, ecology, land use, energy and agro-socio economy.

ii) Sustainable developmental plans and alternate scenarios generation for land resources, water resources, biological resources and socio-economy.

iii) Technology Transfer and Capacity Building for the users' community.

Location of Study Area

Currently, the coordinated programme has been initiated for the States of Himachal Pradesh and Uttaranchal (Garhwal and Kumaon transects). Representative micro-watersheds (size between 500-5000 ha) covering lower, middle and higher Himalayan altitudinal transects as identified are:

For Himachal Pradesh:

i. MeGad Watershed in Lahaul & Spiti district.

ii. Mandhala Watershed in Solan district.

iii. Moolbery Watershed in Shimla district.

For Kumaun Region:

i) Dabaka in district Nainital.

ii) Dhulgarh –Uttari Kosi in district Almora.

iii) Saryu in district Bageshwar.

For Garhwal Region:

i) Pathri Rao in district Haridwar.

ii) Fakot in district Tehri.

iii) Gomukh in district Uttarkashi.

ANNEXURE – 7

COASTAL RESOURCE MANAGEMENT AND CONSERVATION

The coastal zone – the transition between the land and the sea, is one of the most fragile, complex and a productive ecosystem. It is bestowed with enormous resources, both – living, non-living and is a potential area for recreation and harnessing non-conventional energy resources (wave and wind energy). This is the zone of dynamic activity, constantly transforming itself to maintain equilibrium, under the varying intensity of the natural processes operating here Coastal zone is a region of diverse activity, both complementary and conflicting to

each other. Accelerated and unscientific developmental activities have induced catastrophic consequences. In order to optimally utilize & reap the benefits, without hampering the fragile balance, it is necessary to adopt integrated coastal management strategies based on solid scientific foundation that allow for multiple use of the resources without causing serious damage to the environment.

Some of the major issues that requires to be addressed are,

Assessment of renewable and non-renewable resource potential.

Assessment f coastal stability – measures of stabilization.

Assessment of tourism potential, carrying capacity of the environment and plan for infrastructure development.

Assessment of energy generation potential – Wave and wind energy.

Assessment of vulnerability of the coast to – cyclones, floods, typhoons etc. and contingency planning.

Assessment of impact of human activity on the coast & control measures.

ANNEXURE – 8

GROUNDWATER MODELING

Groundwater is the major resource for meeting the water demand of the community throughout the year. The spurt of industrial activities and intensive agricultural practices in last two decades has led to severe scarcity for clean and hazard-free water. Therefore, to focus our efforts on evolving a more "holistic groundwater management strategies for resource evaluation and sustainable use" a sub-programme on ground water modeling was initiated under the NRDMS. The programme was developed through national symposium and brainstorming sessions. Under this programme research initiatives relating to – resource estimation, resource exploitation and its effect on the

environment, groundwater pollution – quality assessment and its remedial measures, employment of newer techniques in groundwater estimation, are considered. Support is also extended for organizing symposia and seminars having relevance to the subject for encouraging the scientific community to come together in evolving newer lines of investigative methods to address specific problems relating to groundwater management. Training programmes aimed at sharing new technologies in assessment of quality, estimation of quantity and pattern of flow etc. of groundwater are also supported under this sub-programme.

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