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Improving Spatial Data Management for Developmental Planning in India*

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Summary

Five Year Plans have been the hallmark of economic development in India since its independence. The Eleventh Five Year Plan (2007-2012) was concluded in March 2012 with the launching of the Twelfth Plan with focus on 'Faster, Sustainable, and More Inclusive Growth'. This being an immensely information-intensive task would require a major improvement in our strategy to manage data sets collected by various National and State agencies from a variety of sources including remote sensing, ground-based surveys, and computational/ analytical systems/techniques.

Recognizing the above, a multi-institutional and multi-disciplinary R & D Programme – Natural Resources Data Management System (NRDMS) – has been launched by the Department of Science & Technology and is being re-oriented during the Twelfth Plan. NRDMS Programme aims at promoting R&D in emerging areas of Geo Information Science and Technology. NRDMS being an R & D and Capacity Building initiative, efforts have been made to develop tools and prototypes to demonstrate their utility in developmental planning. Some of the typical application areas where specific tools/ prototypes have been developed in the recent years include use of Web Map Service (WMS) in water management, cartographic generalisation, spatio-temporal data analysis, sensor node development for web enablement, disaster management (landslides and tsunamis), etc. Technical capacity has been built through a series of training and user awareness workshops amongst the scientific and the end user communities and setting up of advanced facilities and laboratories.

In spite of several initiatives launched by various Departments of the Government over the past decades to promote the use of spatial data and tools/ technologies like Geographical Information System (GIS), Positioning System, and Remote Sensing at different levels of planning, there has not been adequate improvement in the quality of resource management decisions/ strategies. In order to overcome the problems, it has been decided to set up National Spatial Data Infrastructure (NSDI). Revised National Map Policy 2005, NSDI Resolution 2006 establishing a governance framework for the management of geo-spatial data; National Policy on Data Sharing and Accessibility, 2012; provision of interoperable Web Map Service (WMS) by various National Survey Agencies; establishment of State level SDIs, International collaboration/ participation have been the major steps towards improving management of geo-spatial data in the country in support faster, sustained, and more inclusive economic development of the country. National GIS is being set up on a priority to provide the required decision support to the stakeholder agencies.

1. Background

Five Year Plans have been the hallmark of economic development in India since its independence. Implementation of the recently-concluded Eleventh Five Year Plan (April 2007 – March 2012) was guided by the objective of 'faster and inclusive growth' with a GDP growth rate of roughly 8% - an indication of the speed at which Indian economy grew over the past five years.

As the country enters the Twelfth Five Year Plan (April 2012 – March 2017) with a projected growth rate of 9%, the Plan's strategy has been partially redefined to be 'faster, sustainable, and more inclusive growth'. The objective has been to improve in uniformly distributing the benefits of development spatially across different districts of the country. To this end, various flagship programmes of the Government launched in Eleventh Plan in sectors like Rural & Urban Development, Health, Education, Water Resources, Power, Agriculture etc. are thus being re-oriented for making the design of developmental programmes/ schemes more flexible to reflect ground-realities, encouraging innovation, promoting convergence to avoid duplication and creating synergies to improve the quality of outcomes. At the heart of this strategy remains the requirement to understand the inter-relationships and interdependencies between the sectors and conflicting interests of stakeholders so that the insights gained could be utilised in formulating integrated development strategies. This being an immensely information-intensive task would require a major improvement in our strategy to manage data sets collected by various National and State agencies from a variety of sources including remote sensing, ground-based surveys, and computational/ analytical systems/techniques. In line with this requirement, the Plan highlights the need to identify Geo-information Science as a priority area for collaborative research between Research Institutions and Universities.

2. Introduction

Recognising the above, a multi-institutional and multi-disciplinary R & D Programme – Natural Resources Data Management System (NRDMS) – has been launched by the Department of Science & Technology and is being re-oriented during the Twelfth Plan. NRDMS Programme aims at promoting R&D in emerging areas of Geo Information Science and Technology. Studies supported under the Programme contribute to the development of methods and techniques for operationalising the concept of local level planning and building the required human resource base in support of this strategy. Outputs of the studies are useful in drawing up local level planning strategies in support of the 73rd and 74th Constitutional Amendment Acts relating to the Panchayati Raj Institutions (PRIs) and Urban Local Bodies (ULBs) those have been formed to decentralise governance to local administrative units. Sharing of spatial data by data providing agencies in the framework of Spatial Data Infrastructure (SDI) is an essential prerequisite and the National Spatial Data Infrastructure (NSDI) has thus been a major initiative.

This report brings out important activities completed/ launched in the recent past under the NRDMS Programme and NSDI Initiative in Sections 3 and 4 respectively. The collaborative mode of working between the Government, R & D Institutions and academia, Private Sector, and Civil Society Organisations/ Non-Governmental Organisations in support of NRDMS and NSDI has been described in Section 5. The Report concludes with a brief set of activities for the future in Section 6.

3. NRDMS Programme

NRDMS being an R & D and Capacity Building initiative, efforts have been made to develop tools and prototypes to demonstrate their utility in developmental planning. Some of the typical application areas where specific tools/ prototypes have been developed in the recent years include use of WMS in water management, cartographic generalisation, spatio-temporal data analysis, sensor node development for web enablement, disaster management (landslides and tsunamis), etc. Technical capacity has been built through a series of training and user awareness workshops amongst the scientific and the end user communities and setting up of advanced facilities and laboratories. National Geotechnical Facility at Dehradun and the Advanced Laboratory on Geo-information Science & Engineering (GISE) at Indian Institute of Technology (IIT) Bombay are two major initiatives in this direction.

3.1 Application of Web Map Service (WMS) in preparation of panchayat level plans

Strengthening Panchayati Raj Institutions (PRIs) and empowering local communities with improved access to up-to-date information is essential to their effective participation in local level planning. In a study conducted in Takula Block, Almora (Uttarakhand), year wise local development plans for a select set of villages have been prepared using up-to-date resource maps and made accessible through OGC-compliant WMS. The village level plans have been prepared with the involvement of local villagers and panchayats and uploaded to the district data node at Almora with a view to sharing the maps with the concerned stakeholder agencies. The present study aims at sharing the water resources information with the panchayat representatives and villagers for ensuring their participation in recharging the endangered Kosi River basin vital to meeting water requirement in the district. A cluster of 158 revenue villages covered in 8 Nyaya Panchayats, 89 Gram Panchayats, and 1 Kshettra Panchayat (Takula, Almora) and the Almora District Zilla Panchayat have been involved in the preparation of the natural resource inventory and the local level plans. Individual village level plans are proposed to be combined to prepare a block level master plan for Takula block water resources conservation planning.

3.2 Cartographic generalisation

A city map primarily consists of features like buildings and roads. While viewing such a map at a reduced scale, as on mobile devices, the features not only become smaller but tend to overlap as the small area available for visualisation gets smaller. Cartographic generalization plays an important role in overcoming these effects and preserves the required legibility considering the need for communicating (maps) geographical data to mobile devices in support of local planning activities. Various computing operations are performed during generalization of these features. One of the important processes - simplification of the features like buildings, roads, contours etc. - involves automatic smoothing and elimination of small but unimportant features.

3.3 Spatio-temporal analysis of cyclone data from Bay of Bengal region

Study of movement (trajectory) of cyclones is a pre-requisite to improve early warning and devise better strategies for preparedness. Behavior of tropical cyclone trajectories needs to be better understood in order to isolate potentially predictable aspects of landfall. Cyclone trajectories in a given ocean or sea can be better analyzed using cluster analysis by grouping them into small subgroups with homogeneous spatio-temporal characteristics. A set of 139 tropical cyclone tracks over the Bay of Bengal has been studied and classified into different subcategories using spatio-temporal data sets for the period 1990-2009 and applying K-means clustering algorithm based on the concepts of vector geometry and higher order statistical moments. Using the first two moments of a cyclone track, it has been possible to estimate a measure of its central location, length, orientation, and to an extent, its curvature. A vector of five attributes (two centroids and three variances) per track has been considered for clustering. Relative movement of cyclone tracks could be analysed using the method.

3.4 General purpose wireless sensor node

A general purpose wireless sensor node has been fabricated with a view to equipping the IITB smart campus grid with sensor nodes for capturing information to support campus resource management. Designed to be a low cost and easily deployable device, the node consists of a Zigbee Module (ZM), GSM/GPRS Modules, and a GPS Module. Multiple sensors can be connected to this node via 6 serial ports, 8 ADC channels, one SPI port, and 8 General Purpose I/O lines. The GSM/GPRS module can send data to a Server via SMS or the internet via GPRS for automatic sharing with the end user community.

3.5 Landslide Hazard Mitigation

Under Landslide Hazard Mitigation, site specific studies have been undertaken in three areas i.e. Naptha – Jhakri in H.P., Ooty in Tamilnadu and Munnar in Kerala. All these three sites have been instrumented to collect real time data on various parameters from surface and sub-surface

profiles to understand the underlying cause and effect of landslides and also develop an early warning system based on the monitoring of the active slopes. The exercises would help in developing the threshold of the parameters which are responsible for triggering of landslides. Also, based on such studies, it would be easier to design suitable preventive measures for controlling the landslides.

3.6 Urban Flood Risk Mapping of Chennai City

Urban Flooding is of great concern to the Planners in India with cities like Mumbai, Chennai facing havocs during monsoon. In order to provide S&T solutions for urban flood mitigation and management in Chennai City, a joint project with the State Govt. has been initiated by NRDMS. The efforts have been made to develop a detailed spatial database of city, analyse models and suggest mitigation measures to the flooding problems of Chennai. Airborne Laser Terrain Mapping (ALTM) has been used to collect data on high resolution topographic information to develop Digital Elevation Model (DEM) with an accuracy of about 15cm in altimetry. The process involves use of laser pulses emitted from the instrument fitted on Aerial Platforms like Air Plane, Helicopter to measure the variation of the ground thus help in generating much needed elevation data of the terrain. The Photogrammetric process has been used in mapping physical features like buildings, trees, roads, culverts, bridges, drainage network at very high positional accuracies. These features influence the flooding process that occurs due to high imperviousness, encroachment of natural drainage. Other attribute data like Rainfall, Observed Runoff in the Rivers, Socioeconomic condition of people, Shelters, Medical Facilities have been compiled through ground survey and integrated with spatial information in Geographical Information Systems. Such integrated database acts as decision support system for the planners and administrators by providing physical, socio-economical and environmental information required for mitigation and management planning.

Flood Simulation Modeling using tools like MIKE 21, SWMM with input of topography and other spatial, non-spatial parameters have been used in modeling the scenarios for different quantum of rainfall. The resulting output of flood risk maps has been used in identification and quantification of areas and facilities that may be inundated for a given rainfall i.e 10cm, 20cm. Information derived from the simulation helps quantify the stress on typical urban infrastructure like roads, electricity, communication for quick reaction of the authorities to avoid loss of human life and damage to property.

3.7 Tsunami Wave Propagation Modeling of Nellore Coast

The project at Anna University aims at understanding the propagation of Tsunami after it is generated due to an uplift of ocean floor caused by a massive earthquake of magnitude above 8.0. The MIKE21, a powerful modeling tool has been used to simulate the tsunami wave propagation. The model has been developed with the source parameters that caused 2004 tsunami and validated with observations from coastal tidal observations and similar model output of NGI, Norway. The validated model has been further used to predict the future possible scenarios to assess the tsunami arrival time and wave height at shore.

3.8 National Geotechnical Facility (NGF)

In order to develop the capacity for geotechnical engineering particularly for rock and soil testing, advanced laboratory facilities - a National Geotechnical Facility has been set up in 2008-09. Over the last few years, the emphasis of the programme has been to set up state of the art equipment that can support cutting-edge research in the area of Geotechnical Engineering. At present, the country is focusing on developing infrastructure facilities like dams, metros, highways, bridges, underground constructions and micro hydel projects. All these projects require high standard soil and rock testing facilities to develop the foundation design and also maintain the performance of the project. The facility created under NGF would be useful in implementing such major projects in the country. As part of this, the facilities like step frequency ground penetrating radar has been acquired from Norwegian Research Council, which are technically

collaborating to set up the NGF.

3.9 Advanced Research Laboratory on Geo-information Science & Engineering (GISE)

In order to promote R&D in different emerging facets of Geo-information Science and Engineering, an advanced laboratory on Geo-information Science & Engineering (www.gise.cse.iitb.ac.in) has been set up at the Department of Computer Science & Engineering, Indian Institute of Technology Bombay. Some of the activities being pursued at the Laboratory include Spatio-temporal Data Analysis, Geo-spatial Statistics, District Geo portal prototypes, General Purpose Wireless Sensor Node Development etc. The Laboratory is expected to facilitate closer interaction between different research groups in the area of Spatial Data Management Technologies for the achievement of long term goals in the field of Geo-information Science by leveraging the expertise and experiences available at various IITB Centres/Departments, and other similar research organizations in the country or outside.

4. NSDI Initiative

In spite of several initiatives launched by various Departments of the Government over the past decades to promote the use of spatial data and tools/ technologies like Geographical Information System (GIS), Positioning System, and Remote Sensing at different levels of planning, there has not been adequate improvement in the quality of resource management decisions/ strategies. Non-availability of and inaccessibility to spatial data of desired resolution and currency, incompatible data sets; lack of user-friendliness of the processing tools; and inadequate capacity amongst the end-users have been the major bottlenecks. It has therefore been imperative to improve the spatial data management practices and appropriately align the tools/ technologies with the work flow or business processes of the panchayats (rural institutions)/ nagarpalikas (urban institutions) in the framework of Spatial Data Infrastructures (SDIs). Revised National Map Policy 2005, NSDI Resolution 2006 establishing a governance framework for the management of geo-spatial data; National Policy on Data Sharing and Accessibility, 2012; provision of interoperable Web Map Service (WMS) by various National Survey Agencies; establishment of State level SDIs, International collaboration/ participation have been the major steps towards improving management of geo-spatial data in the country.

4.1 National Map Policy 2005

In May 2005, the National Map Policy has been revised to bring out two series of topographic maps published by the Survey of India – the Defence Series Maps (DSM) for use by the Indian Defence Forces and the Open Series Maps for use in Developmental Planning.

4.2 NSDI Resolution 2006

Through a resolution of the Union cabinet in June 2006, it has been decided to set up a governance framework for improving management of geo-spatial data in the country at the national level. As per the resolution, a two tier structure – an apex level National Spatial Data Committee (NSDC) under the chairmanship of the Union Minister of Science & Technology and a lower NSDI Executive Committee under the co-chairmanship of Surveyor General of India and the Director, National Remote Sensing Centre - has been established for management of geo-spatial data collected and compiled by various national level Survey Agencies. Members are drawn from the senior Government level functionaries and from the respective organisations. Academia, Private Sector and the Civil Society Organisations are adequately represented in the Committees. A set of eight Working Groups on various themes relevant to geo-spatial data management support the implementation of the directives of the above Committees.

4.3 National Policy on Data Sharing and Accessibility 2012

The National Policy on Data Sharing and Accessibility (NDSAP) has been approved by the Union Cabinet in March 2012 for making the sharing of data sets collected through public funds mandatory for the Governmental agencies. The Policy has been prepared through intensive public consultations and several Inter-Ministerial meetings.

4.4 Provision of Interoperable Web Map Service (WMS) for Open Series Maps (OSM) of Survey of India

Interoperable Web Map Service (WMS) for the OSM data is now being provided over the web. Operational WMS for the State of Andhra Pradesh in its entirety and for a part of Maharashtra has been released. Two training Workshops have been organised for the senior officials of Survey of India for preparing the OSM data for provision of WMS for the rest of the country. The Committee is presently looking into re-engineering OSM data for setting up an interoperable data node in SOI to store the topographic OSM data for provision of Web Feature Service (WFS)/ Web Feature Service – Transaction (WFS-T). WFS-T will be useful in faster updation of topographic data and sharing. As a single window access mechanism to access geo-spatial data from multiple sources, the India Geo Portal has been upgraded to access the WMS of SOI OSM data and that of NRSC and Forest Survey of India (FSI) concurrently. The mechanism provides for concurrent viewing of geo spatial data sets from multiple sources over the web.

4.5 Establishment of State level SDIs

State level Geo portal and clearinghouse has been developed and demonstrated for Karnataka and similar portals are under development for other States. During the Twelfth Plan, it has been decided to set up State level SDIs in various States on competitive grant basis.

4.6 International Collaboration/ Participation

A Memorandum of Understanding (MoU) has been signed with the Natural Resources Canada (NRCan) for launching collaborative projects on development of SDIs in India in November 2009. As a follow up of the MoU, a work plan has been drawn up between NSDI/ DST and NRCan for pursuing collaborative activities on ‘Spatial Data Infrastructure (SDI)’ and 'Natural Disaster Management (Landslides)'. Some of the specific sub-areas that may immediately engage attention include 'Geospatial Policy', ‘Geo Portal Development (landslides)’, 'GI management', ‘Knowledge Exchange’, and 'Academic Exchange Visits'.

India has been participating in the UN initiative on Global Geospatial Information Management. The First High Level Forum on UNGGIM held in Seoul in October 2011 has been addressed by Secretary, Department of Science & Technology.

5. Participating institutions and management of NRDMS/ NSDI

A network of Government Organisations, Survey Agencies, Research and Academic Institutions and Non- Governmental Organisations helps implement the NRDMS/ NSDI. In addition to the governance structure mentioned in Section 4.2, at the national level, several thematic Expert Committees of the Department of Science & Technology consisting of scientists, experts, and academicians from several but allied disciplines provides technical guidance and monitors the activities of NRDMS Programme and NSDI Initiative. At the State and District levels, State/District Coordination Committees under the chairmanship of State Chief Secretary/ District Collector with members from different Line Departments provides guidance to the NRDMS and State SDI activities. A network of governmental organisations, survey agencies, leading research & academic institutions, and Non-Governmental Organisations supports implementation of the NRDMS/ NSDI.

6. Conclusion

With demonstration of the required tools/ technologies and the availability of a core expert base for setting up of SDIs and developing their applications, NRDMS/ NSDI are now poised towards building capacities of various organisations/ institutions engaged in Developmental Planning including Panchayats/ nagarpalikas and the civil society. In support of this requirement, local research or academic institutions countrywide need be networked and equipped with the tools/ technologies for providing the requisite scientific & technical back up to implementation of Decentralised Planning. During the XII Plan, the focus will therefore be on refinement/ customisation of the tools/ technologies and their use in demonstration of multi-level pilot scale SDIs in various application domains like Land Administration, Water Management, Biodiversity/ Ecology, Coastal Zone Management, Health, and Disaster Mitigation. Priority will be given to setting up of facilities for Research & Development on different facets of Geo-Information Science & Technology. National GIS is proposed to be set up in the next three years to provide the required GIS back up to the stakeholder Ministries and other user agencies towards translating the NSDI vision of 'Sustained Economic Growth' for the country.

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