

## THE NATIONAL (NATURAL) RESOURCES INFORMATION SYSTEM

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### ABSTRACT

The National (Natural) Resources Management System is an important component of the National Natural Resources Management System. The NRIS seeks to provide an integrated database for the use of remotely sensed data and collateral information in the framework of a spatial information system that can be used for decision support by the Government functionaries at the state and district. This paper describes the scope of the system and the technical and managerial issues involved. The NRIS implementation has started with an Interim Plan and a larger operational implementation is in preparation

### 1 BACKGROUND

In 1983, the Department of Space, DOS, realised that to promote the wide use of the technology of Remote Sensing it would be necessary to integrate the applications of the technology into the existing information systems which were in day to day use by resource managers and planners. With this in view a major programme called the National Natural Resources Management System; NNRMS was launched under the aegis of the Planning Commission. One of the important elements of the NNRMS was the NRIS or the National (Natural) Resources Management System. The parenthetical adding of the word 'Natural', in a way, explains the *raison d'être* of the NRIS. Resources management is a very involved task and requires the combined efforts of different experts, ranging from natural resource scientists to economists and bureaucrats. The technology of Remote Sensing, however, primarily addresses the information needs of the natural resource scientists and any associated information system would therefore be oriented towards natural resources. The NRIS would thus be a feeder information system to the larger information system of the Government, which would include socio-economic information and models.

1983	National Natural Resources Management System to promote use of Remote Sensing and GIS established. <ul style="list-style-type: none"> <li>• Preparatory Committee for NNRMS set up by Planning Commission.</li> <li>• NNRMS Seminar: Concept of NRIS presented for the first time.</li> <li>• PC-NNRMS becomes Planning Committee.</li> <li>• Several Task Groups set up including NRIS and Cartography set up by the Planning Commission.</li> <li>• Several Pilot Projects initiated in areas such as Regional Planning, Urban Planning, etc.</li> </ul>
1990	Inter-departmental Expert Committee to finalise NRIS Action Plan.
1992	Integrated Mission for Sustainable Development launched.
1996	NRIS Programme launched with sanction of Interim Plan.

Table 1 A Chronology of Events

## 2 SCOPE OF NRIS

The NRIS, as illustrated in Figure 1, consists of a set of databases on natural resources distributed according to the Indian administrative structure of Centre, States and the Districts. In the case of Central Government sectoral departments, the hierarchy followed will be Centre-Region-Project. The databases will be linked to each other by way of telecommunication links such that information should be only a mouse click away. The crux of the NRIS is customised application shells that allows the administrator to interact with the system and get information as and when needed. This called for the development of generalised query shells as well as specific decision support shells running user defined models. These databases and shells can handle spatial data in the form of satellite imagery and maps derived from them and other sources. The spatial data is linked to socio-economic information available from the Census, DISNIC, BES and other databases. To this extent, the boundary between the natural resources and other resources becomes diffuse.

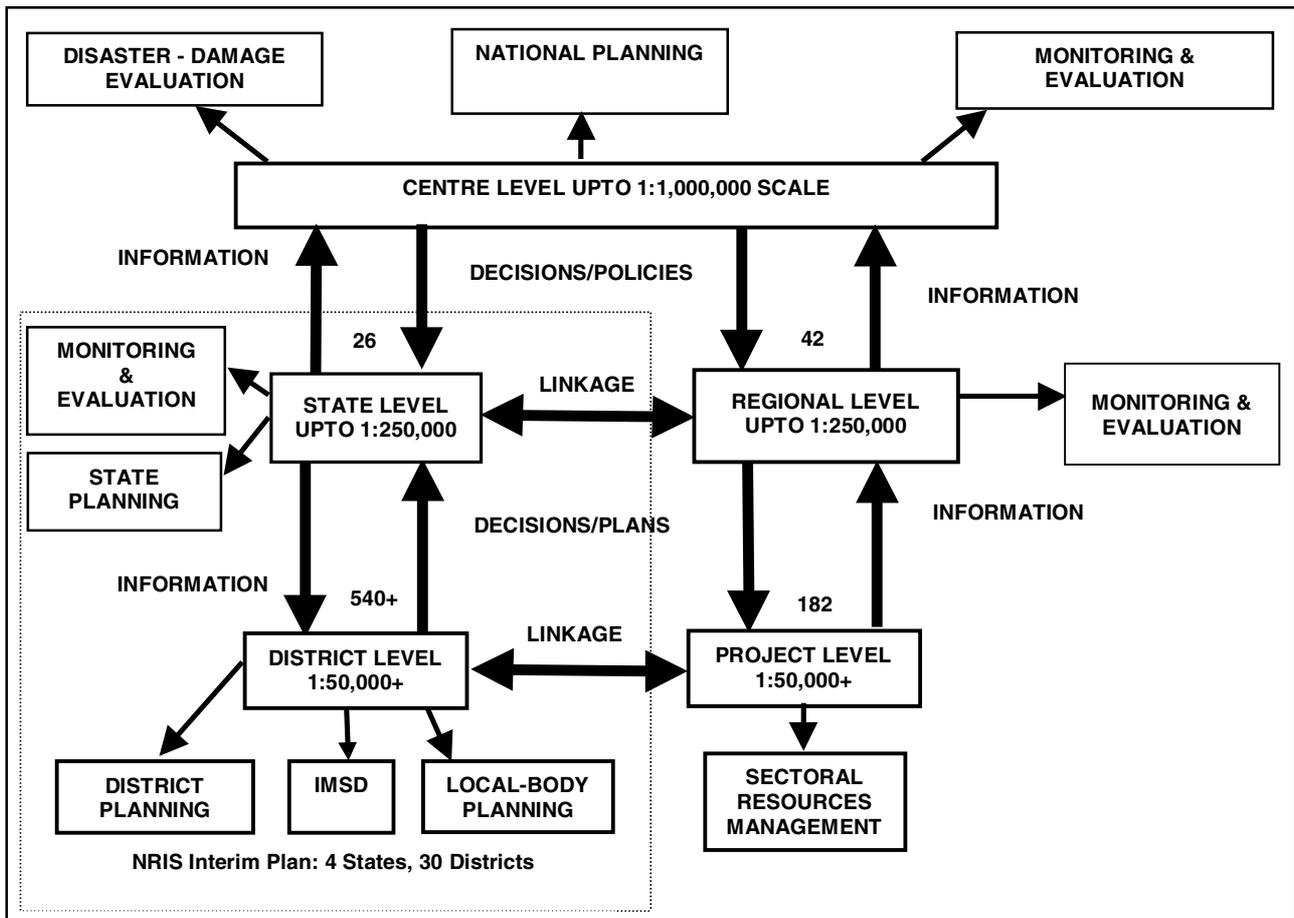


Figure 1 The NRIS Concept

## 3 EVOLUTION OF NRIS

This concept was debated and discussed at several forums. An inter-departmental Expert Committee laid down the dimensions of the proposed system in 1990[1]. However, many felt that this was an idea ahead of its time. Consequently, a series of pilot projects were planned and executed to understand the technological, scientific and operational intricacies of the system [2,3]. Finally, in 1996 the Department of Space, as the nodal agency for NNRMS, decided to launch the NRIS programme in a modest way. An Interim Plan was drawn up to implement the concept in a selected set of States and Districts. The Plan also envisages some experimentation on the inter-linking and remote access of the databases using modern computer communications systems.

#### 4 THE NRIS INTERIM PLAN

The NRIS Interim Plan spatial databases are being set up in four States and 30 Districts. The States are Andhra Pradesh, Maharashtra, Orissa and Gujarat. The districts are seven from these states and another 13 from the states of Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal, Assam, Mizoram, Tamil Nadu, Kerala, Madhya Pradesh, Rajasthan, Punjab, Haryana and Karnataka. The State databases contain information on natural resources at a scale of 1:250,000 while the District databases have information at the detail of 1:50,000. The districts have been selected based on data availability. All these districts have been covered under the Integrated Mission for Sustainable Development, IMSD. Each database has up to 20 map layers and 8 socio-economic tables [Tables 2 and 3]. As stated earlier, the databases are operated through application shells that have been designed to provide a simple front end to the database. In addition, based on discussions with the state and district administrators, customised decision support shells have been provided for specific planning scenarios like soil conservation, water harvesting, watershed management, etc.

S.no	Element	Source
1	Landuse / cover map for different dates. nnnn indicates year of map preparation	Remote Sensing Data (RS)
2	Geomorphic units & Landforms captured from source map	Hydrogeomorphological map (RS)
3	Rock Group/ Lithological units	-DO-
4	Geological structures like lineament, fault, fracture etc., - captured from source map	-DO-
5	Soil type, depth, texture etc., for associations / series/family etc.,	RS/Soil agencies
6	Drainage	Toposheet/ RS
7	Canals	Toposheet/ RS/ Irrigation Dept
8	Elevation contours/ spot height points with value in metre at suitable interval	Toposheet/ RS
9	Watershed hierarchy polygons	All India Soils & Land Use Survey up to Water shed level.
10	State/District boundaries (State/ Centre node only)	Toposheet
11	District/Taluka boundaries(Both State/District node)	Toposheet
12	Village boundaries (District/Node only)	Census maps
13	Forest management / Administrative boundaries like Division/ range / compartment etc.,	State Forest Dept., Toposheet
14	Location of Wells, nature of Wells, yields particulars, water quality etc.	State/Central Ground Water Depts.
15	Settlement locations / areas spread	Toposheet/Census maps
16	Roads	Toposheet/Public Works Depts./RS
17	Rail network along with Railway Stations	Toposheet/ RS
18	Rainfall / temp observation locations for Rainfall/ Temp data - monthly (Min/Max. /Ave.)	Met Dept.
19	Minerals	Geological Survey of India/ Dept. of Geology & Mines
20	SOI toposheet references, Lat.-Long. reference	Toposheet

Table 2 Primary Spatial Database Elements

S.no.	Table Name	Source	Acceptable Age / Update frequency
1.	Demographic data Village wise - District Node Taluka Wise - State Node	Primary Census/ District Information System of NIC	10 yr.
2.	Occupation data	- do -	- do -
3.	Educational Facilities	Bureau of Economics & Statistics/ DISNIC	Bi-annual
4.	Medical Facilities	- do -	- do -
5.	Communication Facilities	- do -	- do -
6.	General Facilities	- do -	- do -
7.	Land Use	- do -	- do -
8.	Power	- do -	- do -

Table 3 Primary Non-Spatial Elements

## 5 IMPLEMENTATION OF THE NRIS INTERIM PLAN

A team of scientists from DOS, along with the State Remote Sensing Applications Centre, SRSAC, visited each state to present the details of the programme to the senior administrators and to solicit their co-operation and support. The actual task of database realisation is the responsibility of the State Remote Sensing Applications Centres. Hence, each of the SRSACs is the designated work centre under NRIS. The seven DOS work centres, Space Applications Centre, National Remote Sensing Agency and the Regional Remote Sensing Service Centres at Bangalore, Nagpur, Kharagpur, Dehradun and Jodhpur are in liaison with the state centres and are helping to facilitate the work. The DOS has also funded a large part of the plan by providing the necessary hardware and software as well as the services of its staff. The states have also providing significant contribution by way of infrastructure, staff and data. A set of remote sensing entrepreneurs have been identified by the Department of Space and qualified by the NRIS Project for data digitisation as per the NRIS standards. Other vendors have been identified for mapping from remote sensing data and for data entry.

## 6 STANDARDISATION

In order to standardise the databases to facilitate information exchange a detailed Standards Document has been prepared and distributed to all work centres [4]. The NRIS Standards cover the database specifications, naming conventions, accuracy specifications and hierarchical classification of each theme. It also lays down procedures for database validation and accuracy estimation. Drawing upon the accumulated experience of remote sensing and GIS, scientists working in DOS and user agencies arrived at these standards. A change management procedure has also been incorporated. The standards were revised to include changes to accommodate a more elaborate soil classification scheme and to remove certain anomalies observed during the initial database implementation phase. This approach has yielded results in two ways. Firstly, it has been possible to distribute the database creation jobs to entrepreneurs without worrying about registration problems. Secondly, application modules can be easily integrated with the database. This allows simultaneous development of application modules for the databases and interoperability between modules and databases is assured.

S. No.		District Node	State Node	Centre Node
<b>A. Input Specifications</b>				
1	Location Reference	.Latitude-Longitude/ Permanent features		
2.	Scale	1:50,000	1:250,000	1:1,000,000
3	Projection/Map standard	Preferably polyconic (SOI Base)		
4	Thematic Accuracy			
4.1	Minimum Spatial Unit (2mm)	10,000 m <sup>2</sup>	250,000 m <sup>2</sup>	4,000,000 m <sup>2</sup>
		0.01 km <sup>2</sup>	0.25 km <sup>2</sup>	4 km <sup>2</sup>
4.2	Mapping	90/90	90/90	90/90
		Sample checks in field		
5	Control Accuracy ( with respect to control points on Survey of India Toposheets)			
5.1	Planimetric (RMS)	50 m	250 m	1000 m
6	Legends	As per details in Integrated Mission for Sustainable Development technical guidelines		
<b>B. Database Specifications</b>				
1	Spatial Framework			
1.1	Registration scheme	A set of Registration points-preferably SOI sheet corners/Lat.-Long. intersections/road intersections etc.		
1.2	Projection/Co-ordinate system	Polyconic (local to district)	Polyconic (local to State)	Polyconic (local to Centre)
	Subject to further study	Central meridian & standard parallel at the centre of node		
1.3	Co-ordinate units	metre	metre	metre
2	Accuracy/Error Limits			
2.1	Element Registration into system (RMS)	12.5 metre	62.5 metre	250 metre
		Location check against permanent features		
2.2	Area	0.3%	0.3%	0.3%
		Sample check Digital area, Values subject to experiment		
2.3	Weed tolerance	12.5 metre	62.5 metre	250 metre
		Inspection of log file		

S. No.		District Node	State Node	Centre Node
2.4	Co-ordinate Movement Tolerance (CMT)	12.5 metre	62.5 metre	250 metre
2.5	Sliver Polygon Tolerance	2500 m <sup>2</sup>	62500 m <sup>2</sup>	1000000 m <sup>2</sup>
		0.025 km <sup>2</sup>	0.625 km <sup>2</sup>	1 km <sup>2</sup>
		Digital MSU- 1mmx1mm map equivalent		
2.6	Grid size (For Raster GIS)	25x25 m	125x125 m	500x500 m

Table 4 Node Database Design Specifications

## 7 REALISING THE NRIS

The process of realisation of a DBMS is well established. It starts with the definition of the user requirements and an understanding of the user capabilities. From this we derive the hardware and software specifications and then proceed with the database design, validation and customisation as per user needs. The system has to be installed and the end user has to be trained in the use of the system. User needs and Capabilities

The users of the system are the State government officials at the district and state offices. The first attempt to ascertain their needs met with limited success. A large wish list emerged which is shown in Table 5. Some attempts were made to arrange these by priority but it was clear that the determination would have to be an ongoing process. Therefore, it was decided to concentrate on providing land and water management plans based on the IMSD models and a means of querying the database for deriving information on a need basis. The latter would take care of the day to day information needs till some specific applications were identified and modelled.

Simple queries (Retrieval, formatting and presentation)	Criterion Table Based Siting (if-then-else, weighted criterion etc.)
Locate fields with ownership - when purchased -surrounding field	Artificial recharge Energy plantations Fodder development
Monitoring development plans	Aqua-culture (coal Mines)
Distribution of homeless - community wise - blockwise	Irrigation Wind energy Forest fire
Personnel database - beneficiaries - voters list	Agricultural Practices Catchment area treatment Groundwater development
Irrigation / command area monitoring	Crop suitability
Backward area	<b>Mathematical/ Statistical/ Geometric modelling</b>
Flood relief	Disease incidence
WS implementation monitoring	Population growth
<b>Location - Allocation Modelling</b>	Population migration
Alternate sources potable water (fluoride affected areas)	Drought relief index
Industrial Amenities	Water budgeting
Agriculture Amenities	Irritability index
Health Amenities	Watershed modelling
Education Amenities	Village development Indices
Milk collection/ distribution centre	Damage due to hail storm
Drinking water source	Surface water yield
<b>Descriptive/ fuzzy (needs more details)</b>	Fuel-wood budget
Joint forest management	Village crop production
Impact of development plans	- grain storage
Environment Impact in open cast mines	-fertiliser needs
Impact of Watershed Development Programmes	Watershed prioritisation

Table 5 NRIS Applications Requirements Categorised by Designer's Perspective

In terms of capabilities these persons are expected to have, at best, some familiarity with personal computers for office automation. They will not be able to assimilate spatial database technologies nor should this be attempted because the users would rather concentrate in their own tasks of resources management than pick up new skills.

## 7.1 Choice of Software

The NRIS is being realised around a core Geographical Information System, GIS, software. Considering the needs it was decided to use a GIS with versatile modelling and customisation tools. Modelling tools are required to be able to realise user defined applications models like soil conservation models and ground water recharge models. Customisation tools are needed to realise user friendly interfaces, which would enable the user to specify parameters and run the models and generally interact with the database without having to learn the GIS commands. Several products were evaluated, including an in-house product. Finally the product which met most of the requirements was ArcInfo.

The choice of Operating System was difficult due to conflicting requirements. The Windows platform was the easiest to 'learn' but the GIS on these platforms lacked essential features. Windows NT was considered but rejected as it involved a learning period for the developers of the databases, which would cause project delays. Hence, UNIX was chosen because of its reliability and the familiarity of the developers with UNIX based Arc Info GIS. The down side to this decision was that the users would have to learn a minimum set of UNIX commands and the State Remote Sensing Centres and hardware vendors would have to provide an extra support when needed.

## 7.2 Choice of Hardware

The choice of UNIX as the OS meant that the choice of the hardware platform had to be restricted to workstations. Two types of workstations have been procured. The district systems are entry level workstations while the state systems are more powerful. All systems have been provided with adequate disk capacity and large displays. The workstations are multimedia compatible so that they can be used for training purposes if required. It can also handle multimedia databases as and when such databases become available.

## 7.3 Systems Installation and Training

Training has been provided to the SRSAC staff on the hardware and software installation, operations and day to day maintenance. On site the vendors under a 3-year comprehensive contract provide maintenance. The intention is to allow the users to concentrate on the task of system usage rather than worry about logistics issues.

## 7.4 Database Design and Validation

In India the topographic base is set by the Survey of India. The topographic maps are in the Everest spheroid, using a Polyconic projection. The scale chosen for the district databases was 1:50,000 while for the state databases it was 1:250,000. All the thematic maps are created on these two scales with the topographic map as the base map.

To realise the database the topographic map layout was used. The individual thematic maps were digitised and tiled after edge matching. Thus the database consists of separate tiles which are virtually joined. The join is seamless and transparent to the user. The corner co-ordinates of the map sheets are used as tie points (tic marks) for this purpose.

Each map is created as per the standards laid down and the digitisation is also controlled as per these standards. The inputs are subjected to two rounds of validation. The thematic layers created from satellite data are subjected to a quality assessment, which includes accuracy assessment. The layer is tagged with the accuracy figure. This process is waived where the map is obtained from published sources. The second validation is implemented after the map has been digitised. Only after this step is the database cleared for the next step: integration with application modules.

## 7.5 Application Shells

For applications, user friendly shells have been developed which lay users who are not familiar with UNIX, GIS and remote sensing can use. These shells are developed using the macro language of Arc Info and provide a simple point and shoot interface that requires only a basic familiarity with mouse based navigation.

Currently, two types of shells have been provided. The first type is a generalised query shell. This allows the user to interact with the database and build up scenarios using simple queries. The second class of shells is application specific and address land and water management scenarios. In these shells the user can use a predetermined application model, or a modification of the same or a *de novo* model developed by him. In addition, at a later date more application modules can be added as per the user needs.

In addition, a utility shell has been provided for housekeeping tasks like data validation, image to map registration and image map creation. Image maps provide the user with updated information of spatial features. These maps can be created at scales up to 1:12,500 using high-resolution data from satellites like the IRS 1D. Users have indicated that such maps will be needed to precisely locate sites for implementation of development works like check dams, gully plugs and so forth.

## 7.6 System Commissioning and User Training

Each database is put through an automated validation process which checks each layer of information for compliance with standards. After the databases have been rectified they are integrated with the shells and the integrated system is checked functionally.

At this stage training is imparted to the SRSAC personnel on the installation of the shells. This training is also training for future trainers as the SRSAC personnel are expected to train the end user agency personnel in turn.

The state level user training is aimed at problem solving using the system. Hence, apart from a general exposition on remote sensing and GIS the training concentrates on case studies which illustrate the usage of the system.

## 7.7 Preliminary Usage

The deployment of the system and training was followed by the preparation of several case studies suggested by the end users. The idea was to see how well the system could meet user expectations. The users were encouraged to look beyond the Land and Water Resources action plans and consider other resources as well as socio-economic applications. Some of the most popular case studies have been selecting villages for locating schools, finding out villages which lack connectivity to roads, selecting watersheds for soil and water conservation, to name a few. Other studies currently under way are demarcating malaria endemic areas, locating polluting industries and management of abandoned limestone quarries.

The end users have uniformly declared that the system is very useful and have begun to explore further extension of the applications. There is a greater stress on facilities and amenities related applications. There is a demand for more in-depth training and more hands-on experience. The novelty of 'information at your finger tips' is a great attraction.

## 8 THE NRIS LINKAGE AND NETWORKING PROJECT

The original NRIS plan calls for the systems to be physically located at the districts. However, during a recent review it was seen that this approach might not be effective due to logistical difficulties of maintaining systems and databases remotely. There will be issues of database synchronisation, integrity and timely updating. It was also seen that all states are investing in state-wide networks. Hence, it is now proposed to locate the databases centrally at the SRSAC and provide remote access via the state network.

The NRIS Linkage and Networking Project, LNP, was conceived to examine the issues related to remote data access and to assess the various technologies of networking. The project has experimented with several configurations and it appears that the choice may ultimately be a Web based system using moderate bandwidth links for the actual connectivity. Several leading Web GIS vendors have been consulted and a project for the realisation of different Web based solutions is under implementation by several vendors. This project is also examining issues related to data aggregation and interoperability of databases and systems. This is necessary, as the future systems may not be restricted to only one system and software. Legacy systems also have to be protected.

## 9 LESSONS LEARNT

The creation of a digital database is a time consuming and tiring effort. On an average the time to get a database ready from existing hardcopy data is 18 months. Even accounting for the learning curve it takes six months to a year to get a database up. This means that a considerable part of the data can become dated and lose its utility very soon. Therefore there is a need to develop fast database updating procedures. On screen digitisation of satellite imagery and direct digital updating has to be explored.

Making use of the database for practical problems is still at its infancy. At the outset, just having data at ones fingertip is a novelty that is being explored. This has to be supplemented by models. Initially lookup table models like that for land capability, are the easiest to implement. The user is yet to venture forth into any overtly 'mathematical' model. However, the power of the system will truly be realised once such models are attempted.

Training is required repeatedly. In fact, small training sessions repeated often may be better than a single large session. Handholding is essential to enable the user to become familiar with the system. The designers have to be flexible to accommodate user needs and preferences. One centre has hit upon a novel approach of creating HTML pages of 'standard' queries and loading them on the users PC to give the user an illusion of a database at his fingertip. Such an approach to make the system easily accessible can act as an icebreaker.

Institutionalisation of the system is necessary. At the moment it is driven by a few early adopters and supported by a few patrons among the senior management. While this is a good start, there is a need to get the system operationally

integrated with the rest of the administration. Mechanisms have to be set up for the database updating and maintenance. There are also issues related to data security and reliability.

## 10 THE FUTURE

The interim plan implementation has raised many issues, which have to be addressed in the next phase of implementation.

The results obtained so far from the NRIS LNP experiment show that with the use of Internet technology it is possible to extend remote access to a centrally located and managed database. Thus each State could be the central repository of its database with remote access provided to the Districts of that State as well as to the Central (Federal) Government agencies located in the State and at the Capital. There are administrative issues related to security and access control. Suitable access control mechanisms have to be developed.

The NRIS Standards need to be harmonised with the Digital Vector Data format of the Survey of India. The DVD format is a data exchange format and will be useful to define inter-system transfer specifications. This will also take care of any issues related to a National Spatial Data Infrastructure, which is being planned by the Planning Commission.

A very important need is to develop interfaces in Indian languages, as the field level operators are more comfortable in their regional language rather than English. The problem is that there are fourteen official Indian languages and the interface has to define terms in these languages.

Another step being implemented is to write down a formal database creation manual, which can be the basis for future work. This manual is based on the experience gained and will help the speedy implementation of the next phase.

Advanced application shells have to be developed based on the requirements emerging from the use of the databases. Mechanisms have to be created for the regular upkeep and updating of the databases. The level of detail of the database has to be upgraded to 1:25,000 and 1:12,500. This will be possible through data from future high-resolution satellite sensors like CARTOSAT and RESOURCESAT.

We also need to address the emerging need of Panchayat (Local Self-Government) Information Kiosks where the user will be an individual, a group such as a co-operative or may be a private enterprise. Information may be bought and sold like a commodity. There are security issues as well as legal angles arising out of the consequence of the use of the retailed information.

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