NATIONAL (NATURAL) RESOURCES INFORMATION SYSTEM (NRIS)

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1. NRIS OVERVIEW

During the Interim Phase of NRIS, 30 selected Districts (Table-1) from 17 States have been covered at 1:50,000 scale.

1.1 Demonstrated Enduses

NRIS design and organisation had been specifically focussed on providing information systems support to the Integrated Mission for sustainable development (IMSD). IMSD is a major programme launched by ISRO-DOS for generating and implementing the locale specific, integrated land and water resources development plans for 174 problem districts in the country. These plans are based on the inputs generated from remote sensing and other collateral sources on Land-use/ Land-cover, Soils, Groundwater prospects, slope and combined with the local socio-economic scenario.

While the NRIS is being extensively used for generating the integrated land and water development plans as envisaged under IMSD, it is exhaustive enough to provide development planning support with specific reference to rural development. Some of the demonstrated case studies in this context include:

- Identification of Drinking water sources for fluorosis affected villages.
- Demarcation of the regions having high potential for dairy development
- Prioritisation of Micro-watersheds for implementing development schemes.
- Identification of villages for placing new schools
- Identification of priority villages to be taken up for development under Ambedkar Yojana
- Identification of Check-dam sites for rainwater harvesting
- Identification of areas suitable for afforestation for integrated forest development
- Decision support system for fertiliser management and distribution.
- Plan for reclamation of salt affected lands.
- Priority villages for providing road connectivity.
- Priority villages for locating middle schools and for providing road connectivity.

1.2 Node Database Contents

The NRIS node database consists of integrated spatial/ non-spatial data elements comprising of the map inputs from remote sensing as well as conventional sources and village-wise non-spatial data on socio-economic and infrastructure aspects. The database is designed and organised in a manner such that it minimises the data redundancy and maximises the multiplicity of usage of each data element. A Summary list of the data elements is given in Table-2.

1.3 Query and Decision Support Shells

The ultimate end users of the NRIS system are expected to be the planners and decision makers, experts in their respective areas/ disciplines, who need not be the experts in the technologies like GIS and Remote Sensing. The mechanisms for access of the database elements are therefore made easy and explicit. On the one hand NRIS not only facilitates standards/ protocols/ procedures for database creation/ organisation, updating and database access using appropriate GIS and other software packages, but also includes customised shells for decision support. These shells focus on providing the user a transparent access to the database and software package environments and address the user specific planning problems. The shells are customised based on the analysis models specified by the users and the customisation tools provided within the GIS and other packages. The Query and Decision Support Shells consists of the generic query components and various problem specific decision support components.

Generic query shell provides an easy to use, menu based access mechanism in *point and shoot* mode for making integrated query on all aspects (i.e. natural resources, socio-economic and infrastructure) in a single environment. It offers appropriate menus, graphic screens and icons to a user for specifying query in various modes like *what lies* here, *where lies* this, theme surface, criterion surface, reference, *spatial window* and on-the-fly the generation of user specified indices. The shell also presents different user (spatial and functional) views of the database in user terminology, provides an illusion of *seamlessness* on the horizontal spread of the data base contents. A user does not have to know about the where and what of the data base elements in the computer storage.

Problem Specific *Decision Support Shell_(SDSS)* facilitates selection of the best course of action based on pre-decided objectives, decision rules and constraints. It also facilitates modification of the decision rules and navigation of the solution space in an interactive, iterative and integrative environment.

One of the problems addressed at present is the prescription on land development actions based on diagnosis of the land characteristics like slope, soil, current land-use and the ground water prospect. This particular shell works on a default if-then-else logic pre-captured in the system which can be modified by the subject expert end user in an interactive manner. Another problem specific shell facilitates planning the optimum location of water harvesting structures. It is also based on diagnosis of the land characteristics like slope, soil, current land-use hydrogeomorphology and the ground water prospect and provides ample scope for incorporation of the subject expert's knowledge base. Yet another shell addresses the problem of estimating surface water run-off modelling and morphometric analysis.

Various other problem specific shells are in the pipeline. These include soil erosion index generation for prioritisation of soil conservation measures etc.

2. NRIS NODE DESIGN CONCEPTS

The major areas of concern addressed while evolving the NRIS Node Design and Standards were:

- Decentralised and distributed strategy for database implementation.
- Complexity and variability of input data formats.
- Nation-wide spread of the spatial framework of databases.
- Minimisation of database redundancy and increasing the data integrity.
- The database quality controls.
- End-user profile calling for independent development of applications facilitating explicit and transparent access to the databases and for planning and decision support.

This called for a systematic study for arriving at baseline design standards, which incorporate:

- The Node Database contents along with the associated coding schemes, level of details and the update cycles for each of the element at different levels of node hierarchy and ultimately the structure of data base organisation.
- The Spatial Database design standards including the spatial framework addressing the issues related to the co-ordinate system and the spatial and thematic accuracy levels to be enforced at the time of data input.
- Database Structure including the naming conventions and the schema for establishing linkages amongst spatial and non-spatial data components.
- The standards for easily usable Database Query and decision support shells for enabling the usage of the NRIS system by the planners and decision-makers themselves directly.

2.1 Decentralised Implementation Strategy

NRIS is being implemented on a nation-wide scale by a number of agencies, which are geographically spread all over India. Furthermore, these agencies represent a variety of specialisation in implementation of GIS and Remote Sensing based information systems. These include

- State Remote Sensing Centres, with expertise in Remote sensing applications and exposure to GIS. These centres are placed in the state headquarters, and are the nodal agencies for realising and managing the NRIS nodes for the districts falling in state purview.
- Various centres of ISRO-DOS geographically spread all-over India. These centres are entrusted with the task of database design, database organisation, data quality assurance and applications software development.
- Private entrepreneurs from all-over country who were initially entrusted with the task of analogue to digital data conversion and are progressively getting ready to take-up up the development of turnkey systems.

2.2 Input Data Variability

The inputs for NRIS are from different sources in a variety of formats including spatial as well as non-spatial form at various levels of details vis-à-vis the scales and the spatial units of observance. All these had to be brought to a common framework in order to realise the seamless and integrated database.

2.3 Nation-wide Spatial Framework

NRIS is visualized as multi-tier network of spatial databases. The obvious requirement is for access of spatial databases across various nodes involving bottom-up, top-down and horizontal data transfers. Moreover, the components of the system had to be implemented through a variety of agencies spread all-over country. Such a requirement raised various design and standardization issues. The solutions has to comply various requirements as follows:

a) Ability of the system to represent database features within acceptable limits of accuracy at different levels of details i.e. Centre, state & district.

b) Ability of the system to facilitate across node data transfers in a seamless manner. This would include data transfer from states to centre, districts to state and district-to-district.

c) Ability of the adoption of the scheme for easy and transparent implementation using standard GIS software tools on all the NRIS nodes. This is important because, the database creation will have to be done through private entrepreneurs using standard GIS software tools. Any proprietary restrictions associated with the selected scheme will act as a bottleneck.

This part of the study lead to freezing various aspects of spatial framework which include:

a) Definition of control/ tie point identification scheme, which facilitates unique identification number for every tie point all across Indian Territory. The approach adopted is on the basis of latitude/ longitude co-ordinates.

b) Adoption of projection co-ordinate system. As an interim measure NRIS has evolved a strategy to adopt polyconic projection for each node. Veracity of this approach is being further examined in order to arrive at a suitable projection/ co-ordinate system. Alternatives being evaluated are Lambert conformal conic projection (LCC), universal transverse Mercator (UTM), projection neutral co-ordinate system (spherical co-ordinate system in terms of latitude-longitudes). Initial studies indicate that for large size databases such as NRIS, it is best to adopt projection neutral coordinate system.

2.4 Database quality benchmarks

The need for controlling the quality of database elements needs no special emphasis. Considering the fact that the task of database creation and organization was decentralized, the laying down of database quality control parameters was of utmost importance. The parameters were thus specified which include

a) Accuracy thresholds for different levels of databases categorized into thematic and control accuracy for analogue inputs

b) Accuracy thresholds for digitised elements categorized into multi-layer registration accuracy (rms), tolerable area errors in terms of percentages, co-ordinate weed tolerances, co-ordinate movement tolerances and tolerances for removal of sliver polygons.

c) Acceptable age and update frequency for each data element.

Apart from specifying the thresholds for data quality, detailed procedures for enforcing the data quality standards were laid down for

a) Checking, verification and quantitative assessment of the accuracy of analogue inputs

b) Checking, verification and acceptance of digitised inputs.

2.5 Feature codification schemes

As listed in table-2, the NRIS node databases cover various aspects including natural resources, manmade resources and socio-economic backdrop of the area concerned. These include

a) Input elements based on mapping & digitisation of themes from remote sensing viz. Landuse/ landcover, geomorphology, lithology & structures, ground water prospects, soils and drainage etc.

b) Control/ reference layers from Survey Of India (SOI) toposheets including administrative boundaries like states, districts and taluk/block, elevation contours and spot height points, transportation network including roads and railways, hydrological network including drainage, rivers, canals, well locations etc.

c) Layers from other collateral sources including village boundaries and settlement locations from census maps & revenue maps, soils data and other natural resources data from various line departments.

d) Non-spatial data on demography, economic status and village amenities available at village level in tabular form from Census Department, National Informatics Centre and State Bureau Of Economics & Statistics (BES),

Each of these aspects has its own requirement for digital conversion prior to creation and organization of NRIS node databases.

The data on natural resources aspects like landuse/ landcover, hydrogeomorphology, soils, drainage etc is available from thematic maps generated using rs and conventional data. Each of these thematic maps is generated for specific purposes and follows different legends depending upon the intended end use. A case for example is the landuse/ landcover maps, which are available in form of generalized landuse maps, wasteland maps, forest type maps, inland wetland maps and coastal landuse maps. Many a time the landuse/landcover for same piece of land is shown by different names under different thematic maps. This kind of variations in naming the theme class due to different end use perspectives leads to serious conflicts while creating digital databases in GIS environment.

The data elements covering terrain, infrastructure and socio-economic aspects again follow different naming conventions. Moreover, each of these data elements follows unique hierarchy at different levels of detail. The codification scheme for each of the data elements had to be worked out based on the following principles:

- Identify a list of mutually exclusive list of data elements.
- Classify the elements into primary input elements and derivable elements in order to minimize redundancy e.g. Elevation vs. Slope.
- Take note of the hierarchy followed in naming convention of each data element at different levels of detail. The hierarchy could vary for each element and would be in the form of parent child relationship. The relationship could be governed by natural boundary demarcations as in case of watersheds, administrative boundary demarcations as in case of state/district or forest management units, classification schemes like landuse levels or soil phenology.
- Assign a unique code for each land parcel within each data element in order to avoid duplication of feature codes and thus maintain database integrity.

Using these basic principles a mammoth exercise was conducted, which involved bringing together various thematic experts in order to evolve a consensus on codification of features under each data layer in the database. A typical codification for landuse/ landcover is enclosed as table-4. Similar tables were prepared for all the elements listed in table-2. While this exercise was conducted for freezing on the codification schemes, it was realized that this would be a continuous process and standing working group will have to be identified for this purpose. The codification schemes for various data elements, already worked out, will have to be regularly updated and /or extended from the point of view of:

a) Accommodating the needs of sectoral and project level information systems like geology, urban, disaster management system e.t.c this may not only require extension of codification schemes for already identified data elements in the standards document. Certain additional data elements also may be appended to the standard list.

b) Area specific variations in the feature classes, which are likely to surface as we go along with the project implementation.

c) Incorporation of further detailed level codification into certain thematic layers e.g. Level-4 codes for landuse. This may be required due to extension of the level of details in the data elements owing to availability of better resolution data from remote sensing and/ or incorporation of cadastral level data into the system.

2.6 Transparent and Easy Access Mechanisms

Design of NRIS had to recognized the fact that the effective use of such a system will be possible only when the system can be accessed directly by the planners and decision makers who are the experts in their own respective fields of activity, specifically in the problem solving domain. In order to be able to use such a complex and technology heavy system, end user would have had to not only possess complete understanding of the problem in hand, but also the:

- Full understanding of the capabilities of the GIS, which in itself could be a combination of multiple software packages; high level of proficiency vis-à-vis usage of GIS system along-with the related software packages. This would include system commands and sequencing the commands.
- Complete knowledge of the details of the underlying database, including the database design, reference details of the database elements and the relationships amongst the various data elements.

It would have been be highly unreasonable to assume that the real planners and decision-makers would have sufficient time to be able to attain full expertise on the above aspects in the technology domain. NRIS had to be therefore conceptualised, designed and implemented in a manner that not only it facilitate database creation/ organisation, updating and access using appropriate GIS and other software packages, but also includes customised shells for decision support. These shells focus on providing the user a transparent access to the database and software package environments and address the user specific planning problems. The Query and Decision Support Shells consists of the generic query components and various problem specific decision support components.

The task of developing such access shells was also decentralised and could be possible due to the fact that the database design and standards had been already specified.

3. CONCLUSIONS & FUTURE WORK

NRIS in the initial phase has clearly demonstrated the possibilities of creating digital databases for selected districts and proved its utility for the State/District administration in a decisive manner. Under the phase-I of the NRIS implementation, databases have been implemented for 30 districts using NRIS standards, one of the major contributions under the project, as the basis for database creation. The ultimate scope of the project is to create digital databases for all the states and union territories of the country and provide remote access to the NRIS databases and decision support systems under the web technology framework. With the growth in the technology it is now found feasible to implement ***web-GIS technology***, which would be a cost-effective and most amicable solution for the State Governments. The major focus of the future NRIS mission would therefore be to:

- Create state level databases for entire country
- Provide web access to these databases and the front-end decision support systems for use by the users at district/ block level. In this context, various alternative technologies are under scrutiny.

Our experience in the implementation of NRIS has shown that sound design concepts followed-up with initial efforts on formulation/ design of standards pay rich dividends in terms of ease of implementation and trouble shooting. The design of standards is a very important element of any Information system design. The standards are not static but must change as new technologies and applications are added. This requires that a mechanism be established to periodically review and upgrade the standards. The standards are neutral to platform and software packages hence they can be used in any configuration of hardware and software.

The design concepts and standards, formulated as a part of NRIS, have been harmonised with data exchange standards like Survey of India DVD to evolve National Spatial Data Exchange formats which will facilitate for data interoperability across various systems likely to be implemented at different Resource Domain agencies concerned with various National Resources Survey, Inventory and Development. These could include agencies concerned with Geology, Topography, Soils and Landuse, Forests, Zoology, Demography, Infrastructure etc. The database design approach followed under NRIS could also be gainfully used for evolving the design of databases at various domains Servers envisaged under National Spatial Data Infrastructure (NSDI).

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Table - 1 : List of Districts covered under NRIS Interim Phase

A.P: Anantpur	
Assam: Kamrup	
Bihar	
	Palamau
	Jamui
Gujarat	
	Panchmahals
	Gandhinagar
	Bhavnagar
Haryana	
	Bhiwani
	Gurgaon
HP: Chamba	
Karnataka: Bijapur	

Kerala	
	Palghat
	Thrisur
Madhya Pradesh	
	Datia
	Jhabua
	Sidhi
Maharashtra	
	Ahmednagar
	Chandrapur
	Ahmedngar
Mizoram: Aizwal	
Orissa : Kalahandi	
Punjab: Bhatinda	

Rajasthan	
	Dausa
	Bharatpur
	Nagaur
Tamilnadu	
	Dharampuri
	Nilgiris
Uttar Pradesh	
	Lalitpur
	Bulandshahar
West Bengal	
	Midnapur
	Purulia

Table-2: Data Elements Available in the NRIS database at District Level

Landuse / cover
Geomorphology
Lithology & Geological Structures
Soils Taxonomic Classification & Profile
Drainage/ canals
Elevation Contours/ Spot Heights
Watersheds
Taluk/ Block Boundaries
Village Boundaries/ Settlements
Forest Management Boundaries
Well Locations/ Well log data
Road / Rail Network

Meteorological Observations
Demography/Occupation
Village Amenity availability (Education, Medical, Communication, Power and Others)
Land Utilization Statistics
Slope Classes
Ground Water Prospects
Land Resources Development Plan
Water Resources Development Plan
Land Capability for Agricultural Use
Soil/ Land Irrigability

Table - 3 NRIS Database Design Specifications

SN		District Node	State Node	Centre Node
A.	**Input Specifications at Analogue stage**			
1	**Scale**	1:50,000	1:250,000	1:1,000,000
2	**Thematic Accuracy**			
2.1	MSU (2mm)	10000 sq. mtrs	250000 sq. mtrs	4000000 sq. mtrs
2.2	Mapping	90/90	90/90	90/90
3	**Control Accuracy**			
3.1	Planimetric (RMS)	50 mtr	250 mtrs	1000 mtrs
B.	**Digital Database Specifications**			
1	**Spatial Framework**			
1.1	Registration points	Lat-long intersections/road intersections		
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	meters	meters	meters
2	**Accuracy/Error Limits**			
2.1	Registration (RMS)	12.5 meters	62.5 meters	250 meters
2.2	Area	0.3%	0.3%	0.3%

Table - 3 NRIS Database Design Specifications				
SN		District Node	State Node	Centre Node
2.3	Weed tolerance	12.5 meters	62.5 meters	250 meters
2.4	Co-ordinate Movement	12.5 meters	62.5 meters	250 meters
2.5	Sliver Polygon	2500 sq. m	62500 sq. m	1000000 sq. m

Table 4. Example Codification for landuse/ landcover			
Code	**Description**		
	Level 1	**Level 2**	**Level 3**
01-00-00-00	**Built-up**		
01-01-00-00		Towns/cities (Urban)	
01-01-01-00			Residential
01-01-02-00			Industrial
01-01-03-00			Commercial
01-01-04-00			Recreational
01-01-05-00			Public & Semi- Public
01-01-06-00			Mixed Built- up land
01-01-07-00			Open Spaces/ Vacant Land
01-01-08-00			Others
01-02-00-00		Villages (Rural)	
02-00-00-00	**Agriculture**		
02-01-00-00		Crop land	
02-01-01-00			Kharif
02-01-02-00			Rabi
02-01-03-00			Kharif + Rabi (double cropped)
02-01-04-00			ZAID Crop (Summer)
02-02-00-00		Fallow	
02-02-01-00			Current Fallow
02-02-02-00			Permanent Fallow
02-03-00-00		Plantations	
02-03-01-00			Tea
02-03-02-00			Coffee
02-03-03-00			Rubber
02-03-04-00			Coconut
02-03-05-00			Arcanut
02-03-06-00			Citrus wood land
02-04-00-00		Acquaculture	
03-00-00-00	**Forest**		
03-01-00-00		Evergreen/ Semi evergreen	
03-01-01-00			Dense/ Closed
03-01-02-00			Open
03-01-03-00			Scrub Forest
03-01-04-00			Forest Blanks
03-02-00-00		Deciduous (Moist/Dry)	
03-02-01-00			Dense/ Closed
03-02-02-00			Open
03-02-03-00			Scrub Forest
03-02-04-00			Forest Blanks
03-03-00-00		Forest Plantations	
03-04-00-00		Mangroves (Littoral swamp forest)	

Table 4. Example Codification for landuse/ landcover			
Code	**Description**		
	Level 1	**Level 2**	**Level 3**
03-04-01-00			Dense
03-04-02-00			Sparse
03-05-00-00		Shifting cultivation	
03-05-01-00			Old Shifting Cultivation
03-05-02-00			Abandon Shifting Cultivation
03-05-03-00			Current Shifting Cultivation
03-06-00-00		Crop Land in Forest	
04-00-00-00	**Wastelands**		
04-01-00-00		Salt Affected Land	
04-02-00-00		Gullied/ Ravenous Land	
04-03-00-00		….	
05-00-00-00	**Water bodies**		
05-01-00-00		River	
05-01-01-00			Water channel area
05-01-02-00			Sandy area
05-01-03-00			….
05-02-00-00		Canal	
05-03-00-00		Lakes/Ponds	
05-04-00-00		….	
05-08-01-00			Back waters
05-08-02-00			Estuary
05-08-03-00			Creek
05-08-04-00			Lagoon
05-09-00-00		Cut-off Meander	
06-00-00-00	**Wetlands**		
06-01-00-00		Inland Wetlands	
06-01-01-00			Water logged
06-01-02-00			Marshy/ Swampy
06-01-03-00			Ox-bow lakes
06-02-00-00		Coastal Wetlands	
06-02-01-00			Marsh Vegetation
06-02-02-00			Algae
06-02-03-00			Mud flat
06-02-04-00			Sand
06-02-05-00			Coral Reef
06-02-06-00			Rocky coast
07-00-00-00	**Grass land / Grazing land**		
07-01-00-00		Dense	
07-02-00-00		Degraded	
08-00-00-00	**Snow covered**		
08-01-00-00		Perennial	
08-02-00-00		Glacial area	