

The database and GIS integration has been made with flexibility of map scale, abstraction levels and modeling capabilities for planning alternative impacts and forecasts. The customized GIS solutions for watershed characterization, watershed prioritization, runoff modeling, demand based irrigation scheduling, decision support system for water resources development plan and Land resources development plans have been achieved through software like SAMRUDDHI, NRIS-GEOLAWNS, GARDSS, GEOMORSIS, VARUN, etc.

Based on the user requirements certain indigenous GIS packages have been developed like NAKSHA for viewing and printing “Chaturseema” maps; GYAN (Gramin Yojana Suchana Pranali) for visual display and query of natural resources and socio-economic data.

Possible Applications of Geo-referenced village (cadastral) maps are Micro-level Planning and Implementation of Developmental activities, Parcel level monitoring the impact of developmental activities, Crop identification at parcel level & water levy Assessment at village level, Precision farming, Land value assessment, Parcel level soil health cards, Smart cards for farmers to facilitate e-governance and e-banking, Efficient settlement of compensation claims, Land acquisition and rehabilitation in infrastructure projects, Crop insurance, Community/village resource centers, Digital Cadastral India.

The advantages of the establishment of digital databases on natural resources have been optimally realized for the priority requirements of various departments of the state of Chhattisgarh and some of the major applications accomplished are:

- i. Prioritization of watersheds and water resources development plan for priority watersheds, for

the Department of Panchayat and Rural Development, Govt. of Chhattisgarh.

- ii. Rural Road Connectivity to villages through the forest for 12th Finance Commission, Govt. of Chhattisgarh.
- iii. Identification of suitable sites for horticulture, floriculture and vegetable crops in Mahasamund District, for CEO, Zilla Parishad, Mahasamund.
- iv. PURA (Providing Urban amenities in Rural Areas)
- v. Forestry Management Information System (FMIS), for Forest Department, Govt. of Chhattisgarh.
- vi. Hydrology Project of Chhattisgarh State (Funded by World Bank), for Water Resources Department, Govt. of Chhattisgarh.
- vii. Election Commission GIS for delimitation of constituencies, for Chhattisgarh State Election Commission.
- viii. Identification of suitable areas for siting industries in the state, for Chhattisgarh State Industrial Development Corporation (CSIDC)
- ix. Optimal routing of High Power Transmission Lines, for Chhattisgarh State Electricity Board.
- x. Developmental planning of major towns of Chhattisgarh State, for Town and Country Planning, Raipur.
- xi. Development Planning of new Raipur City, for Town and Country Planning, Raipur.

Many more applications are being developed in consultation with various state departments for better use of GIS database thus saving time and resources in executing the projects.

About Author



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Use of GIS in Improving Rural Health Services

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Preamble

Health care systems in rural India face increasingly diverse and complex problems, such as rapidly growing populations, and severe resource constraints. Rational allocation of scarce resources is difficult and is dependent on the size of populations existing in the area.

Health care management and the use of health information at the village level are constrained by bureaucracy, lack of funds and scarcity of trained personnel. Problems also exist in the flow of information from the village to the Primary Health Care centres (PHCc). Delays, non-reporting, no response, and low quality of data collected further complicate matters. Moreover, reporting occurs only during acute and brief illness episodes. Even then those who live far away, are too sick to travel, are worried about cost implications, or are chronically sick and disabled and have little to benefit from a visit remain ignored by the service system and overlooked by planners.

It must be noted that the population in Indian villages is heterogeneous with ethnic, religious, and socioeconomic differences influencing illness concepts and demands for health care. However, the only available information on the local population is the Census data, which may be out of date and does not reflect true population numbers served by health facilities. The health information system should reflect these circumstances, but available data are almost always about people who visit the PHCc. A need exists for a more precise and complete description of the population and health situation. It is important to generate this information at village, taluka and district levels.

Some additional problems are also relevant.

- A) Health care planning and programing are highly centralized and mostly incremental.
- B) Most staff are poorly prepared for data recording, maintaining the data, planning and implementing.

- C) Existing health information systems are unsatisfactory for planning, development and implementation.

Hence health care professionals must look at alternative technologies. Geographic Information Systems (GIS) is eminently suitable for assessing the population to be served, for studying pattern of incidence of illness and for formulating effective remedial strategies.

Geographic Information Systems (GIS)

GIS is designed to work with spatially referenced data. Therefore GIS has both attribute (non-spatial) data and spatial data with capabilities to analyse the data using a set of operations.

The essential components of a GIS are:

- Data acquisition
- Preprocessing
- Data management
- Data manipulation and analysis and,
- End Product creation.

Data should be acquired through field surveys, and should include analyses of existing secondary data from maps, aerial photographs, reports and other documents. Data accuracy and completion must be ensured.

The main emphasis in data analysis should be on the production of maps depicting demographic data, location data and pattern (or trend) interpretation. To maintain the integrity the data areas from which no data is being generated should also be recorded. These are treated as zero incidence locations, but may not truly be so. By the process of interpolation, these locations can also be included in the overall analysis.

This point data are imported into the GIS database. A digital map is generated which is used to build a correct topology with related feature attributes. (Topology refers to a mathematical structured manner in which the relationship between

points is recorded. Most GIS softwares automatically create the topology) Additional information can be added to the data, for example gender, age, literacy level etc.

Whenever a patient visits the PHCc, data about village name etc are collected. The frequency of visits becomes an important parameter. Interpretation of this data takes into account several factors; transportation costs, condition of roads, availability of medically trained staff etc. For each PHCc, a plot showing where patients come from in a given period will be displayed in a digital map.

Health officials have to deal with the problem of selecting the optimum location for a health facility in relation to the spatial distribution of the population and infrastructural facilities already in place. The application of GIS helps in deciding the location of each PHCc. A study to find the best location for a PHCc requires the location of villages, road networks, and other infrastructural facilities. For the allocation of PHCc, a number of variables such as road conditions and types and travel times will have to be considered.

The various solutions generated will have to be evaluated against the criteria specified for siting the health facilities. Such criteria may be to locate a facility where travel costs are minimized.

Determination of populations in the nomadic communities is a difficult problem. One possible solution is to use high resolution satellite data to identify migratory movements and to estimate population sizes. Mobile vans equipped with suitable equipment can be deployed in focal points where the nomadic population tends to converge.

Conclusion

It is evident that by using GIS the effectiveness of the health measures implemented by the government in rural areas can be significantly improved. GIS can also be used to support the analysis of where to locate a PHCc so that its reach is maximized. Complementary technologies such as Global Positioning Systems (GPS) and satellite remote sensing can be availed of to refine the analysis.

About Author



Dr. G. S. Rao completed his postgraduate studies from IIT-Bombay specializing in GIS and Remote Sensing. He then worked in IIT-Bombay on an ONGC sponsored project for oil exploration using GIS and Remote Sensing. Subsequently he worked in the training cell where he was tasked to design and execute training programs for government and semi-government organizations. He left for Canada to pursue his Ph D degree. His research work was on use of . Artificial intelligence in mineral exploration using GIS and Remote Sensing. Upon Completion of his PhD he worked in the Dept of Computer Services where he helped Set up and run a fully integrated computer laboratory. In 1985 he returned to

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Application of Remote Sensing and GIS in Water Resources Management

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Abstract

Appropriate management of water resources needs monitoring, evaluation and analysis of several parameters that vary spatially and temporally. The efficient use of land and water resources through better management of natural resources, for economical and social sustainability is of prime importance, under the conditions of severe water shortage, in the country like India, due to erratic monsoons. The efficient water management in the water resources projects is the need of time, which should have structured database of all the relevant parameters required for planning, design and operation of the irrigation projects. For generating and analysing this database, remote sensing and Geographic Information System techniques are very important. Remote sensing becomes an effective tool in the water resources where timely information of the dynamic changes is required. Along with Remote Sensing, Geographic Information System (GIS) provide effective and efficient tool for storage and manipulation of remotely sensed data and other spatial and non-spatial data types for scientific, commercial, management and decision making purposes. The Water Resources Information System can be developed using remote sensing & GIS for effective use in project design, operation, maintenance and monitoring. This will be a holistic approach in which catchment area, reservoir and command area of the water resources project are considered as one system which makes it possible to study the impact of one sub system over another. This paper discusses few applications in the surface water resources development and management.

Introduction

The systematic planning and management of surface water resources in the region, require information on quantity and distribution of water resources in the region. The information on inventory of existing water bodies, selection of suitable site for water resources project, estimation of the water demand, inventory of crops and preparation of irrigation scheduling in command areas are very important for this purpose. Data acquisition can be by field data collection, through Data Collection Platforms (DCP), existing reports & maps and Satellite remote sensing. Taking into account the large area coverage of the catchment and command areas, conventional methods to collect this information prove to be costly, time-consuming & cumbersome. Hence remote sensing becomes an effective tool in the irrigation command areas where timely information of the dynamic changes has to be taken in to consideration. This technique provides us synoptic, repetitive, multi-spectral coverage of large areas and data is quantifiable.

Along with Remote Sensing and Data

Collection Platforms, Geographic Information System (GIS) provide effective and efficient tool for storage and manipulation of remotely sensed data and other spatial and non-spatial data types for scientific, commercial, management and decision making purposes (Burrough, 1986). GIS comprises of spatial information generated from remote sensing satellite data and available maps as well as non-spatial information collected from different sources. Indian Remote Sensing satellite (IRS) data from LISS-II, LISS-III, PAN & WiFS sensors are extensively used for generating spatial databases. Multi-date satellite data covering the entire irrigation project area are considered necessary guard against any information loss and to improve data sensitivity. (Krishna Murthy et.al., 1999). Remote sensing based inventory of irrigated crops is useful for timely estimation of crop areas and types is useful for estimation of water demand over time & space, irrigation scheduling and for overall performance assessment of Irrigation project. The Remote Sensing based inputs along with field data in GIS are used for various applications in catchment area, reservoir and command area, which are listed below. In Catchment area, this technique

is used for Runoff Analysis, Erosion Studies, Watershed Development, Change Detection etc. The studies related to reservoirs include, Water Spread & Capacities, Sedimentation, Reservoir Optimisation Models etc. In command areas Crop Inventory, Water Demand, Canal Network Analysis, Water Logged & Salt Affected area mapping, Change Detection, Irrigation Scheduling are possible. This paper mainly covers the runoff analysis, capacity estimation of reservoirs, crop mapping & irrigation scheduling aspect, which is very important from water management point of view.

Inventory of Water Bodies

For any developmental activity, the available surface water resources play significant role. Satellite Remote Sensing in the past has shown the capability to map these surface water bodies. With the emergence of radiometrically advanced sensors like AWiFS, which is having 10-bit radiometry, it is possible to map even the smaller water bodies and due to bigger swath, the cost of satellite data also can drastically come down. Fig.1 depicts the *Malgajari* Tanks (small in sizes) in Bhandara District of Maharashtra using AWiFS data, which is comparable with LISS-III data.

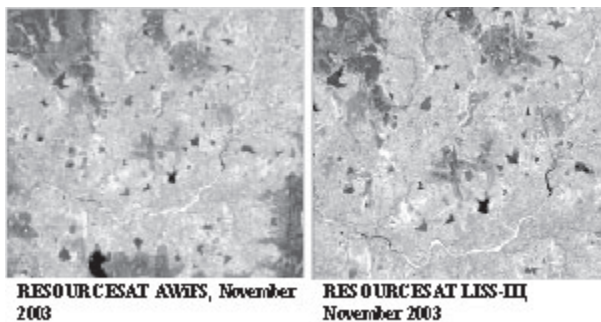


Fig. 1 Inventory of Water Bodies

Pre-feasibility Studies for Hydropower sites

The satellite remote sensing is useful for pre-feasibility studies of proposed reservoirs for hydropower generation. For this purpose, Indian Remote Sensing Satellite (IRS 1D/P6) LISS-3 and PAN sensor digital data is used to make quick analysis in terms of estimation of the submergence area at proposed Full Reservoir Level (FRL) and mapping of land use/land cover information within and in immediate surrounding of the proposed submergence area as inputs for Initial Environment Study (IES) of the pre-feasibility Report. Fig.2 shows the Land Use/Land Cover map within the FRL as well as 7 km

radius area of proposed dam site, at Bauras (Chauras), in M.P.

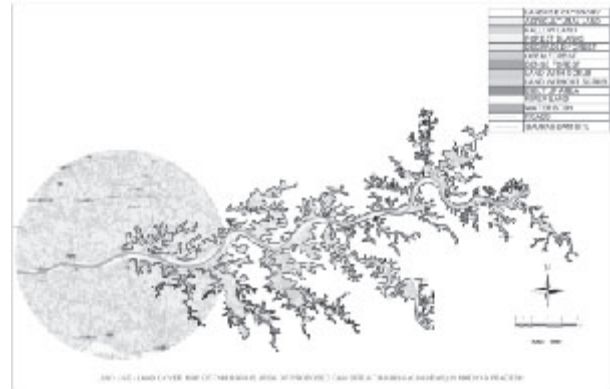


Fig. 2 Land Use/Land Cover map within the FRL as well as 7 km radius area of proposed dam site at Bauras (Chauras), in M.P

Run-off Analysis

Development and management of water resources require understanding of basic hydrological processes like rainfall-runoff relationship for the watershed under study. Hydrograph and excess rainfall hyetograph analysis play a vital role in Hydrologic design of water structures, thus are important for the development of water resources as well as for the mitigating the adverse effects of floods. Manual computation for this kind of analysis takes lot of time and sometimes is very cumbersome. Most of the time for small water structures, implementing agencies generally use thumb rules rather than studying the hydrological processes in detail due to time and financial constraints. In the small catchments, the raingauge density is very inadequate and stream-gauging facility is virtually absent. These limitations have reduced the hydrologic design of small structures to oversimplified design method using empirical formulae. This particular package VARUN (Value Added Rainfall-rUnoff analysis) has been conceived and developed for rainfall - runoff analysis using SCS curve number method, keeping in mind the user requirement on ground, particularly for designing water harvesting structures like Percolation Tanks, K.T. Weirs (Kolhapur Type Weirs), Small Dams and Nala bunds (Fig.3). The package also can play a pivotal role in monitoring the impact of watershed development program. This package primarily uses derived themes like Land use/Land cover & Hydrologic Soil groups from remote sensing data along with slope information, rainfall and other collateral parameters.

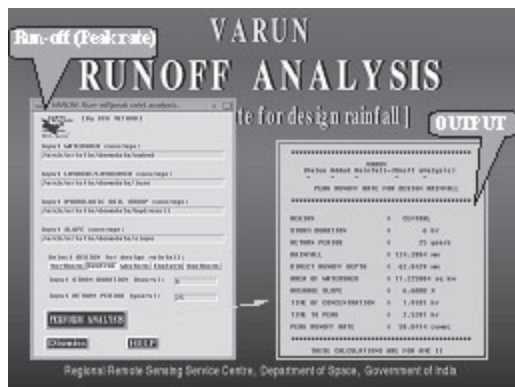


Fig.3. VARUN Package

Capacity Estimation of Reservoirs and Reservoir Sedimentation

In any water supply reservoir project, the inflow into the reservoir during the flood periods and outflow from reservoir during water release is estimated using Elevation-area-capacity curve. This curve is prepared depending on the topographical conditions when reservoir is constructed and it represents the water levels, associated by water spread area and capacity of reservoir. While preparation of this curve, water spread area is determined as the area enclosed within the contour line from topographical map. Generally the areas of intervening contours at smaller intervals are interpolated by taking square root of surveyed contours on assumption that the square root of interpolated ones vary in exact proportion to their vertical distance apart. These interpolated contours are used to determine the incremental volumes stored between two successive contours by simple average formula. Sometimes other methods like Cone formula, Prismoidal formula and Integration technique are also used. Manual interpolation of elevations for preparing elevation-area-capacity curve is time-consuming and cumbersome and may induce some errors in their corresponding water spread area and capacity values. To minimise these errors, Remote Sensing data and Digital Image Processing Techniques can be effectively used. Multidate IRS LISS-III/PAN data provides us useful information of natural resources at that particular time. Making use of this feature, actual water spread of the reservoir is monitored on different dates, thus providing elevation contours in form of water spread. Incorporating water elevation contours into the contour map of the submergence area for better accuracy to generate Digital Elevation Model (DEM). While generating DEM, the elevation data between

contour lines are filled using different interpolation methods like Morphology-Dependent Interpolation Procedure, Finite Elements method, TIN (Triangulated Irregular Network) etc. The DEM is then used for capacity estimation of reservoir at given water level. This methodology can be for validation of Elevation-area-capacity curve for the reservoirs. Fig.4 shows the case study of Upper Wardha Reservoir.

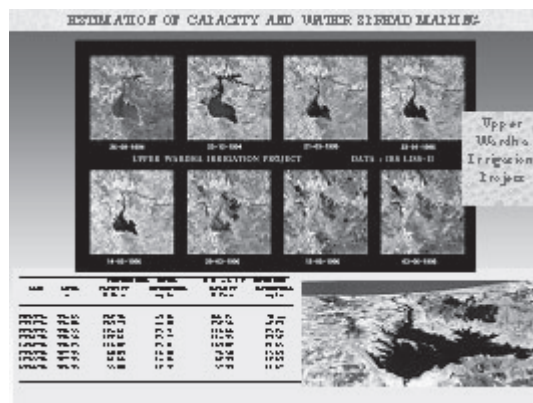


Fig. 4. Capacity Estimation of Reservoirs

For estimating the peripheral sedimentation for assessing live storages of reservoirs, remote sensing technique is now widely being used. Due to peripheral sedimentation, the water spread area of reservoir for the particular water level decreases, thus reduces the storage capacity. The reduction in live storage capacities of reservoir between two time steps is attributed due to sedimentation.

Crop Mapping

The applications of Remote Sensing in the field of agriculture range from crop discrimination, inventory, assessment and parameter retrieval (Dadhwal, 1999). Identification and discrimination of various crops require differences in their data and mostly digital image processing techniques are used for this purpose (Navalgund *et al.*, 1991). Remote sensing technology has potential in estimating crop acreage at different levels (region, command, district, village and levels) due to its multi-spatial, multi-spectral and multi-temporal nature.

In order to plan need based irrigation facilities and to collect the revenue from the farmers in form of water assessment and water levy, there is need for early acreage estimation of sugarcane on different scale, i.e., on 1:50,000, 1:25,000 and 1:12,500 scales. The timely assessment of area under sugarcane and spatial distribution before harvesting is immensely

useful for sugar industries, optimizing sugarcane management and future planning. The conventional methods of collecting the information on sugarcane acreage are cumbersome, costly and time consuming especially when it is for a large area.

Fig. 5 shows the classification results obtained from RESOURCESAT LISS-III and AWiFS in the Panchaganga Command area. As the irrigation authorities require this information within the stipulated time, the results obtained by AWiFS, gives acceptable accuracy, with less cost and time due to better radiometry and large swath.

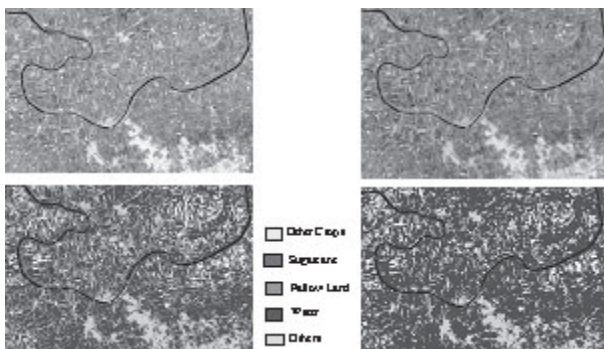


Fig.5. Mapping of Crops

Irrigation Scheduling

The role of Remote Sensing and GIS in irrigation scheduling is also very important. The availability of timely information with high accuracy and analysis of spatial as well as non-spatial data makes these tools quite efficient. The two packages SARITA and SINCHAN has been developed in GIS environment.

SARITA (Scheduling and wATER Requirement for Irrigation projecT pLanning):

Once the information on crops is made available, the crop map along with other maps & field data is put in GIS. Some times the user may not be very conversant with GIS package. For this a user friendly package SARITA (Scheduling and wATER Requirement for Irrigation projecT pLanning) is developed in 'C' and customized in Arc/Info using Arc Macro Language (AML) to compute the potential evapotranspiration, Crop water requirement and irrigation scheduling parameters which can be used by the Irrigation Managers & Engineers for effective irrigation project planning (Fig.6).

GIS Based Simulation Model SINCHAN

A GIS based simulation model SINCHAN,

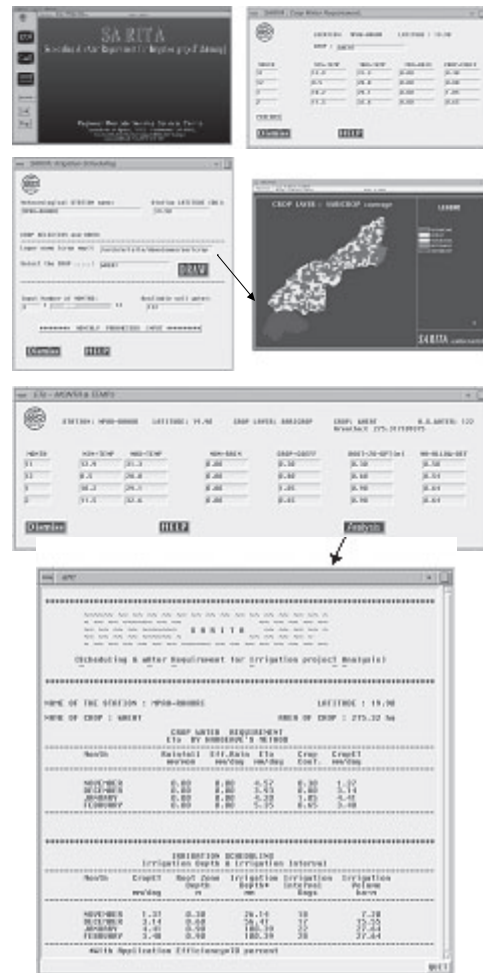


Fig.6. SARITA Package

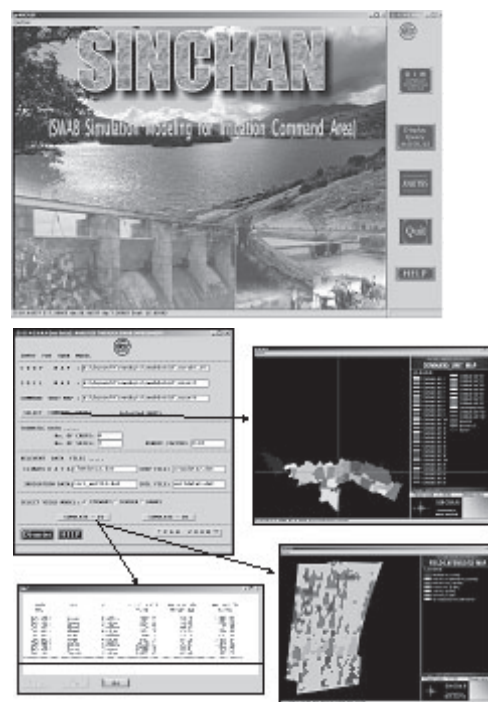


Fig.7. SINCHAN Package

which enables estimation of soil moisture in the root zone; actual evapotranspiration and crop yield is developed for the purpose of scheduling of irrigations in the command area aimed at an optimum utilization of water. 'SINCHAN' has been developed using 'C' programming and Arc/Info. The core programme for simulation processes is developed in 'C' and entire package is customized in Arc/Info using Arc Macro Language (AML). The database integration, display of spatial maps and collateral data, their connectivity, and analysis are achieved through the AML programmes.

The use of package for Nazare Irrigation Project is shown in Fig.7.

Conclusions

Potential of different sensors of Indian Remote Sensing Satellites has been very effectively used for wide range of applications in water resources. The remote sensing & GIS technique help in analysing the different spatial and non-spatial data for decision making in water resources development and management.

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Role of Geoinformatics in Site Selection and Characterization of Radioactive Waste Disposal Facilities

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Introduction

Safe disposal of radioactive waste is the primary concern of all the countries engaged in nuclear power programme. It is a central issue for the future of nuclear power and poses considerable concern, be it technical, political or social. Such wastes are required to be isolated from biosphere for large time scales spanning over tens of thousands of year to allow their radioactivity to decay to a level where they do not pose any harmful effect to man and environment. Emplacement of such wastes in carefully designed facilities located in depth range of upto 1000m in suitable geological formations and set up has emerged as preferred choice for their permanent disposal. Such facilities are known as Geological Repository. A deep geological repository for radioactive waste with very long half-lives is expected to provide long term

protection against radiological exposure to mankind and environment. The duration of these periods of safety extends to tens of thousands of years. It is in this context that demonstration of safety offered by such a facility differs significantly from that of other nuclear establishments like reactors and other units. The choice of geological disposal has been driven by the proven occurrences of a variety of rocks at depth that has remained stable over millions of years without any geological, geohydrological or structural modifications.

Granites are under active consideration as potential host rock for a deep geological repository meant for ultimate disposal of high level radioactive wastes in majority of countries viz, India, China, Canada, Sweden etc (Mathur et al, 2001, Bajpai, 2004, Bajpai & Narayan, 2005, Bajpai & Narayan,

	<u>ATTRIBUTE</u>	<u>CONDITION-(PHASE-I)</u>	<u>CONDITION-(PHASE-II)</u>
		(1:250,000)	(1:50,000)
1	GRANITE DOMAIN:	UNIFORM	HIGH INCIDENCE AND
2	STRUCTURAL FEATURES:	ABSENCE/LOW INCIDENCE OF MAJOR REGIONAL FEATURES	LOW INCIDENCE OF ZONE LEVEL FEATURES
3	INTRUSIVES:	ABSENCE/LOW INCIDENCE OF REGIONAL FEATURES	ABSENCE/LOW INCIDENCE OF ZONE LEVEL FEATURES
4	MINERAL POTENTIAL:	NEGATIVE	NEGATIVE
5	SURFACE WATER BODIES:	ABSENCE OF MAJOR PERENNIAL FEATURES	LOW INCIDENCE AND EXTENT OF PERENNIAL
6	TOPOGRAPHY:	GENTLY UNDULATING	GENTLY UNDULATING WITH OUTWARD RUN-OFF
7	FOREST COVER:	---	TO BE AVOIDED
8	POPULATION DENSITY:	---	LOW
9	ACCESSIBILITY:	---	GOOD
10	SENSITIVE AREAS:	---	AWAY FROM SOCIO- ECONOMIC, POLITICAL, AND ECOLOGICAL SENSITIVE AREAS