Geoinformatics Based Village Information System- A Case Study of Ralegoan Siddhi, Ahmednagar District, Maharashtra

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Abstract: A well known fact that India lives in her villages and would continue to do so. But rapid urbanization and consequent haphazard growth of cities has resulted in neglecting of villages. It lead to deterioration of infrastructure facilities, health hazards, loss of agricultural land and water bodies, besides many micro-climatic changes disturbing the ecological balance. Further, there is exodus of population, driven by lack of adequate facilities/opportunities in villages, from rural to urban areas. Though the urban regions have developed faster as compared to rural, the basic objective of a balanced development of different regions has still remained a distant dream. Instead, this has widened the gulf between the developed (urban) and the less developed regions (rural), thereby creating islands of prosperity. Hence there is an urgent need to reduce the cleavage between the rural and the urban areas through appropriate development planning for the villages. The advent of space technology all pervading and the pace of ICT(Information Communication and Technology) facilitating the data acquisition on almost real-time mode gives opportunity for judicious decision making at all levels of governance for the developing world for reduction of redundancy and time and for optimum utilization of the scarce resources. The main objective of the present study is to prepare a village package which could be run by any simple villager and contains all the information related to the village in the package. To achive this objective the spatial data of the village on 1:10,000 scale pertaining to Drainage, surface water bodies, watershed, transport network, Land Use Land Cover, hydro geomorphology, Slope, Soil and etc. was generated using multi-temporal satellite data. The non spataila data bases for the village were generated by field survey. These spatial and non spatial data bases were linked in the GIS. Even though it is widely recognized that the Geographic Information System (GIS) has the capacity to analyze both spatial and temporal data on a cost effective manner for effective planning and management, its application at the micro level for participatory planning and management is limited. In view of this scenario, an attempt has been made to actually apply the GIS Package, simple, user friendly, customized, local need based, interactive and can be handled by the local youth and Village functionaries.

KEY WORDS: **Village GIS, Spatial data,   land use, Ground Water, Slope, soil etc.**

I. INTRODUCTION

A well known fact that India lives in her villages and would continue to do so. But rapid urbanization and consequent haphazard growth of cities has resulted in neglecting of villages. It lead to deterioration of infrastructure facilities, health hazards, loss of agricultural land and water bodies, besides many micro-climatic changes disturbing the ecological balance. Further, there is exodus of population, driven by lack of adequate

facilities/opportunities in villages, from rural to urban areas. Though the urban regions have developed faster as compared to rural, the basic objective of a balanced development of different regions has still remained a distant dream. Instead, this has widened the gulf between the developed (urban) and the less developed regions (rural), thereby creating islands of prosperity. Hence there is an urgent need to reduce the cleavage between the rural and the urban areas through appropriate development planning for the villages. The advent of space technology all pervading and the pace of ICT(Information Communication and Technology) facilitating the data acquisition on almost real-time mode gives opportunity for judicious decision making at all levels of governance for the developing world for reduction of redundancy and time and for optimum utilization of the scarce resources. The planning process has undergone a drastic change in recent years where decentralized participatory decision-making is resorted to ensure sustainability. However for this participatory decision-making, accessibility to a comprehensive data base which is easy to access and understanding of land records, topography, resources, settlement patterns and infrastructure new methodology and technology are needed. This is an area where spatial technologies play a key role in generating timely and reliable information for planning and decision-making at all levels. Planning requires association and integration of various activities with spatial (geo-referenced) and non-spatial characteristics. Facility planning and management is one such an important area. Geomatics-based approaches to facility planning and management have, of late, gained prominence as they offer rational, efficient and effective solutions. Further, the rapid advances in the hardware and software technologies coupled with a growing competition among the related vendors have brought down the cost of Geomatics /GIS technology by manifold, making it affordable for deployment on a large scale for use in decentralized planning. Even though it is widely recognized that the Geographic Information System (GIS) has the capacity to analyze both spatial and temporal data on a cost effective manner for effective planning and management, its application at the micro level for participatory planning and management is limited. In view of this scenario, an attempt has been made to actually apply the GIS Package, simple, user friendly, customized, local need based, interactive and can be handled by the local youth and Village functionaries. It could be called Village GIS, which has all inbuilt features of various decisions at the village level integrating various layers of information both spatial and attribute pertaining to the Raelgoan siddhi village.

Study area : For the preset study village GIS package has been prepared for the Ralegan Siddhi, village situated in parner taluka; it is located in the geographical extents of the true origin (74 degree 22min 0sec E & 18 degree 54 min 0 sec N) of the Ahmednagar District of Maharashtra State. It is 87 km of Pune city towards north-east, 5 km away from Pune -Ahmednagar State Highway. It is a drought-prone and resource poor area with annual rainfall ranging between 50-700 mm and. The temperature varies for 12ºC to 44ºC The village is surrounded by small hillocks on the northeast and southern sides. The land is undulating and slopes vary from 3-15%. The soils are shallow. In lower areas, patches of black soils mixed with pebbles are seen but towards the higher areas the soils are inferior and unsuitable for cultivation. In about 70% of the area the soils are light to medium in structure. Inadequacy and uncertainty of rainfall leads to failure of the crop. The soil type of the village is light to medium having maximum soil depth up to 45cm only. The N.P.K. contents of the soil are low, Medium and high respectively. The total Geographical area of the village measures 9.67 Sq.km.

II. THE OBJECTIVES OF THE STUDY ARE

- To prepare land base map for ralegoan siddhi village to analyze demographical and cadastral information.
- To prepare various types of thematic maps (land use and land cover, Drainage, ground water (well and bore wells), soil maps etc.
- To identify rural resources for generating self employment and stronger village based economy.
- To identify the constraints in agriculture /economic expansion.
- To study basic services like education, health, transport details for identifying the standards of rural areas.
- To suggest various action plans and decision rules for rural development using existing standard information.

III. METHODOLOGY AND ANALYTICAL FRAMEWORK

The methodology used for development of Village GIS essentially consists of design and creation of appropriate spatial as well as attribute databases and integration of the same to facilitate the creation of various planning scenarios for facility planning and management.

IV. METHOD AND NATURE OF DATA COLLECTED

- Integrated resource surveys (Natural resources and Human resources) and mapping at the Village level involving local volunteers, Panchayat officials etc.
- Surveys relating to basic infrastructure of the village roads, drinking water resources, schools etc.

- Household information, housing structure, type of material used in house construction, basic amenities like electricity, water, telephone etc.
- Photographs of the house and its members.
- Household wise collection of data relating to house tax, water tax etc.
- The resource surveys using cadastral map in the scale of 1: 5000. Plot wise information was collected.

Methodology for natural resource management: The land base map was prepared for the study area using the high resolution satellite imagery globe world view one imagery of 50cm resolution at 1:1000 scale. The total image of the study area was divided in to grids of 500 m by 500m and the plots were taken at 1:1000 scale in such a manner that 1 mm on the map will be equal to 1 meter on the ground. The land base map is prepared by taking these plots to the field where all the houses, field bunds and pump sets locations will be marked on the field plot. These field plots were digitized and the land base map is prepared for the entire study area. The data models were prepared for collecting the land base details like the house address, the no of floors, family info details etc. These data collected will be linked to the land base map for generating the final land base map. For generation of natural resources thematic maps land use land cover , Hydro geomorphology, Soil, Slope etc the merged data of cartosat 1 and IRS P6 LISS IV images was used . Taking the SOI Top sheets as source, the thematic layers like drainage and contours are prepared at 1:25,000 scales. The slope map is derived using Survey of India topographical sheets at 1:25000 scale with 5 meter contour interval. The rainfall and temperature data and other collateral data of the study area are collected and is integrated in the GIS Domain.
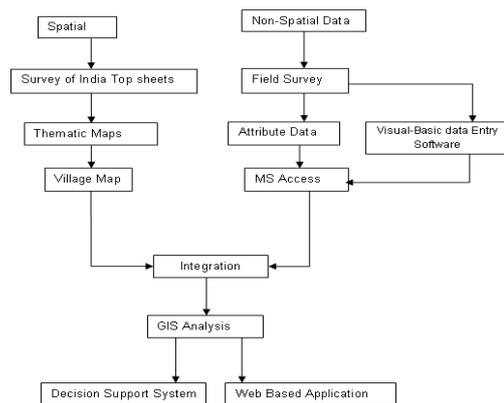

Fig 1. Flow Chart Depicting Broad Methodology

V. SPATIAL DATABASE CREATION

As per the methodology and guidelines described above, state-of-the-art Arc GIS 9.0 and Dot Net Software were used for creation of the required spatial database in digital form. The digitized map information is stored in the GIS database appropriately in the form of layers, each layer representing a unique entity in the spatial data dictionary.

VI. NON-SPATIAL DATABASES

Data sets related to the following were used to illustrate the nature of attribute data for consideration in the exercise for facility planning at village level. Status on village-level basic amenities Population Census Special requirements as identified by the villagers. The database on village level basic amenities under provided the status on the schools, hospitals/dispensaries, Gram Panchayat Building, Anganwadi, etc., and accessibility to telephones, and road, amongst others. The population census provided the demographic profile for the village, while the special requirements for Gram Panchayat were related to village administration and management, besides data related to weekly market places.

VII. INTEGRATION OF SPATIAL AND NON-SPATIAL DATABASES

For the purpose of integration of spatial and non-spatial databases, the attribute databases were conveniently organized to correspond to required distinct areas of planning, which include education, health, transport, communication etc. These data sets are linked and integrated with the spatial databases to facilitate the development of facility planning and management system.

VIII. PARTICIPATORY RURAL APPRAISAL (PRA) METHODOLOGY

A Participatory Rural Appraisal (PRA) exercise was carried on to understand the priorities and needs of the people of Ralegoan siddhi village. The PRA Resource Map showed good understanding of people about their village spatial spread, resources, infrastructure, Governmental programmes and projects and their neighborhood. The entry level activity taken up was information on education, tutorials, admission, coaching, Question Banks, Career prospects, skill development and related aspects. The database on the same was built up from existing database of the Ralegoan siddhi village, Ahmednagar District information base. This was further consolidated with Maharastra Sate and other web based materials making it accessible for youth, students, Panchayat Factionaries and others. Various relational database of the village were integrated with the land base vector layer and analysis based on the Gram Panchayat day to day decision requirements were attempted for use by the village for local level application.

Results and Discussions: A flexible and user friendly information system was developed to assist planners for village level planning with reference to managing the resource of Religion Siddhi village. An important task of Village GIS is to facilitate the link between non-spatial point information and the spatial information. The non-spatial information like census, socioeconomics, agricultural input dealers, etc would be available in tabular form and has to be retrieved from the relational database management system (RDBMS). On the other hand, the spatial information is in the form of maps, referenced to the geographic latitudes-longitudes. The non-spatial tabular information is linked to the spatial information through a customized GIS approach. This query-shell facilitates data handling. The strength of GIS is the integration of multi-layered data from different sources and various scales. The integration of different layers of information has been a difficult task manually until the maps were drawn on a transparent film. With the availability of GIS, which takes the data into digital space, the ability to see through maps, which are overlaid one over the other digitally and analyze the maps is achieved. Database management systems integrated with graphic interface have a powerful query capability. This will finally give the analytical ability to pose complex query and extract information spatially. The land resource development module is broad based suited to different users wherein the expert system approach provides land suitability maps at a quick instance for the village and also acts as a storehouse of expert's opinion. But this approach lacks dynamism, which is a normal prerequisite for the changing site conditions. The fuzzy approach can be used for site specific analysis and the membership grades can be used for queries for successive suitability rating for the area. The query shell is flexible for an expert user to query for his preset conditions and check for the spatial extent and accordingly suggest plans. This can be particularly useful to check for possible drawbacks or potential of an area before going in for any developmental activities in the area. The soil information module of the system is a veritable knowledge base of detail soil related information of the village, which can help in scientific planning, and development. The information can be used to assess the capability of the area for its shortcomings and hence to improve the productivity capacity. Furthermore the spatial analysis tool of the system is a handy option for the planners to correlate spatial information and hence to zero in areas of the planners interest, such site suitability assessment for and developmental activities, funds allocation etc. The points discussed is a few of the many functionality of the Information system and with the ease of use of the system and the temperament of the user much more valuable information can be retrieved for formulating more accurate and concrete plans.

Village Natural Resources planning: Land use planning in rural areas has received scant attention in comparison with town planning until recently. This can hardly be justified in a country like India, which is predominantly agricultural. The planning of agricultural sector in rural areas has been carried out in laissez faire manner. A land use map gives thorough and clear picture of land to the planners for the determination of future use and planning the agricultural sector to maintain the land potentials. In this way, land use planning is concerned with the future use of the land and the changing demands of the society.

Land Use Land Cover: The knowledge of spatial distribution of land cover/land use of large area is of great importance to regional planners and administrators. Satellite data can provide information on large areas and the temporal data can be utilized for change detection and updating old

data. The land use / land cover categories that can be obtained from the remotely sensed data include level III classes of land use classification system such as water bodies, forest, grass land, agricultural land, barren land, and scrub land. The Spatial Distribution of the various land use land cover classes found the study are listed in the table: 1
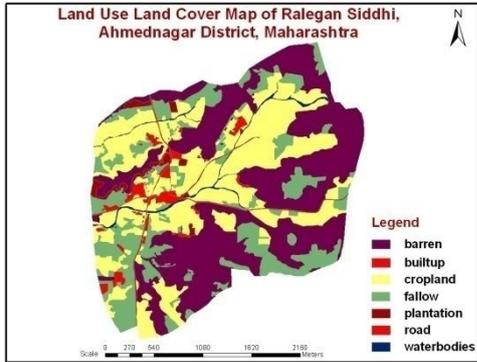

| Mapping Unit	Land use/Land cover category	Area in Sq.Km
1	Barren Land	1.32
2	Built up Land	0.23
3	Crop land	3.5
4	Fallow Lands	1.67
5	Plantations	0.07
6	Water bodies	0.12
7	Scrub land	2.76
	Total	**9.67**

Table: 1 Areal extent of Land Use Land Cover

Hydro geomorphology:

Hydro geomorphology deals with the study of landform in relation to groundwater occurrence and availability. It is manifested at the surface, mainly by geology, geomorphology, structure and recharge conditions. All the four parameters were studied and integrated to arrive at the groundwater prospects under each geomorphic cum litho logic unit, designated as hydro geomorphic unit. Ground water potential maps are prepared by integrating information on geomorphology, slope lithology, structural features and the precipitation. The Geology and Geomorphology of the study area have been studied and by combining the individual litholo-landform units the Geomorphology map is prepared. These Geomorphic units have been evaluated for their Ground Water Prospects based on the hydro geological characteristics of the geological and geomorphologic parameters. In the village around 3.65 sq.km of area under moderate ground water potential area ,2.54 sq.km of area in under poor or severe shortage of the ground water potential , 3.18 sq.km of area is under very poor or very severe shortage of ground water potential.
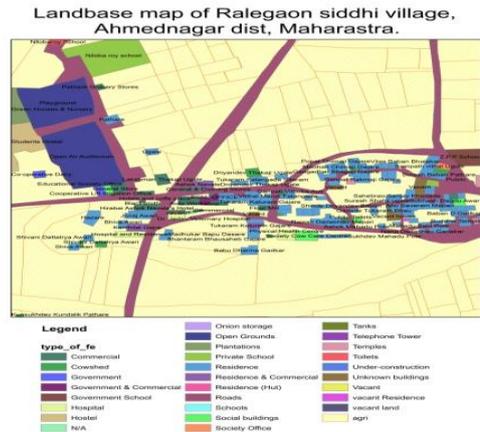

Soils: On the basis of physiographic analysis of the satellite data. Clay, Clay Loam, Sandy Clay, Sandy Clay Loam, and Sandy Loam were delineated. These were further subdivided based on the tone, texture, pattern, slope and land use. The Sandy Loam and Clay are nearly level, intensively cultivated and mostly irrigated. Sandy Clay Loam is all most covered with built-up lands Clay Loam is mostly used for cultivation and certain areas are cover with built-up lands .Sandy Clay is barren rocky area. It is a little elevated area. The soil samples were collected and analyzed for particle size distribution, pH, EC, $CaCO_3$, organic carbon, cation exchange capacity and exchangeable cations. The soils are slightly alkaline (pH 8.5-8.9), having low electrical conductivity (0.05-0.8 dsm-1), low organic carbon (0.01-0.4%) and variable calcium carbonate content. The low organic carbon content (<0.4%) of these soils is due to limited biological activity and rapid decomposition of biomass under the prevalent torric conditions.
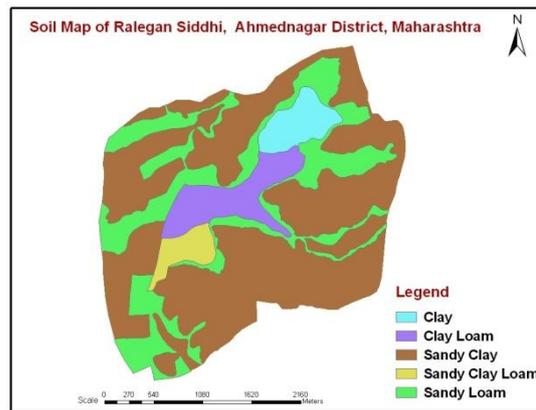
Based on the difference in soil texture, drainage and profile development, the soils were grouped into five soil series. The soil - physiographic relationship was established. The soils were classified as per Soil Taxonomy (Soil Survey Staff, 1996) as Ustic Torripsamments (Soil Series 1 and 2), coarse loamy Ustic Haplocambids (Soil Series 3 and 5), and Fine loamy Ustic Haplocambids (Soil Series 4). The final soil map was prepared on 1:10,000 scales.
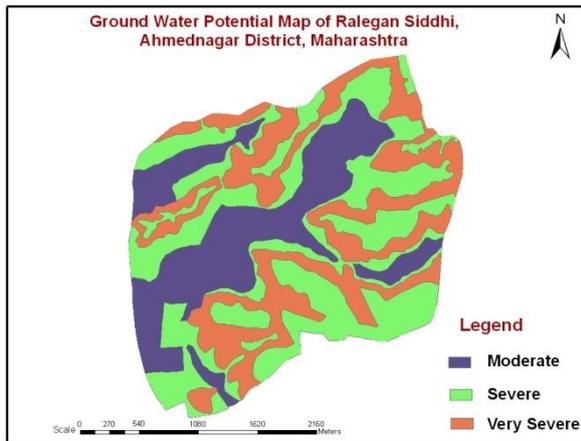
Slope: Slope refers to the inclination of the surface of the land. It is defined by gradient, shape and length, and is an integral part of any soil as a natural body. The length and gradient of slope influences soil formation and soil depth, which in turn affects land development and land use. Around 5.65 sq.km of area under village is level to nearly level slope, 1.65 sq.km of area is under 3-5 % sloping lands and 2.37 sq.km is covered under 10-15 % and above slope.
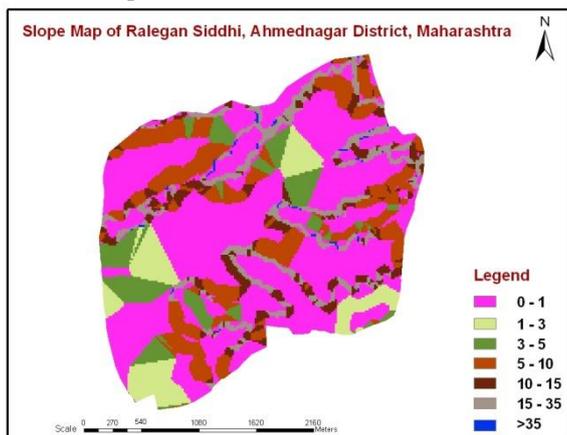

Cadastral map:

The cadastral map was procured from the revenue department. The scanned cadastral map was converted in to GIS form and the survey numbers were attached for each land parcel. Using the DGPS the cadastral was georeferenced. Ths georeferenced cadastral was overlaid on the land use maps to identify the crop land details based on the survey number.
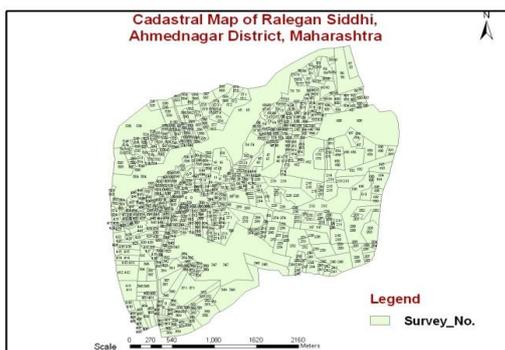
IX. VILLAGE GIS SYSTEM

The Village GIS has been developed using Arc GIS 9.0, Dot Net working under WINDOWS. A standard Pentium IV system would suffice the hardware requirement for its implementation. The following are some of the salient features of Village GIS.
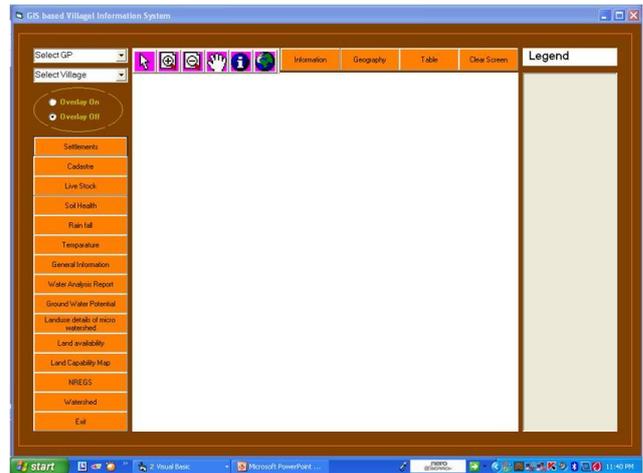
Main screen of the Village GIS Package

Open-ended Design: Presently, it covers about 30 facilities for illustrative purpose. However, Village GIS offers a seamless integration of any additional facilities owing to its open-ended design.

Thematic maps: Thematic maps are often required to provide decision support information for spatial planning in several key areas. Village GIS facilitates efficient generation and display of thematic maps directly by the end user to enable him perform situation analysis and gain an insight for proper decision-making. It also supports map tool bar (zoom, pan) on any thematic map.

Display of village profile: This contains set of predefined attributes of the village (village name, Panchayat name, population details, availability of facilities etc.) User can view the profile of any specific sector by clicking on the sector in the map or by choosing the desired item from the Village menu list displayed on the screen.

Query shell:
An in-built query shell is also provided in Village GIS to enable the end users build both simple and complex queries using any of the parameters (alone or in combination) contained in the attribute databases. The corresponding output can be obtained in the form of a map. The query shell thus aids in meaningful presentation of the data to arrive at appropriate planning decisions.

User-friendly interface:
Village GIS provides an interactive and user-friendly interface and it does not require any GIS expertise for its operation. It requires about 4~5 hours of learning time and could be thus easily deployed in the rural areas where the operating personnel are usually novices.

Applications of Village GIS: Village GIS has been customized for facility planning and management for the Ralegoan siddhi village in Ahmednagar District of

Maharastra State. Although Village GIS can support a wide range of applications due to its open-ended design, it is presently being contemplated for use for the following applications. Facility planning (Identification of suitable locations for creation of new facilities such as primary schools, middle schools etc.) Monitoring the functional status of various village amenities such as transformers, hand pumps, schools, hospitals etc. Monitoring and evaluation of the implementation of various rural development and poverty alleviation programmes/schemes (Mid-day meals scheme for school children, housing and employment guarantee schemes etc.)

- Management of road network.
- Village connectivity to Panchayat Headquarters.
- Land Holding Analysis
- House Type Analysis
- Income Analysis
- Occupation Analysis
- Social Strata and eligibility analysis
- Age Group Analysis for education infrastructure.

Need for Village GIS:

Data Set Issues: Techno-science paradigm of GIS in its first phase must be reworked as it lacks socio economic, demographic, ethnic, societal data. Remote sensing offers a great deal in environmental and land-cover mapping, but socioeconomic data require expensive field surveys; raise issues of ethics and power. However they lack spatially referenced datasets, such as basic registration data and their location features and spread. Census data can be accorded the same status as a carefully ground-truthed map from a satellite image and Topo Sheet data layer. The cost of converting data into a digital format though looks prohibitive, with wide use and applications the unit cost appears affordable. Even where datasets exist and can be converted to a digital form, there will be inconsistencies in referencing systems or geographical scales, and difficulties in the sharing of data and the coordination of information flows between users. Data sharing may be especially problematic in environments which are not "information-driven" and in which bureaucracy presents particular obstacles. Competitiveness and empire building prevent the free flow of data because common goals are not shared.

Data Analysis : The inventory, analysis and mapping capabilities of GIS have wide applications in rural and regional planning, ranging from data retrieval and site selection to project monitoring and programming, information retrieval, development control, mapping, land suitability analysis and a host of related applications varying at different stages of the planning process.

GIS as an Integrating Tool: GIS have evolved by linking a number of discrete technologies into a whole that is greater than the sum of its parts. GIS have emerged as very powerful technologies because they allow integrating the data and methods in ways that support traditional forms of geographical analysis, such as map overlay analysis. But they also make possible new types of analysis and modeling that are beyond the capability of manual methods, including

visualizing alternative futures. With GIS it is possible to map, model, query and analyze large quantities of data all held together within a single database.

X. CONCLUSIONS AND RECOMMENDATIONS

The Information Technology is one such significant creation which has changed the dimensions of man's thinking and made him very powerful for the capabilities of IT on information, analysis, storage, sharing, transmission, presentation and decision making anytime anywhere. The GIS being closely linked to IT rather ICT(Information Communication and Technology) is adding spatial dimension to the database and make man's understanding of the earth features more meaningfully and why and how the situations and changes taking over time and space. Village GIS tool, with a motto 'turning data into information', generated in the present study integrating the spatial village maps with non-spatial or tabular information from the NIC system, has demonstrated its potential for grass-root level development planning taking into consideration the local needs and constraints. It has also established its usefulness to the decision-makers in the district to generate views for decision-making at local-level. This prototype Community GIS tool will serve as a first step towards the development of Decision Support System for decentralized planning at dis-trict/sub-district level. Village could have direct application in the districts, even though personnel, institutional and financial issues will continue to constrain adoption. The advantages of the Village GIS package will be (1) Customization: A better Graphical User Interface (GUI) could be built using GIS, as it provides very comprehensive and fast access to information, both graphically and non- graphically. This makes the system more robust in terms of its communication with a variety of users. (2) Strategic Unit for Decentralized planning: Given that all village informatics are now spatially part of a common coordinated system, a number of useful combinations can be performed. The first step in this process is to create integrated Resource Unit (IRU). Each IRU comprises the spatial and non-spatial resource data, and can be taken as a strategic unit for assessing various decisions. Since they exhibit strong uniformity, they can all be expected to respond similarly to given intensi-ties of human use and management strategies. (3) Decision Support System (DSS): As far as rural development planning is concerned, Village GIS Package generated in the present study is unsophisticated but it is robust and functions with the data that are actually available in every NIC District Centre in India. This prototype village GIS could be customized to develop DSS for decentralized planning, proposed to be called 'Decent Plan/DSS', to assist the decision-makers at dis-trict/sub-district level.

Future Developments: Cheaper and faster Information and Communication Technology (ICT) is coming within the reach of most Organizations in the districts. It is therefore appropriate to consider the ways in which this technology has been implemented in the districts. In particular, future

trends must be considered in order to understand the potential information infrastructure to which these districts may aspire – while recognizing that different problems and conditions exist in different districts. With a better database, we can provide a better service to the user organizations to assist in their own decision-making process for developmental planning. A few possible future development programs for better service to the users for decentralized planning are: User friendly interactive GIS data base generated at a micro administrative unit (village) can improve the efficiency of administration, improve resource mobilization and help in informed decision making. The software being simple and customized and open for modifications holds lot of promise for local level applications. The strong aspect of this software is the capabilities of liking wide graphic aspects, like photographs, audios, videos, imageries and analyzed maps etc, which project field realities and help taking appropriate decision making, by people themselves. Village GIS is a GIS based Gram Panchayat Planning system, which has all the data formats to build up data inventory, link graphics, identify locational features, generate various graphic analysis for decision making and shows information both horizontal and vertical. Village GIS is expected to usher in the desired transparency and easiness in the Gram Panchayat planning and enable a faster response to the changing ground realities in the development planning, owing to its in-built scientific approach. It demonstrates that the GIS approach can provide cost effective solutions for local level planning in rural areas, and help bring the benefits of Spatial Technologies to the rural masses.GIS technology is more useful to developing countries since many issues of development relate to large-scale problems requiring integration of large spatial dataset. The availability of remotely sensed data and other national and international databases can facilitate action and GIS have the potential to contribute positively. With local knowledge and local control, accountability set in where a GIS system could direct at real needs, and the design relevant to local conditions. Sensitizing, Training and education village youth, elders, village functionaries and involvement of women, particularly from SHGs work towards sustainable GIS systems at local levels. GIS could become a tool for empowerment, decision alternatives, scenarios, modeling, what if analysis, locational and spatial spread analysis and an integrating tool for interfacing all information for synthesis, which can be a very potential tool for Gram Panchayat Planning and with the changing Map Policy of Government, GIS has come a long way and be an integral part of our life, administration, policies and programmes.

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