Indo - African Journal for Resource Management and Planning
(An International Peer Reviewed Research Journal)

ISSN 2347-1786.
VOL 1. NO. 01
September 15, 2013

Article info
Received on February 10, 2013
Published on September 17, 2013

India

Geo-informatics for Development of Rural Roads under PMGSY in Rajasthan

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ABSTRACT

The key to success of effective planning and monitoring of any infrastructure development project primarily depends on the current, correct & relevant information system. Use of Geo-informatics in recent past emerged as a powerful & effective solution to assist decision makers to get rid of traditional time consuming and tedious methods of managing large projects. After realizing the role of rural road development in social and economical development of India where majority of population lives in rural areas a biggest ever infrastructure development project called as Pradhan Mantri Gram Sadak Yojna (PMGSY) was launched in year 2000. Using Geo-informatics for development of rural roads under PMGSY in Rajasthan has changed the whole scenario of project implementation. The introduction of new concept of Core Network to optimize the cost of road construction to connect all eligible habitation by providing basic connectivity has been implemented very well using the GIS analysis. The online data entry from the location where data is being generated is dynamically linked to attribute data of main GIS data base putting the whole GIS database updated at every moment. The development of Web GIS allowed complete transparency in system and enabled citizens as well as officials to know the updated status of any sanctioned/proposed road in a user friendly and exiting way of visualizing information on map along with desired report. The preparation of comprehensive

road connectivity, upgradation and maintenance plan strictly based on policy has put the whole project away from political interventions. The rich GIS database developed this way also enabled other government departments i.e. Police, Transport, Education, Administration etc. to use this information for their own usage. Encouraged by the successful usage of Geo-Informatics in development of rural road Ministry of Rural Development is searching new avenues in their other developmental activities.

KEY WORDS:

Geo-informatics, Core Network, Online Management Monitoring and Accounting System (OMMAS), GRIMMS (GIS Enabled Road Inventory Monitoring and Management System).

Introduction

Socio economic development of a country like India where majority of population lives in rural areas largely depends on the development of rural road network. Efficient rural road network connectivity puts strong impact on development of agriculture, health, education, forestry, fisheries, small scale industries, trade, commerce etc. **(Raji A.K. et al 2010).**

Rural roads are defined by the road connecting the village to main road which may lead it to market or higher category road. Rural roads provide villages/habitations the access to other economic and social facilities. The rural roads can be classified as Other District Road (ODR) and Village Road (VR). ODR are those roads which connects the rural area to the market centers, block or main roads while VR are those roads which connects villages and group of villages to each other or to the market place or with the nearest road of higher category (**Operation Manual, 2005**). At present, there is a big gap between the urban and rural India in terms of basic civic amenities and employment. Rural roads provide the access to basic amenities and means of transporting agricultural products to nearest market centers. The task of providing an adequate rural road network to cater the needs of the village is not so easy. Realizing the role of rural road

connectivity to transform our country into a developed nation, the govt. of India formulated and implementing the nationwide development programme in rural area, popularly known as **Pradhan Mantry Gram Sadak Yojana (PMGSY)** to provide connectivity to all habitations up to population of 500 and more in general areas and population up to 250 in hilly, desert and tribal areas.

SALIENT FEATURES OF PMGSY SCHEME

The PMGSY scheme is one of the biggest ever infrastructure development project conceived by the Go vernment of India targeting to construct about 368,000 km of new road construction and 370,000 km of upgradation/renewal at a cost of about $26 billion. The planning and execution of

PMGSY roads are unique in many aspects i.e. planning, execution and quality of work **(PMGSY, 2004)**

a. Planning of PMGSY roads are based on the Core network: All roads under PMGSY have been prioritized out of the Core Network.
b. Roads are properly designed based on climatic and traffic conditions Roads and built as per the specifications given in Rural Roads Manual published by the Indian Roads Congress (IRC:SP20:2002).
c. Each state has designated a State Level Autonomous Agency to maintain financial and work execution matters.
d. The District Programme Implementation Units (DPIUs) headed by Superintending Engineers who execute the road works in accordance with the programme guidelines.
e. A 3-tier quality control system has been envisaged to enforce the quality of construction of roads. Contractors are bounded to set up a field laboratory at the work site. DPIU functions as the first tier of the quality supervisor, these DPIU are further supervised by the State Quality Monitor and National Quality Monitors
f. The complete programme is monitored, planned using Online monitoring System called as Online Management, Monitoring and Accounting System (OMMAS).
g. The use of Geographical Information System (GIS) for monitoring, management and building transparency in programme implemented in two pilot states i.e. Rajasthan and Himachal Pradesh.

INNOVATIVE METHODS OF PROJECT PLANNING AND MONITORING

Implementation of PMGSY scheme poses major challenges to the nodal executing agency i.e. National Rural Road Development Authority (NRRDA). It was very difficult to manage this giant project using traditional methods of project management as these methods are not only tedious and time consuming but also difficult to retrieve the desired information. Allocation of fund, in a developing country like India was also a barrier to implement this ambitious project. To overcame these barriers some new concepts and technologies were used e.g. introducing concept of Core Network, use of Online Management monitoring and Accounting System (OMMAS) and use of Geographic Information System (GIS)

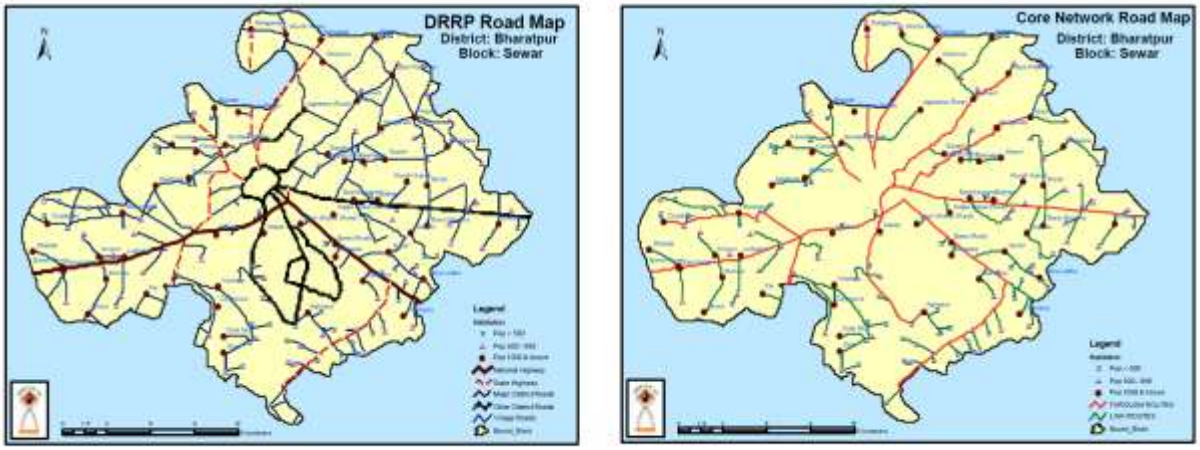

Figure 1: DRRP and Core Network roads

Core Network

The concept of Core network was introduced first time in planning of rural roads. The objective behind adopting concept of Core Network was optimization of Road network and minimizing the total cost of the project. Core network allowed us to connect eligible habitations by providing basic connectivity. "Basic access is defined by one all-weather road access from each village/ habitation to the nearby Market Centre or Rural Business Hub (RBH) and essential social and economic services. Core Network is the network of all the rural roads that are necessary to provide basic access to all the habitation. A core network is extracted out of the total network mentioned in the District Rural Road Plan (DRRP) and consists of existing roads as well as the roads required to be constructed to the as yet connected habitations.

Core network helps in optimizing the requirements of fresh construction and up gradation for ensuring connectivity to all the habitation. It is primary intended to mark out the essential network that is required to be maintained in good condition at all times. The core network consists of "Through Route" and "Link route". Through routes are the ones which connect traffic from several link roads serving a long chain of villages and lead to market centre either directly or through the higher category roads, such as NH, SH etc. On the other hand, link route are the roads connecting a single habitation or a group of habitation to through routes or major link road leading to market centre. **Fig 1** shows it clearly the difference in DRRP and Core Network

Identification of the Core Network

There are three types of habitations in the Block Map-

- Connected, having all weather roads
- Not connected at all,
- Connected only by a fair-weather road.

In the case of connected Habitations, it is possible that there are more than one road connections. In such a case, one road should be selected using socio-economic infrastructural parameter criteria. If for any reason, an alternative road is the preferred choice of the local people, that road may be chosen, but, in any case, only one road should be selected for the core network, as the intension is to provide the basic access. In case of unconnected habitations, a suitable road connection should be identified; this would generally follow the alignment of an existing track. If there is more than one track, selection has to be made on the basis of the parameters. The core network plan shall thus be prepared for the entire block. It should be checked again that all the habitations are connected or will be connected to the nearby market centers, either directly or indirectly through other all weather roads. It is not necessary that each habitation is directly connected to the market centre in a hub-and spoke configuration (www.mprrda.com/citizen/core-network).

OMMAS (Online Management, Monitoring Management and Accounting System)

OMMAS was introduced for effective monitoring of entire programme, improved efficiency, accountability and developing the transparency in the whole system. OMMAS allows common citizens to view various reports and information and also provide authorized officials to update the database related to master data, proposals, sanctions, progress etc. The Easy interface of OMMAS allows data entry at the source to avoid duplication of efforts. The entire application is very robust and very user friendly. It allows a person with least knowledge of computing to work with it. OMMAS stores the

relational database related with Village/habitation, DRRP roads, Core Network roads, various administrative boundaries, proposals, sanctions and tenders etc.

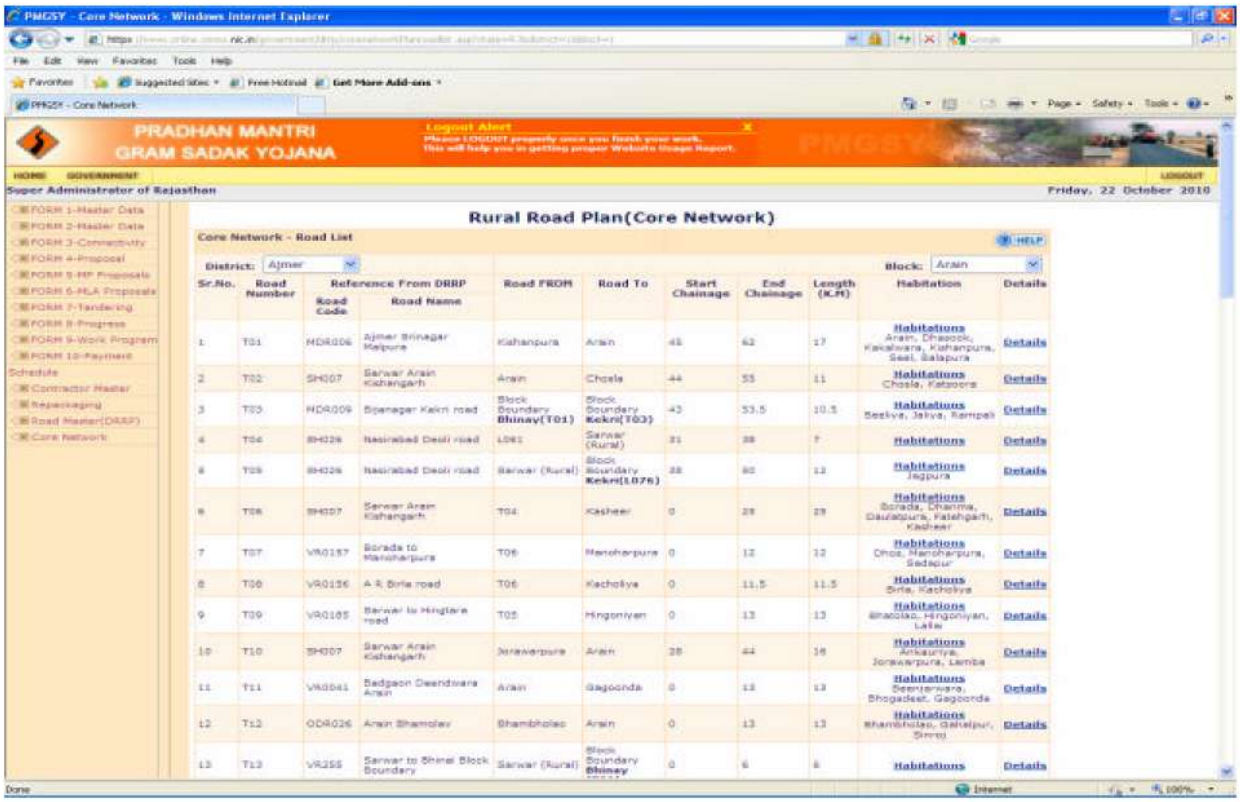

Figure 2: Snap shot of OMMS web page

Geographic Information System (GIS)

GIS is a key component of Geo-informatics is a computer assisted system for capturing, storing, checking, integrating, manipulating, analyzing and displaying, data which are spatially referenced to the earth for solving complex planning, decision making and management problems. GIS is a powerful mapping tool that links information found in databases to geographic locations found on colorful map displays in order to make analysis for decision making clearer. GIS allows us to manipulate and display geographical knowledge in a new and exciting ways. It integrates spatial and other kinds of information in a single system like spatial information and its attribute information. Similar to other information system, GIS also depends on the information content input in a computer but this information system requires special processing. GIS uses geographically referenced data as well as non spatial data and includes operation that supports spatial analysis.

NEEDS OF USING GIS IN PLANNING, MONITORING AND MANAGEMENT

Development of rural roads requires appropriate planning and methods of identification and prioritization of the rural connectivity plan (Gangopadhayay S. 2009). Over the last two decades the study growth in information technology has provides planners and other related professionals familiar with Geographical Information System(GIS) that means particular form of information to geographical data. Spatial data analysis is multi-disciplinary activities concerning land resources, geography, rural/urban planning etc. spatial data sets are frequently heterogeneous having data on soils, water, land use, topography, forestry, administrative boundary, population etc. The management and analysis of such large volume of spatial data require use of GIS (**Y.K.Gupta, 2010**).

Table 1: Questions which can be answered by GIS

1.	Location	What is at...?
2.	Condition	Where is it……..…?
3.	Trend	What has changed...?
4.	Routing	Which is the best way…?
5.	Pattern	What is the pattern……..…?
6.	Modeling	What if…….....?

In planning process, integration of various spatial data and their characteristics is required to arrive at different alternatives. GIS is useful tool for the integration and analysis of the multi thematic information for a particular application. This provides managers and planners with necessary information required for planning. GIS can be effectively used for generating new information from existing thematic layers of information required for particular need. In GIS both spatial and non-spatial data may be integrated and set of spatially registered layers can be analyzed independently or in a combination. **Table 1** show the questions which can be answered by the GIS. Complex spatial analysis in GIS offers Quantitative as well as qualitative advantages. Planning scenarios, decision models, change detection and analysis and other type of plans can be developed in GIS by making refinements to successive analysis. GIS is a decision making tool in the hands of planners and is increasingly being used for planning and management of resources. The followings are some causes which makes use of GIS a necessity

· To make existing maps more quickly and cheaply.

· To make maps for Specific user needs.

· To facilitate map making and updating when the data are already in digital form.

· Analysis of the data that demand interaction between statistical analysis and mapping.

· To create maps that is difficult to make by hands e.g. 3D maps or stereoscopic map.

To fulfill this need PMGSY in Rajasthan started using GIS software for the development of rural roads. The online data entry from the data source is dynamically linked as attribute data of main GIS data base putting the whole GIS database updated every moment.

DEVELOPMENT OF GIS FOR RURAL ROADS.

The development of GIS database has gone through following stages to ensure meaningful output. Following are different phases of database development.

· Data acquisition and input.

· Data storage, linking & verification.

· Data retrieval.

· Data transformation and analysis.

· Data updation

· Data output and presentation.

The database of GIS contains spatial data (geo-referenced or data with co-ordinates) and attributes data (that describe characteristics of spatial objects/entities). A GIS has possibilities to combine different layers of spatial information and also link spatial data with attribute data. Here the spatial data containing more than 21 layers while all attribute data is being stored in OMMAS.

Data Acquisition and Input

Data input covers all aspects of transforming data captured in the form of existing maps, field observation and different remote sensing products in to a compatible digital form. Here the statistical data for PMGSY consist of three different basic features such as DRRP/Core Network, various administrative boundaries and village. The maps created by (SoI) at the scale of 50,000 are used as base map for creating DRRP and Core net work maps. Core network maps are subset of DRRP maps with an additional layer of network of through Route and link routes. These maps are overlapped on digital maps received from Survey of India (SoI). The following features were included in the maps

· District, Block, MLA constituency, MP constituency, Divisional boundary and Circle Boundary, water bodies.

- Different category of roads i.e. NH, State Highway, Major District Roads, Other District Roads, Villages roads and other roads, river or major streams , Railway track
- Administrative Head Quarters, All habitations, town and cities, religious/tourist places, quarry sites , market places, bridges and CD works etc.

These maps were scanned and digitized to form vector data. Separate layers were created for different categories of roads. These digital maps were then Geo-referenced (a process by which the features on the maps are assigned real world coordinates)

Linking Data and Verification

Once both the spatial and non-spatial data have been input, the linking operation provides an ideal chance to verify the quality of both spatial and non-spatial data. Here creation of data base for GIS linking of spatial data i.e. map to nonspatial data. That is OMMAS requires common linking IDs and total number of feature represented in map should match with corresponding attribute data.

Data Retrieval

GIS combines possibilities, which can be found in database software or in CAD. Retrieval operations on the spatial and attribute data involves the selection search, manipulation and output of the data without the need to modify the geographic location of features or to new spatial create entities. Simple data retrieval can be compared to the GIS capabilities for output. A map can be retrieved on the basis of the requirements of the user. If different elements of a map (road types, rivers, land use) are stored in different layers any combination can be made for a user specific output map.

Thematic mapping on the basis of non-spatial attributes is also a retrieval operation. It is the critical component directly

affects user, the ability to get the information behind the data and to structure the information to solve a specific problem.

The retrieval operations can be performed on spatial data alone, or on spatial data in combination with attribute data.

Data transformation and analysis for decision making

It embraces two classes of operations. Namely (a) transformation needed to remove errors from the data sets and (b).the large array of analytical methods that can be applied to the data in order to achieve answers to the question asked for the GIS. Transformations are operated on the spatial and non-spatial data either separately or in combination. After completing the data base creation part of the database ready for several GIS operations. One of these operations is topology

creation. Its develops the relation among roads and its spatial relation with other features e.g. adjacency, disjoint, crossing etc. once the topology is build successfully the data is ready for analysis and preparing various reports, different queries can be performed which can be further used for decision making.

Data updation

The GIS databases which consists of spatial (Map data) and attribute data requires updation over the period of time. Since the attribute data is dynamically linked with backup of OMMAS web site this part is being updated continuously. The updation of spatial database due to change in alignment or new construction or due to any other reason has to incorporated as and when required. GPS and Total Station for marking new alignment is being used extensively in addition to the different maps received from different sources to update such changes.

Data output and presentation

The ways the data can be displayed and the results of analysis are reported to the users is very user friendly. Data can be produced as maps, tables and figures, text etc in several ways in the digital format or in a hard copy as well. The desired information can be produced in a user friendly format which conveys the result of any analysis thus making the output usable by the officials whom are otherwise not conversant with computing. The out come in digital format helped very much during Power Point presentation among decision makers. Symbolized map out put emphasis on desired parameters.

Customization of GIS software

The data base developed under this project involves the huge investment and requires the optimal use by the user. Since the operation of GIS software requires special training and methods to use it, therefore a customize interface easy enough to be operated by novice user was developed using V.B net, Arc Objects and arc GIS etc. and several common analysis took place to single button commands. The stand alone GIS enable Road Inventory Monitoring and Management System. (**GRIMMS**), which provides GIS, interface to the existing online management and monitoring system (OMMS).

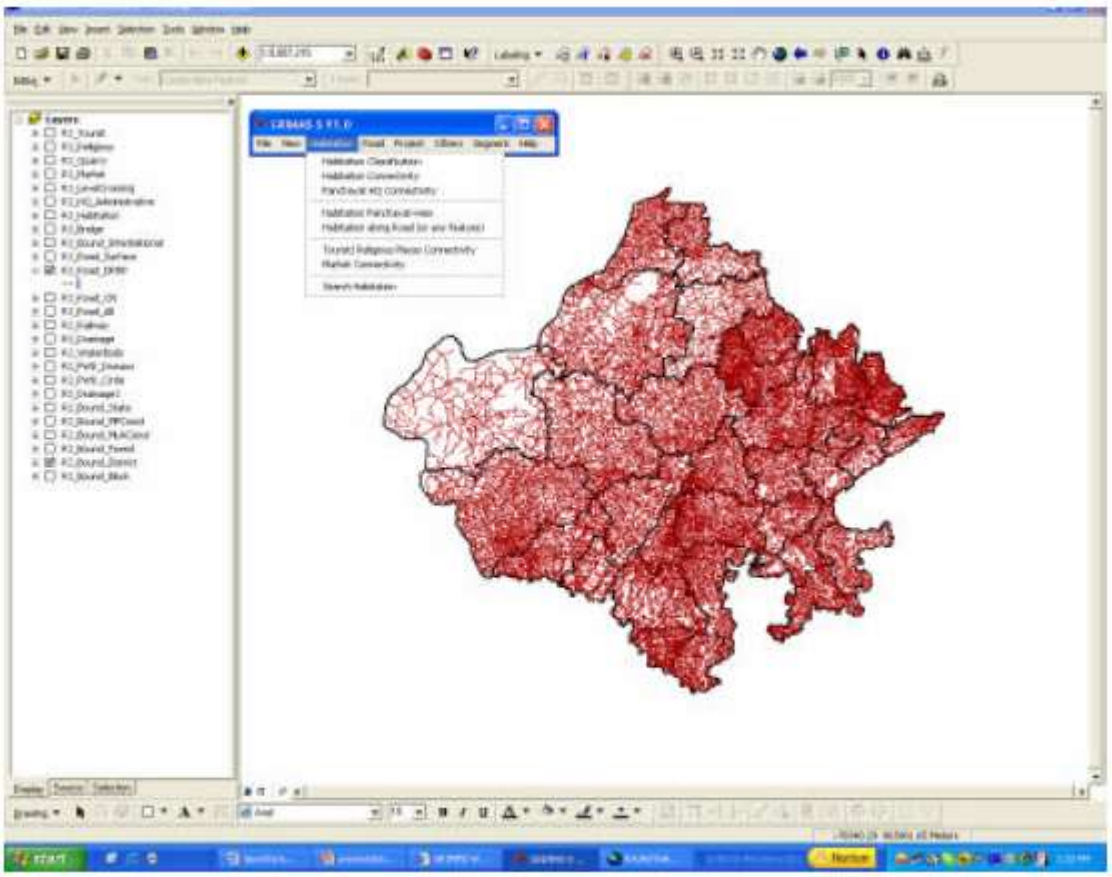

Figure 3: GRIMMS -S standalone version of customized GIS

The PMGSY GIS project involved generation of spatial database, customization of a standalone GIS system (GRIMMS-S) and development of web GIS (GRIMMS WEB).The stand (GRIMMS-S) has been developed using Arc Editor 9.0, Arc objects and V.B Net tools . The stand alone version has the capability to activate the Arc editor and use its objects to run required GIS functions. Users need not know Arc-editor features, as user friendly menus are available separately for GRIMMS-S (see **figure 3***)*.

It is web based GIS, developed using ASP.NET, Java script, objects of map extreme 2004 and SQL server 2000. Microsoft web control is used for the tree and tab controls. In GRIMMS-Web, menus, icons, tree-view of layers/legend, map display, quarry dialog box and attribute data display sections are incorporated for having appearance as that of the stand alone version. It overcame the drawbacks of stand alone system and enabled common person/citizens to operate and view information in an interactive and exciting way on the map with related attribute without any specific hardware and software installation. The web based GIS allows transparency to PMGSY programme and disseminate the related spatial as well as attribute information related to progress and status of PMGSY roads in user friendly manner to all those person who even don't

have heared about GIS (Baliga, 2005). GRIMMS-WEB can be accessed at http://omms.nic.in/grimms .

ROLE OF GIS AND OMMAS FOR PMGSY AND OTHER PROJECTS

The NRRDA has established an Online Monitoring Management System (OMMAS) to effectively monitor and manage various activities under PMGSY. The database for the system is established at various District Project Implementation Units in each state and it being updated regularly. The database includes information on connectivity status of habitations, District Rural Road Network, Core Network, proposals made for each batch of works, works sanctioned, contractors details, physical and financial progress, unit costs, quality monitoring, pavement condition Index etc.

The NRRDA has decided to take lead to further expand these efforts by establishing a comprehensive spatial database for the rural roads. This will be done through establishing a computerized database of OMMAS, and linking these to GIS. The system will promo te a higher level of monitoring, decision making for PMGSY as well as for various rural roads to be implemented by various rural roads organizations.

The system has to meet the requirements of PMGSY as well as other rural roads programs being

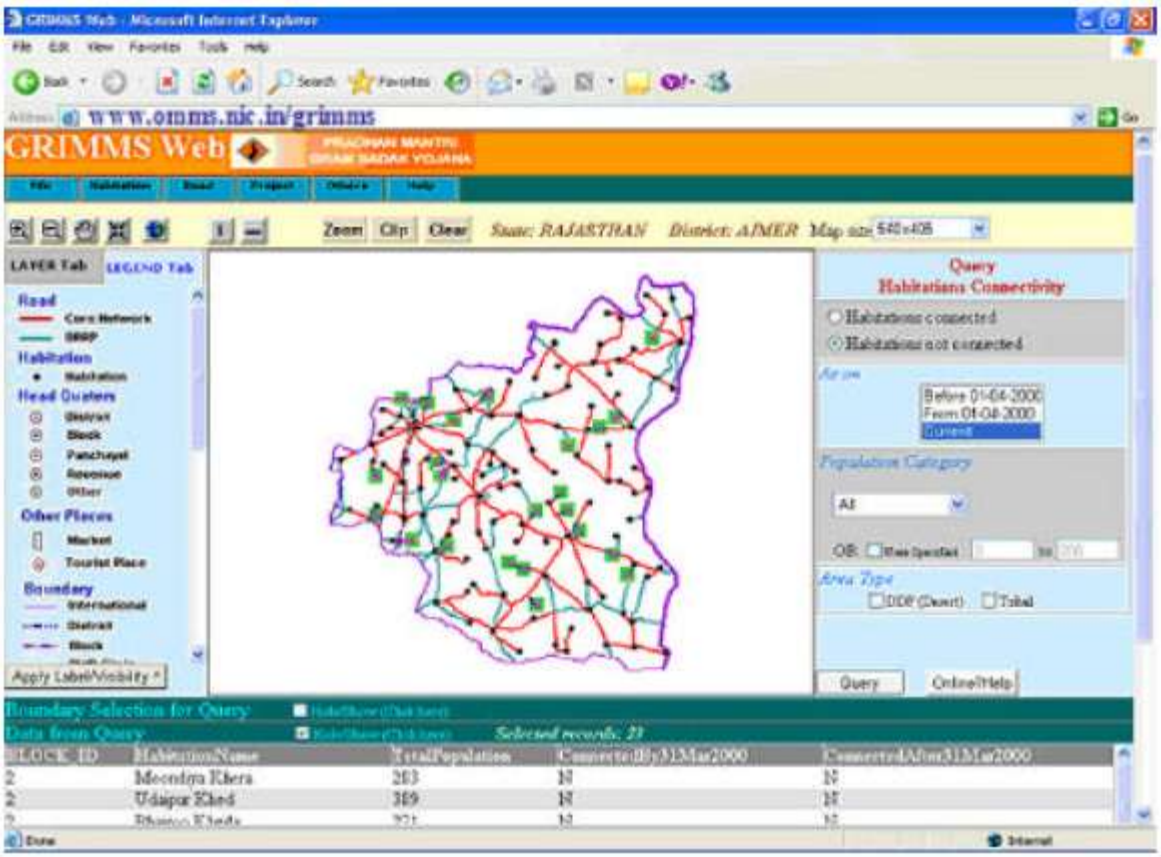

Figure 4: GRIMMS -W Web version of Customized GIS

implemented in the states. The GIS interface is to be developed as Stand alone for the use of PIUs at their day to day use and Web-based for the use in public domain as a seamless extension of OMMAS (Chandrasekhar B.P., 2005). The main goal of the pilot project is to develop and make operational, a computerized spatial database for rural roads in GIS environment, for effective management of PMGSY and various state level programs from construction, improvement and maintenance of rural roads. In future it is envisaged that with time better location planning of socio-economic rural services would be enabled with the use of rural road GIS. The spatial and attribute data shall be linked with the OMMAS in order that the spectrum of information available on-line could be mapped spatially for a seamless graphic output which could be easily assimilated. The ROMAPS software prepared to take care of preparing maintenance plans is also integrated in this system. The integrated system (see **figure 5**) works in an integrated way.

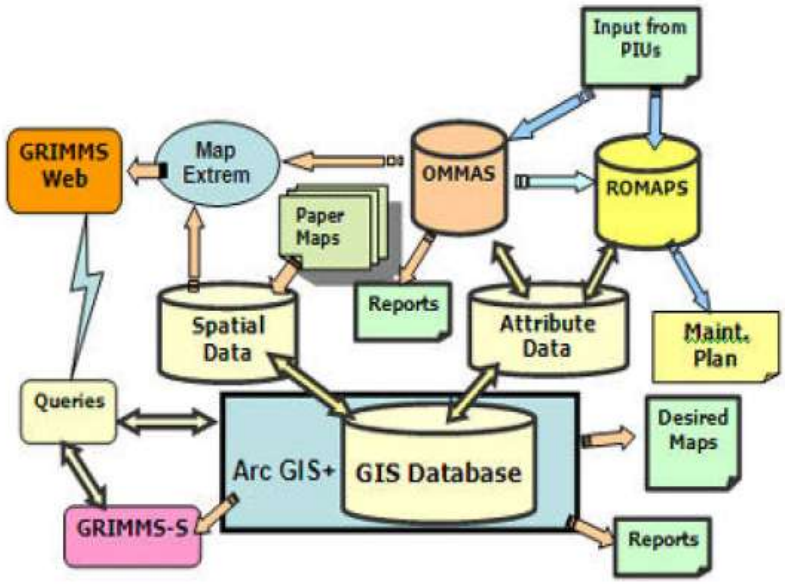

Figure 5: Data flow & relationship chart

It allows user to

· Link OMMAS data with maps
· Addressing basic and advanced spatial queries
· Answer queries on Master data
· Monitoring physical and financial progress
· Generating reports on the quality aspects
· Generating road status reports
· Performing various queries

· Generating road condition reports
· Reviewing maintenance aspects and plan
· Generating management reports as required by NRRDA and the states
· Preparing Comprehensive New Connectivity Priority List (CNCPL) proposals based on the predefined conditions e.g. Population range: 500 - 999 and Connectivity status as on 2007 is "No"
· Preparing Comprehensive Up-gradation Priority List (CUPL) proposals e.g. Road Category belonging to Village Roads or Other District Roads and Pavement Condition Index = 2 and year of Construction of road more than 10 years old.
· Various status reports demanded from time to time e.g. during assembly season can be prepared in an effective and time saving manner

A conscious decision was made to close-couple OMMAS and GIS as this would ensure sustainability of the spatial database. Often GIS systems fall in to disuse due to absolute associated databases. OMMAS is to be updated mandatorily and thus the spatial data would be automatically display the latest information. The web Based GIS system would carry forward the transparency of the programs by dissemination of information relating to programs status in spatial format, which would be user friendly and usable by persons without detailed knowledge of GIS. The huge data base and various reports related with habitations, roads, works etc can be accessed at http://omms.nic.in.

Possibilities of GIS applications for rural roads

GIS can be applied to many types of problem and sets out a general classification of the types of generic questions, which GIS are frequently used to investigate. The usage of Geo-informatics is application based; some of the main possible usages are as follows:

· Knowing pattern to make policies or launch new scheme like (see figure 7 & 8) using different symbolization techniques.
· Study of development along the road or encroachment along the road way.
· Design of road with optimal alignment and grade to save the cost of earth work using 3D GIS. (see **figure 6**)
· Network analysis to find the shortest route or alignment.
· Flood analysis to find out that which part of the road is likely to fall under submergence in case of flood takes place.

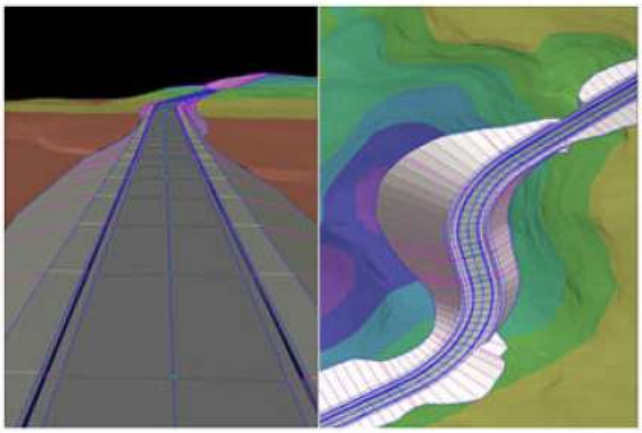

Figure 6: Design of road for optimal E/W using 3D GIS

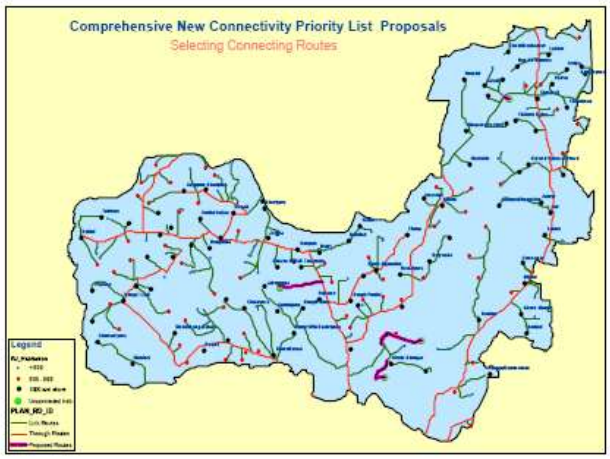

Figure 7: Preparation of CNCPL

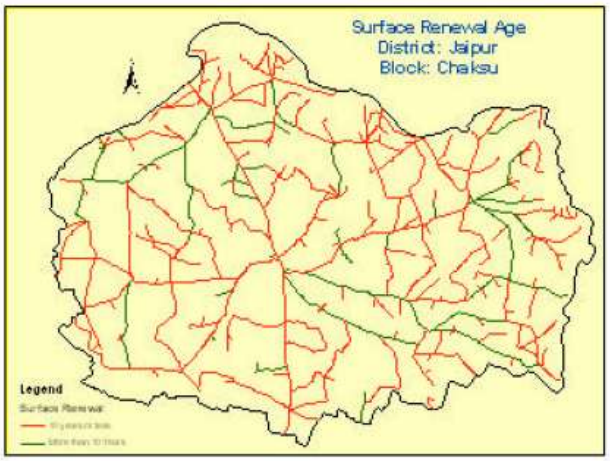

Figure 8: Symbolizing surface renewal age

Benefits of spatial database to other departments

The database created originally for development of rural roads not only proved useful for PWD or rural development department but also proved immensely useful for other departments also. Database prepared this way will also allow the data sharing among different government department which will reduce the cost of duplication.

Following departments have used various layers directly or as reference information for creation of different maps

- General Administrative Department (used extensively during Gurjjar Andolan)
- Directorate of Local Bodies
- Police Department
- Jaipur Development Authority
- Transport department
- Town Planning Department
- Universities for different kind of studies e.g. University of Rajasthan, JNU New Delhi, BITS Pilani etc.

CONCLUSION

The effective planning, monitoring and decision making of any developmental activity mainly depends on the reliable, updated and relevant information system. The GIS over came the drawback of time consuming and tedious traditional methods of planning. Incorporation of Geo-informatics into planning, implementation and monitoring process of PMGSY scheme is changing the whole concept of execution of rural road plan. An authentic database for Rural Road developed using GIS which immensely helped in the planning and monitoring process by maintaining the information in an effective and easily updatable manner. Database prepared this way will also allow the data sharing among different government department which will reduce

the cost of duplication. Considering all these aspects and potential of Geo-informatics, this technology is being used for monitoring, management and implementation of PMGSY scheme in India. The performance of Rajasthan state in implementing PMGSY scheme has proved it. Future applications of GIS are beyond imagination and almost all development projects will use this technology.

REFERENCES

- Guo B., Poling A.D. & Poppe M.J. (1995), GIS/GPS in Transportation, Real World Experiences:

  http://www.cdac.in/html/egov/pmgsy.aspx

- Impact Assessment of Pradhan Mantri Gram Sadak Yojna, (2004) Government of India, Ministry of Rural Development, New Delhi: PMGSY,
- Operation Manual (2005), Pradhan Mantri Gram Sadak Yojna, NRRDA, MoRD, New Delhi
- Rao A. M., Durai B.K., Jain P.K. & Sikdar P.K. (2004), Geographical Information System for Planning and Management of Rural Roads, March 2004, GIS Development, Noida
- Subudhi A.P., Sokhi B.S., Roy P.S. (2001) Remote Sensing and GIS Application in Urban and Regional Studies
- Sushant Baliga (2005), A Geographical Information System for PMGSY, Grameen Sampark, Vol.1 No.3, July-Sep 2005, NRRDA, New Delhi:
- User Manual, Version 1.0 (2005) Online Management , Monitoring and Accounting System, PMGSY, C-DAC, Pune: