Using Geo-informatics for Development of Rural Roads Under Pradhan Mantri Gram Sadak Yojna

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1. Introduction

The development of any country depends on the infrastructural facilities available therein. Good road network facilities plays major role here. The developed countries have good road infrastructure not because of the fact that they are wealthy; instead they become developed because of good road infrastructure. Realizing this fact an ambitious and biggest ever infrastructure development project in India (expected cost of $26 billion) named as Pradhan Mantri Gram Sadak Yojna (PMGSY) under ministry of Rural Development was conceptualized and launched on 25th December, 2000. The objective was to provide basic access by way of all weather roads to the all habitations having population "250 or above in desert and tribal areas" and "500 or above for the rest of habitations" by year 2007 in phased manner.

The role of Rural Roads is very important in a country like India where majority of the population resides in rural areas and the main source of their earning is based on agriculture products. Rural roads provide the access to basic amenities and means of transporting agricultural products to nearest market centers. The Rural Roads can be classified as Other District Roads (ODR) and Village Roads (VR). ODR are those roads which connects the rural areas to market centers, Block, tehsil/taluka HQ or main roads while VR are those roads which connects villages and group of villages and each other or to the market place or with the nearest road of higher category (Operation Manual, 2005).

PMGSY scheme is becoming very popular among rural areas because of the specifications and quality aspect adopted for construction of roads. Although it is a Rural Road Connectivity Project but it has well designed working system, clear guidelines and stream lined efficient monitoring and execution strategy.

2. Salient Features of PMGSY scheme

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

- Planning of PMGSY roads are based on the Core network: All roads under PMGSY have been prioritized out of the Core Network.
- 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).
- Each state has designated a State Level Autonomous Agency to maintain financial and work execution matters. The District Programme Implementation Units (DPIUs) headed by Superintending Engineers who execute the road works in accordance with the programme guidelines.
- 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.
- The complete programme is monitored, planned using Online monitoring System called as Online Management, Monitoring and Accounting System (OMMAS).
- 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.

3. Need of using Geo-informatics in planning, monitoring & management

Implementation of PMGSY scheme poses major challenges in front of nodal executing agency i.e. National Rural Road Development Authority (NRRDA). It was very difficult and hard 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. To overcome these difficulties Geo-informatics is being used for planning, decision making and monitoring of PMGSY scheme. Geo-informatics is a advance technology and science

which emerged very strongly in past 10-15 years , it includes Geographic information System (GIS), Remote Sensing, Global Positioning System, Communication, programming, statistics, geo processing, image processing, digital photogrametry etc..

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. GIS integrates spatial and other kinds of information in a single system like spatial information and its attribute information within a single system. Similar to other information system, GIS also depends on the information content input in computer but this information system requires special processing.

Development of database for GIS involved different stages in a sequence. The database preparation part of GIS development is very important and time consuming because all the out come of GIS is based on the quality, completeness, relevancy and accuracy of data. The following stages are involved in development of GIS data base :

- Data input
  - Entering the spatial data
  - Entering the attribute data
  - Linking the spatial and non-spatial data
- Data correction and verification
- Topology creation
- Spatial analysis
- Data output

The creation of GIS data base requires spatial data and the corresponding attribute data of the spatial features. The Spatial data used here includes various layers of habitations, DRRP, Core network and various boundaries maps etc. while all attribute data is being stored in OMMAS. To implement use of GIS for development of rural roads and creation of GIS data base Rajasthan and Himachal Pradesh are chosen as pilot state.

4. Online Management, Monitoring and Accounting System (OMMAS)

Computerized data has the advantage of reliable storage, easy retrieval, immediate processing and complicated calculation ability which is useful in generating the high level abstract information for use of management. The advantage of a centralized database is that the range of comparison is not only vertical in terms of the time period but also horizontal in terms of geographic spread across districts and states (Operation Manual, 2005).

The online Management, Monitoring and Accounting System (OMMAS) have been designed as an online web-based system with centralized database.

The OMMAS is developed to provide features which were not used earlier. The data entry is being done at the point where the data are generated i.e. at the Programme Implementation Unit (PIU) level for project data and at the State Technical Agency/State Rural Roads Development Agency and National Rural Roads Development Agency level where their intervention contributes to value addition to the data. The data entry is for near real time to enable outputs to be useful for management as well as monitoring.

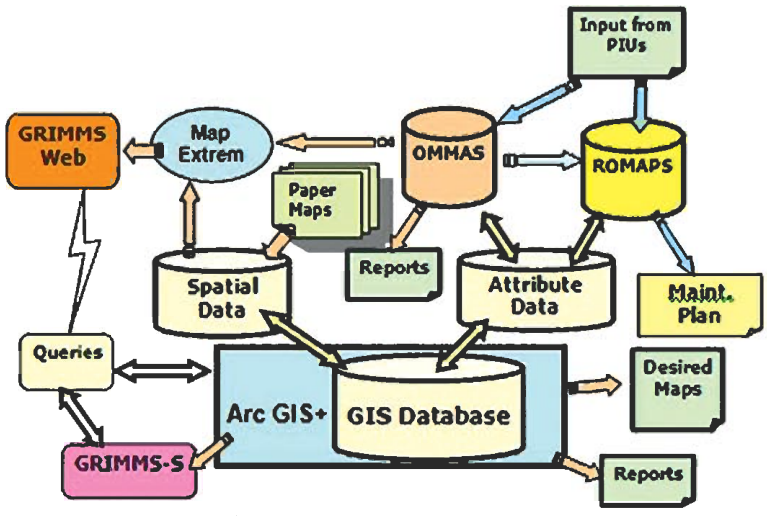

Fig. 1 Data flow & relationship chart.

The huge database and various reports related with habitations, roads, works etc can be accessed at http://omms.nic.in The full power of the software is brought to bear to generate outputs useful at all levels i.e. monitoring and management output at PIU levels, progress management and management-by-exception outputs at SRRDA level and NRRDA and abstracted and analyzed information policy and over all information for use in NRRDA. Transparency is inbuilt in the system enabling abstracted data to be drilled down to basic data, generally up to 'road' or 'Habitation'.

5. Input to GIS database

The spatial data for PMGSY consists of several layers which includes DRRP, Core Network roads, habitations, block and district head quarters, tourist places, queries, boundaries of zones, circles, division, block, districts, forest area etc. The District Rural Road Plan (DRRP) is a long term plan of road network in a district showing the existing road network of all categories, the habitation of various population size and road proposed for connecting the yet connected habitations to already connected habitations by all weather roads in an economical and efficient manner. The Rural Road network required for providing the basic access to all habitations/villages to term as the Core Network. Basic access is defined as one all weather road access from each habitation to the nearest market Centre and essential social and economic services. A Core network comprises of through route and Link Routes. Through routes are the roads which collect traffic from several links and lead it to the market centre or higher category roads. Link routes are the roads connecting to a single habitation or a group of habitations to through route or district road leading to market centre (Operation Manual, 2005).

The maps created by SoI at the scale of 50,000 are used as base map for creating DRRP and Core net work maps. These maps are overlapped on digital maps received from SoI. The Core Network maps are subset of DRRP maps with an additional layer of network of Through Route and link routes. The following features were included in the maps District, Block, MLA constituency, MP constituency, Divisional boundary and Circle Boundary. All category of roads i.e. NH, State Highway, Major District Roads, Other District Roads, Villages roads and other roads are included. All habitations, town and cities, religious/tourist places, quarries, market places, river or major streams, bridges and CD works are mapped. 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).

The attribute data belonging to spatial feature are entered through the Online Management, Monitoring and Accounting System (OMMAS) which is being developed programmatically with assistance of Center for Development of Advance Computing (C-DAC), Pune. The data entry in OMMAS is being done by officials of respective state agencies from their own place through internet. The distributed data entry now resulted into massive information bank (User Manual, 2005).

5.1 Linking Data and Quality Checking

Creation of data base for GIS linking of spatial data i.e. maps to non spatial data i.e. OMMAS requires common linking Ids and total number of feature represented in map should match with corresponding attribute data. The cleaning of spatial feature also takes place at this stage. The linking of spatial and non spatial data is done using ARC GIS software. The completeness and accuracy of data is being checked at this stage as these factors decide the usability of data in this decision support system.

5.2 Manipulating and Analyzing Data for Decision Making

To make the database ready for analysis some operations has to be performed at this stage. One of these operations is topology creation. Topology creation develops the location relationship among the geographic feature besides cleaning of the map. Creating topology checks geometry of the features and removes errors by deleting short objects, clustering the nodes etc. To analyze the roads, network topology has to be created. This operation develops 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 various reports, different queries can be made which can be further used for decision making. The GIS database created this way now makes enable the users to perform several GIS analysis.

The database developed under this project involves huge cost and requires the optimal use by the users. The operation of GIS software requires special training and methods to use it, therefore a customized interface which enabled novice users to use complex functionality with ease was developed using VB.net, Arc GIS, Arc Objects etc. and several common analysis task put to single button commands. The stand alone GIS Enabled Road Inventory

Monitoring and Management System (GRIMMS-S) was developed for this purpose. it is a stand alone GIS software designed for PIUs to use at their office to perform various queries and analysis for their day to day work. The stand alone GRIMMS-S enabled field staffs to perform various analytical GIS processing with ease.

Since the use of stand alone system was constrained to the limited number of users because of the stand alone installation and high cost of the parent GIS software, it was decided to launch Web version of customized GIS e.g. GRIMMS-Web. 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 attributes 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 heard about GIS (Baliga, 2005). GRIMMS-Web can be accessed at http://omms.nic.in/grimms

6. Data updating

The quality and usability of data is largely depends on the age of data and it requires constant updating. The data updating requires field verification and input from field for newly created features e.g. roads, building etc. Global Positioning System (GPS) can greatly help here. GPS is an advance method of positioning which assist in positional data collection/updating of spatial information (maps). This technology uses special signals broadcasted by satellites and uses the information contained in to calculate the position of the GPS receiver. The accuracy of this positioning system varies from 50 m to 1 mm depending on the type of the receiver and the processing of data (Guo et al, 1995). The Differential processing (DGPS) can provide very accurate spatial coordinate and can be used for updating of maps in an efficient and cost effective manner.

7. Applications of Geo-informatics for rural roads

The database prepared through above mentioned processes is being used for decision making and planning. GIS can answer following questions and thus helps in decision making.

- Location (what is at ...?)
- Condition (where is it....?)
- Trends (what has changed since....?)
- Pattern (what spatial pattern exist...?) see figure 3
- Modeling (what if....?)

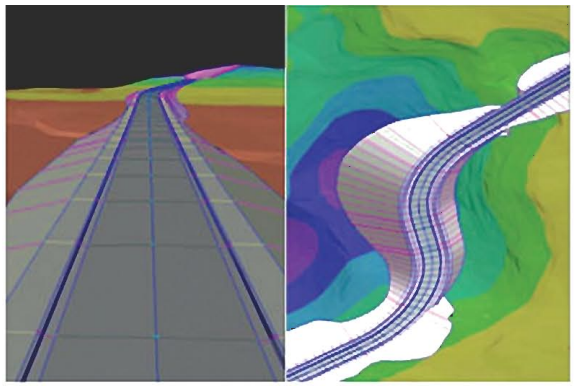

Fig. 2 Design of road for optimal E/W using 3D GIS.

The usage of Geo-informatics is application based ; some of the main usages are as follows :

- Preparing new information based on the existing information.
- Performing various queries to reach to make decisions e.g. which roads are renewed before 10 years and Pavement Condition Index(PCI) is equal to or less than 2 for preparing the maintenance plan.
- Knowing pattern to make policies or launch new scheme like (see figure 3 & 4) using different symbolization methods.
- Various status reports demanded from time to time e.g. during assembly season can be prepared in a effective and time saving manner.
- 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 2).
- Preparing customized maps/reports which shows the features and area of interest.
- Network analysis to find the shortest route or alignment.
- Flood analysis to find out the which part of the road is likely to fall under submergence in case of flood takes place.
- 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 and then preparing the detailed report of these selected roads to prepare Detailed Project reports.
- Preparing Comprehensive Up-gradation Priority List (CUPL) proposals e.g. Road Category belonging to Village Roads or Other District Roads and PCI Index = 2 and year of Construction of road more than 10 years old.

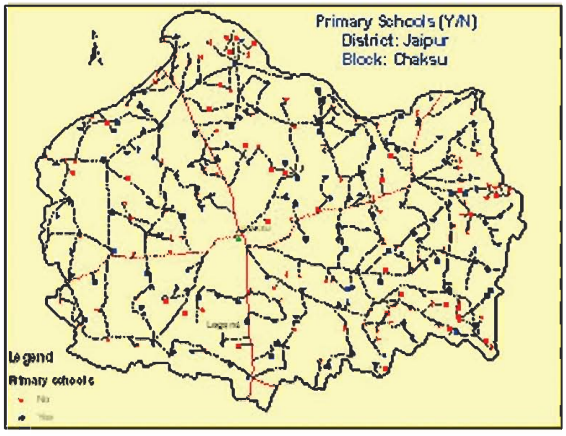

Fig. 3 Spatial Distribution of Primary schools.

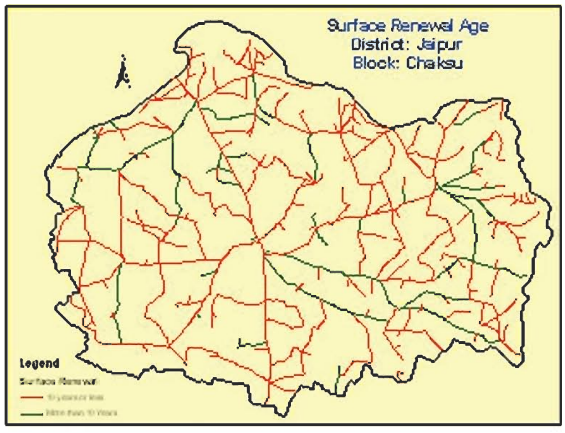

Fig. 4 Symbolizing surface renewal age.

8. 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.

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