ROAD INFRASTRUCTURE MAPPING FOR RI BHOI DISTRICT OF MEGHALAYA

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ABSTRACT:

Development of infrastructure has not yet picked up due to variety of reasons in the states of North Eastern Region of the country. Because of inadequate road connectivity, particularly in rural areas, many areas with high development potential remain isolated from the main land and major portion of the common dwellers of these places get deprived of basic facilities like health care, education etc. Roads play an important role in all aspects of development such as agriculture, fishery, health, education, small-scale industries, trade etc. The absence of roads in rural areas leads to the stagnation of socio-economic conditions of the villagers. An up-to-date road information system is the first step towards proper infrastructure building in any state.

This paper conveys the suitability and applications of Geographic Information System (GIS) technology in the development of Road Information System, which will help the planners and administrators to identify the problems associated with rural road development activities, location and provision of appropriate facilities, monitoring and maintenance management of the assets created in the rural areas.

Study has been carried out for Ri Bhoi district of Meghalaya which covers an area of 2448 Sq. Km with a population of 1,92,790 as per 2001 census. The region is still poor in transportation and communication. NH 40 is the only National Highway passes through the district. The district has a total road length of 893.017kms which includes National Highway, State way, Major district road, other district road and Village road. The long distance from main land and bottleneck in transportation has been main causes for low prices of exportable commodities to the other places and high prices commodities coming into the district.

High resolution satellite imagery (IRS PAN + LISS III merged data) along with other existing PWD road maps, land record maps etc. followed by an extensive field survey with GPS have been used for 1:50K scale thematic mapping activities. Query based services like road connectivity between any two points, distance and accessibility (of various amenities from a given isolated place), information bank based on buffering and proximity analysis, route information like shortest route, alternate route etc. in a given area during emergency situation based on network analysis have been incorporated here.

Road Infrastructure mapping developed under ArcGIS Geodatabase environment has efficiency in monitoring, management, planning and subsequent development of the road network in the district.

1. INTRODUCTION

Transportation system facilitates movement of people and goods. They consist of roads, railroads, waterways, and air transportation facilities. Among these modes of transportation, road is the most common and widespread. Indian roads are basically classified as National highways, state highways, district roads (major and minor) and village roads on their dimensions and functional status. India being a developing nation, overall scenario of road infrastructure is not satisfactory. Situation in North Eastern region is even worse being in the most remote corner of the country and due to its geographical location.

There is a wide difference in the development of land use system between hilly terrain like North Eastern region and other plain areas of the country. The absence of roads in these areas because of geographic conditions and other reasons leads to the stagnation of socio-economic conditions of the villagers. Because, quality of life in a settlement very much depends on the level of availability, accessibility and quality of infrastructure it provides. Planning should promote the objectives like accessibility and connectivity to most of the places in the region.

Places in the hilly terrain need to be connected to the marketing centers for promoting transitional changes in socio economic status of people. Hence, the present scenario in the states of North Eastern region warrants a serious thought on planning road network in a scientific way.

Road Infrastructure mapping project for Ri Bhoi district of Meghalaya has been taken up with the objective of creating up-to-date digital database of road connectivity, accessibility along with various public utility services which can enable efficiency in monitoring, management, planning and subsequent development of the road network in the district.

1.1 Transportation scenario in Meghalaya

Meghalaya, the 21st State of India is carved out of Assam in 1970. It is bounded on the North and East by the State of Assam and South and West by Bangladesh. Shillong, the capital of Meghalaya is located at an altitude of 1496 metres above sea level. There are four National Highways NH 40, NH 44, NH 51, and NH 62 in the State having a total length of 606.284 km (Table1).

Sl. no	Road Category	Total (Km)
1	National Highway (NH)	606.284
2	State Highway	1134.225
3	Major District Road	1219.032
4	Other District Road	3080.317
5	Urban Road	194.100
6	Village Road	1641.622
7	Total	7875.580

Table 1. PWD Roads in Meghalaya as on 31st March 2004

N.B.:
1. 186.76 Km NH udder Border Roads Organization is not included in the above table.
2. Considering 186.76 Km NH under BRO, the road density in the state is 35.95 Km/100Sqm. Km.

The state is still poor in transport and communication facilities and still 50-75% of the villages are yet to be connected.

1.2 Role of GIS in Road Transport Planning

Road Transport related data like road inventory, traffic statistics, construction, maintenance data, etc. need to be organized and integrated properly by using the appropriate technique so that it can be put to maximum use for transportation as well as other purposes. Traditional database system does not allow the user to manipulate, access, and query the database other then in a very limited way. Because, traditional database fails when spatial entity are associated with the non-spatial attributes. This is a key factor for applying GIS technology as a tool in supporting road network planning.

The main benefit of using the GIS is not merely the user-friendly visual access and display, but also the spatial analysis capability and the applicability to apply standard GIS functionalities such as thematic mapping, charting, network-level analysis, simultaneous access to several layers of data and the overlayment of same, as well as the ability to interface with external problems and software for decision support, data management, and user-specific functions.

1.3 Objectives of the Study

The objectives of this study are identified as follows:

1. Preparation of atlas of National highway, state highway, major and minor district roads, village roads.
2. Preparation of location specific GIS maps for various public utility services such as educational institutes, hospitals, community health centers, bus terminus and stops, airport etc. showing connectivity and accessibility.
3. Query based services based on buffering and proximity analysis, route information like shortest route, alternate route etc. based on network analysis during emergency situation like natural disaster, movement of civil authorities during election etc.
4. To provide information system for monitoring, planning, management etc. of Road network.

2. STUDY AREA

Study has been carried out for Ri Bhoi district of Meghalaya which covers an area of 2448 Sq. Km with a population of 1,92,790 (2001 census). Ri Bhoi District is one of the Seven Districts of Meghalaya, carved out from the East Khasi Hills District on 4th June 1992. The Headquarter of the District is at Nongpoh located at 53 km away from the state capital Shillong and 50 km from Guwahati. The Headquarter of the District is connected to the state capital, Shillong and Guwahati by NH40 of 53 km and 50 km respectively. The nearest railway station and airport are situated in Guwahati. There is an airstrip suitable for small aircrafts at Umroi. Nongpoh is well connected with other major places of the district by motorable roads, but villages in the interior areas are poorly connected and transport services are not adequate.

2.1 Road Network in Ri Bhoi District

State PWD has maintained total of 893.017 km PWD roads (Table 2) in the Ri Bhoi district under three PWD divisions; Nongpoh, Umsning and NH Shillong. There are two PWD state highways, Umrit-Ranigodown road (30.000km) and Umsning-Jagi road (80.000km) of total length 110km passing through the district. Abstract of road register for Ri Bhoi district of Meghalaya PWD (Roads) as on 13-03-2004 is given in the following table.

Sl. No	Road Category	Total length (km)
1	National Highway (NH)	65.000
2	State Highway (SH)	110.000
3	Major District Road (MDR)	96.250
4	Other District Road (ODR)	549.209
5	Village Road (VR)	72.558
	Total	893.017

Table 2. Abstract of Road Register, PWD for Ri Bhoi district

2.2.1 State PWD Roads

State PWD has maintained total of 893.017 km PWD roads (Table 3.1) in the Ri Bhoi district under three PWD divisions; Nongpoh, Umsning and NH Shillong.

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3. METHODOLOGY

High-resolution satellite images from Indian Remote Sensing Satellite (IRS-P6) forms the core of the 1:50K mapping of road infrastructure. Necessary spatial layers such as road network, drainage network, settlements, and land use land cover were generated from remote sensing, topographic maps and PWD road maps. The GIS techniques have been used to prepare and analyse spatial layers. The overall methodology adopted for the study is given in Figure 1.

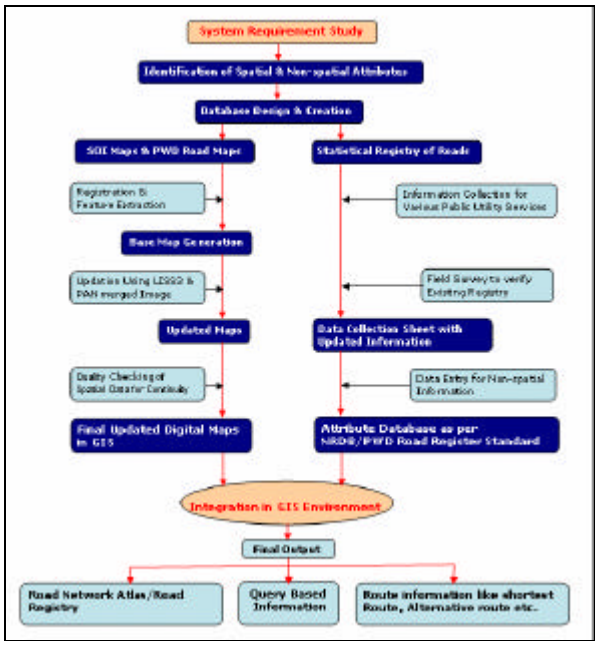

Figure 1. Methodology- various process and their linkages

3.1 Data used

Data used for the study are divided into three categories. They are:

1. Spatial data
2. Non-spatial data and
3. Field Survey

3.1.1 Spatial data:

1. Remote Sensing Data
2. Topographic maps (1975)
3. Land Record maps/PWD road maps

Remote Sensing Data: High resolution satellite images from Indian Remote Sensing Satellites formed the core of the 1:50K mapping activity. Merged data [IRS-1D PAN (2004) + IRS-P6 LISS 3 MX (2004)] with a spatial resolution of 5.6m used for the updation of base maps like transportation network, drainage, settlements etc. IRS-P6 LISS 3 data with a spatial resolution of 23.5m was used for the preparation of Land Use Land Cover map.

Topographic Maps: SOI topographic maps (1975) of 1:50,000 scale have been used for the preparation of base maps for obtaining base line information such as transportation network, drainage, settlements etc. for the entire study area.

Land Record/PWD road maps: Recent land record maps along with SOI topographic maps have been used for the delineation of administrative boundaries. PWD road map (2004) is used for the updation of base map.

3.1.2 Non-spatial data:

1. Census data (2001)
2. Socio-Economic data
3. Road statistics

Census Data (2001): Demographic related data have been collected from Census 2001.

Socio-Economic Data: Socio-Economic data have been collected from various sources. It includes demographic profile, amenities like public utility services such as health, education, transport facilities, communication linkages, social infrastructure etc.

Road Statistics: Road Register (2004) of Meghalaya has been collected from PWD (Roads), Government of Meghalaya. It contains attribute informations such as referencing (name, route ID), geometry (alignment, median width, section length etc.), Category (National High way, State High way, Major District Road, Other District Road, Urban Road, Village Road etc.), maintenance status etc. for each individual road.

3.1.3 Field Survey: Extensive field survey was carried out for the entire study area. All the existing roads of Ri Bhoi district have been surveyed in the field with the help of GPS to map their alignment, surface types etc. GPS reading (point information) has been taken for various public amenities like Education, Health, Post Office, Fire Service, Police Station and Places of Interest etc.

3.1.4 Integration of Spatial and Non-spatial Attributes: Integration of spatial and non-spatial information has been done under ArcGIS Geodatabase environment.

3.2 Network analysis

In this project, we have incorporated Proximity analysis, Network analysis into our geo-database which allows us to solve common network problems, such as finding the least cost route or alternate route, finding the closest emergency facility and also kept provision for Spatial modeling for site suitability and new alternate route analysis.

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Geo-database- Road Infrastructure				
Feature datasets	**Feature classes**	**Sub-type attribute**		**Topology**
Road Network	Road	Category	National Highway	**Line**
			State Highway	
			Major District Road (M)	
			Other District Road (M)	
			Other District Road (UM)	
			Urban Road (M)	
			Village Road (M)	
			Village Road (UM)	
			Pack Track in Hills	
			Cart Track in Hills	
			Foot Track in Hills	
	Location	--		**Point**
Drainage Network	Drainage	Category	Perennial River	**Line**
			Dry River	
Utility	Education	Category	College	**Point**
			Higher Secondary School	
			Upper Primary School	
			Lower Primary School	
	Health		Hospital	
			Community Health Centre	
			Primary Health Centre	
			Primary health Sub-centre	
	Post Office		--	
	Fire Service		--	
	Police Station		--	
Tourist	Places of Interest	Category	Park	**Point**
			Resort	
			Lake	
			Other	
Land Use Land Cover	Land Use Land Cover	--		**Polygon**
M- Metalled road; UM- Unmetalled road				

Figure 2. Database Creation

3.3.1 Route analysis

Creating a route can mean finding the quickest, shortest, or most scenic route, depending on the impedance chosen. If the impedance is time, then the best route is the quickest route. Hence, the best route can be defined as the route that has the lowest impedance, or least cost, where the impedance is chosen by the user. Any cost attribute can be used as the impedance when determining the best route.

Routing analysis for finding shortest or alternate route has the following main components:

Route analysis layer: It stores all the inputs, parameters, and results of route analysis.

Network locations for route analysis: Stops and Barriers are the network locations used for route analysis.

Route analysis parameters: Mainly impedance, Restriction and direction are the route parameters set for set for route analysis.
Directions: It displays turn-by-turn directions and maps with the impedance after the generation of a route in route analysis and closest facility analysis. If the impedance is set to length, then it will give each individual length for each segment of the route.

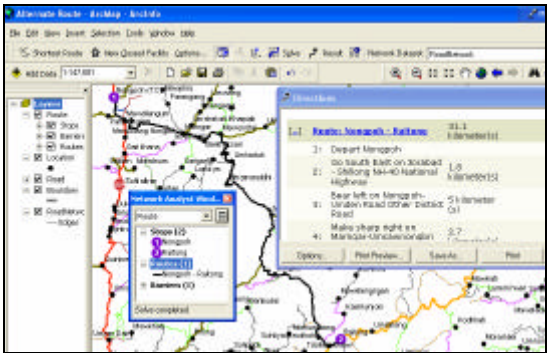

Figure 3. Alternate route between Nongpoh and Raitong

3.3.2 Finding Closest Facilities

When finding closest facilities, we can specify how many to find and whether the direction of travel is toward or away from them. Once we have found the closest facilities, we can display the best route to or from them, return the travel cost for each route, and display directions to each facility. For instance, we can set up a closest facility problem to search for hospitals within a 20km distance of the site of an accident. The hospitals are referred to as facilities, and the accident is referred to as an incident.

Main components of closest facility analysis are:

Closest facility analysis layer: it stores all the inputs, parameters, and results of closest facility analysis. It has four main components; Facilities feature layer, Incidents feature layer, Barriers feature layer and Routes feature layer. Facilities feature layer stores the network locations that are used as facilities in closest facility analysis. Incidents feature layer stores network locations used as incidents for closest facility analysis. The Incidents feature layer behaves in the same manner as the Facilities feature layer. Barriers are used in closest facility analysis to denote points where a closest facility route cannot traverse. Routes feature layer stores the resultant paths of the closest facility analysis.

Network locations for closest facility analysis: Facilities, incidents, and barriers are the network locations used in closest facility analysis.

Closest facility analysis parameters: Route analysis parameters can be used for finding out closest facility.

3.3.3 Provision for Spatial Analysis

Geo-database developed for Road infrastructure mapping has a provision for spatial analysis for various user specific spatial queries such as “Where is the best location for a new facility?” or “What is the least costly path from A to B?” or “what will be the new alternate route for construction from A to B?” etc.

Road Infrastructure mapping project for Ri Bhoi district of Meghalaya has been taken up with the objective of creating up-to-date digital database of road connectivity, accessibility along with various public utility services which can enable efficiency in monitoring, management, planning and subsequent development of the road network in the district.

4. RESULTS AND DISCUSSION

Total area considered for the study is about 2448 Sq. Km, which has a total PWD road length of 893.017 Km (as per PWD road register, as on 31 March '06) of 36.480 Km/100 Sq. Km. road density.

4.1 Road Network

PWD ROADS				
Sl No	Road Category	Metalled road (KM)	Unmetalled road (KM)	Total length (KM)
1	National Highway (NH)	71.284	--	71.284
2	State Highway (SH)	109.699	--	109.699
3	Major District Road (MDR)	84.887	8.355	93.242
4	Other District Road (ODR)	277.354	199.964	477.318
5	Village Road (VR)	22.626	44.612	67.238
Total		**565.850**	**252.931**	**818.781**
OTHER ROADS				
1	National Highway (NH)	--	--	--
2	State Highway (SH)	--	--	--
3	Major District Road (MDR)	--	--	--
4	Other District Road (ODR)	69.504	142.723	**212.227**
5	Urban Road (UR)	3.815	--	**3.815**
6	Village Road (VR)	108.981	376.714	**485.695**
Total		**182.300**	**519.437**	**701.737**
Total of PWD roads and OTHER roads				**1520.518**
TRACKS				
	Pack Track in Hills	--	100.070	100.070
	Cart Track in Hills	--	142.687	142.687
	Foot Track in Hills	--	259.915	259.915
Total				**502.672**
Grand total				**2023.19**

Table 4. Abstract of overall Road Network

1. District has a total of 1520.518 Km road lengths with 62 Km/100 Sq. Km. road density (including OTHER roads).
2. Out of 893.017km PWD roads (as per PWD road register, as on 31 March '06), 818.781 km PWD roads have been mapped under this study (Table 4). Rest 74.236 Km PWD roads could not be identified due to lack of information and this may be solved.

Sl No	Road Category	As per PWD Road Registry (Km)	PWD roads as per the study (km)	OTHER roads (Km)
1	National Highway (NH)	65.000	71.284	-
2	State Highway (SH)	110.000	109.699	-
3	Major District Road (MDR)	96.250	93.242	-
4	Other District Road (ODR)	549.209	477.318	212.227
5	Village Road (VR)	72.558	67.238	485.695
6	Urban Road (UR)	-	-	3.815
	Total	**893.017**	**818.781**	**701.737**

Table 5: Comparative results with PWD Road Registry

3. More than 69% of the PWD roads are black topped surfaced and well maintained. But, both the State Highways Umrit-Ranigodown Road and Umsning - Jagi Road passing through the district need to be upgraded. Physical condition of State Highway Umsning - Jagi connecting Umsning and Jagirod of Assam is not at all satisfactory, because major portion of the roads are damaged due to severe land slides in those areas.
4. Apart from PWD roads, district has about 701.737 Km roads (Table 5) under OTHER roads category (i.e. roads constructed & maintained by other organizations like MeSEB, NEPCO, etc. or local roads in the villages) but more than 74% of the roads are either Kutcha roads or Graveled roads.
5. Total lengths of 502.672 km tracks (Foot track, Pack track and Cart track) are available, which is about 24% of total road and track lengths (2023.19 Km) in the district (Table 4).

4.2 Infrastructure Connectivity

Table 6 shows connectivity & accessibility of various public amenities by existing Road Network. For example, 6 nos. of medical facility centers are across the National Highway, whereas 45 nos. of education facility centers in the district are connected to the villages by foot track, cart track or pack track.

Facility	Connectivity by various Road Category					
	NH	SH	MDR	ODR	VR	*Others
Health	6	5	4	13	4	Nil
Education	25	17	27	162	102	45
Post office	7	4	3	9	5	1
Police station	5	2	2	1	1	Nil
Fire service	3	Nil	Nil	Nil	Nil	Nil

Table 6: Infrastructure connectivity

N.B. *Others roads include foot track/pack track/cart track only.

1. Though district has a good connectivity and accessibility to the various public amenities such as health, post office, police station, fire services etc., but still 11.9% of total education institutes are accessible by foot tracks only.
2. Medical facilities are well accessible as compared to Education facilities in the district.
3. Major portion (48.8%) of the district education centers are across the Other District Roads and most of the roads are Black topped surfaced.

5. CONCLUSION

Road infrastructure mapping developed for Ri Bhoi district of Meghalaya facilitates user friendly GIS environment in which the data for numerous planning purposes can be integrated. It is also useful for creation, maintenance and accessing the GIS database. Road network database is purely dynamic in nature; it has to be updated from time to time with recent information. The developed database can be further supplemented with new information as and when it is available.

It can serve as an efficient tool for decision making with respect to any rural development programme. Various value added services such as query capability like road connectivity between any two points, distance and accessibility (of various amenities from a given isolated place), information bank based on buffering and proximity analysis, route information like shortest route, alternate route etc. in a given area during emergency situation based on network analysis, site suitability for construction of new infrastructure based on spatial analysis etc. have been incorporated here. It can also help concerned departments for day-to-day management of their road network. Statistics of all the roads can be drawn from the GIS based Road registry prepared as per PWD standard which can helps in categorize and classify the roads. The achievements in the fields of roads construction over the years can be drawn from this registry.

This study has confirmed the need for road network planning in the district in an organized manner and this is the first step towards the development of the district. Road Infrastructure mapping developed under GIS environment has efficiency in monitoring, management, planning and subsequent development of the road network in the Ri Bhoi district.

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