Applications of Geographical Information System in Transportation Planning (A Case Study of Nagda, Madhya Pradesh)

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Abstract— **Understanding the basic concept of GIS is a great start of the literature to allow those who don't longer have an idea about GIS to understand what GIS is and what are its application in Transport Planning to deal with the issues of how GIS can be further developed and enhanced in order to meet the needs of transportation applications. GIS-T applications is interdisciplinary in nature and has many possible applications addressing real-world problems.**
The contribution and the practical application of GIS in transportation field is reviewed through two case study. The case study is local to show to which extent GIS application is used in transportation sector in Nagda under AMRUT Mission. The case study is followed by a conclusion of the main findings of study that how transportation issues has been resolved using GIS application.
As a result, there is a broad application of GIS in transportation. On the other hand, there is a lot of value to GIS that is not yet being fully explored in transportation analysis and planning.

Index Terms— **GIS, GIS-T, Transportation Planning, AMRUT, Open Street Map, Vector and Raster data, Geospatial data.**

I. INTRODUCTION

The GIS is one of the maximum modern advances in the study of geography. Since its development in the 1970s, GIS has had a major impact on geographic evaluation and on commercial enterprise practice in government and the private sector. At a broad level, a geographic information system (GIS) is a system specializing in the input, management, evaluation, and reporting of geographical (spatially associated) records. They have transformed and expanded geography through their ability to store huge quantities of data, analyse it and in particular by depicting custom designed cartographic outputs.
The transport sector is one of the backbones of a country's financial system. It's through transport structures that goods and people can circulate as they move approximately their social and monetary activities. Automation of maximum tasks has been witnessed not most effective in industries but also in transport.
Most transportation corporations now use GIS and Geospatial Information Systems for Transportation (GIS-T) is one in every of the most important customers of GIS generation. The large innovation that GIS provides is the ability to control statistics spatially in layers after which overlay these layers to perform spatial analyses. Therefore, a roads layer may be included with a land use layer enabling a buffer evaluation of the land makes use of within a given distance of the road.

II. GIS (GEOGRAPHICAL INFORMATION SYSTEM)

The Department of the Interior of the United States defined the following treatment approaches to architectural conservation:

Like the field of geography, the term Geographic Information System (GIS) is difficult to define. It represents the integration of many subject areas.

A broadly accepted definition of GIS is the one provided by the National Centre of Geographic Information and Analysis: "a GIS is a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modelling, representation and display of geo-referenced data to solve complex problems regarding planning and management of resources" (NCGIA, 1990). Functions of GIS include: data entry, data display, information control, statistics retrieval and analysis.

A more comprehensive and easy way to define GIS is the one that appears at the disposition, in layers (Figure 1), of its data sets. "Group of maps of the same portion of the territory, wherein a given region has the identical coordinates in all of the maps covered within the device". This way, it is possible to analyse its thematic and spatial characteristics to achieve a higher knowledge of this region.

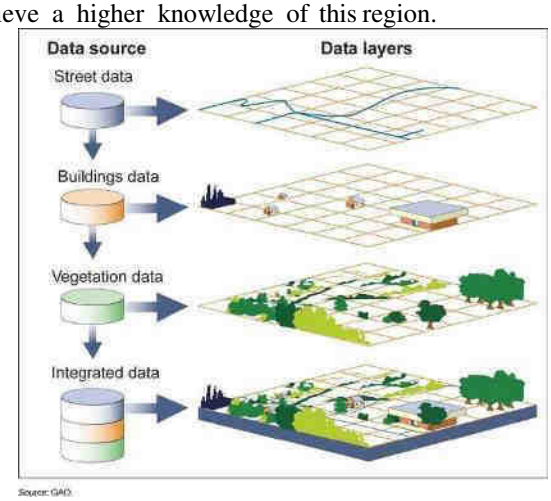

Figure 1 The Concept of Layers (GIS)

A. GIS Applications

1. *Mapping Locations:* GIS can be used to map locations. GIS allows the creation of maps through automated mapping, data capture, and surveying analysis tools.

2. *Mapping Quantities:* People map quantities, like where the most and least are, to find places that meet their criteria and take action, or to see the relationships between places. This gives an additional level of information beyond simply mapping the locations of features.
3. *Mapping Densities:* While you can see concentrations by simply mapping the locations of features, in areas with many features it may be difficult to see which areas have a higher concentration than others. A density map lets you measure the number of features using a uniform areal unit, such as acres or square miles, so you can clearly see the distribution.
4. *Finding Distances:* GIS can be used to find out what's occurring within a set distance of a feature.
5. *Mapping and Monitoring Change:* GIS can be used to map the change in an area to anticipate future conditions, decide on a course of action, or to evaluate the results of an action or policy.[1]

III. TRANSPORTATION PLANNING

Transport making plans is described as planning required inside the operation, provision and management of centers and offerings for the modes of transport to attain safer, faster, comfy, convenient, low cost and environment-pleasant movement of human beings and goods.
Under transportation planning, specific practices which include urban development, urban transport policies, legislative activities, funding bodies and project management come collectively. It includes diverse agencies and corporations for successful transportation planning, [7].

IV. GIS IN TRANSPORTATION

The application of GIS has relevance to transportation due to the essentially spatially distributed nature of transportation associated data, and the need for various forms of network stage evaluation, statistical analysis and spatial analysis and manipulation. Most transportation influences are spatial. At GIS platform, the transport network database is generally prolonged via integrating many sets of its characteristic and spatial statistics via its linear referencing system. Moreover, GIS will facilitate integration of all other socio- economic statistics with transport network database for wide variety of planning features.

The essential benefit of using GIS is its potential to get right of entry to and analyse spatially distributed facts with recognize to its actual spatial region overlaid on a base map of the vicinity of insurance that permits evaluation no longer possible with the opposite database management structures. The main advantage of using the GIS isn't simply the person-pleasant visible get entry to and show, however also the spatial evaluation capability and the applicability to use standard GIS functionalities along with thematic mapping, charting, simultaneous access to numerous layers of data and the overlayment of identical, as well as the ability to interface with external programs and software for decision support, facts management, and user specific functions.

In a large sense, a geographic information system (GIS) is an data gadget specializing in the input, management, analysis, and reporting of geographical (spatially related) facts. They have transformed and expanded geography by using their ability to save huge amounts of information, analyse it and especially via depicting customized cartographic outputs. Among the extensive variety of capability packages GIS may be used for, transportation issues have acquired loads of interest considering that they are at the same time fairly depending on visualization and analytical techniques. A particular branch of GIS applied to transportation troubles, commonly labelled as GIST, is one of the pioneer GIS utility area.

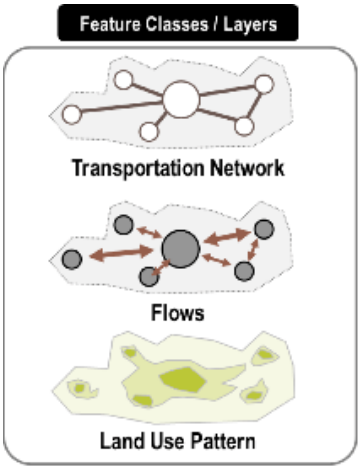

Figure 2 Geographic Information System and Transportation (Source- GIS-T [1])

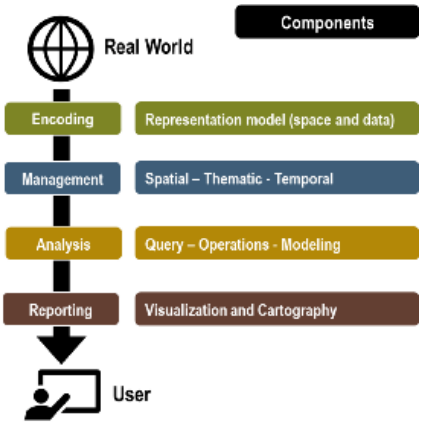

Figure 3 Geographic Information System and Transportation (source-GIS-T [1])

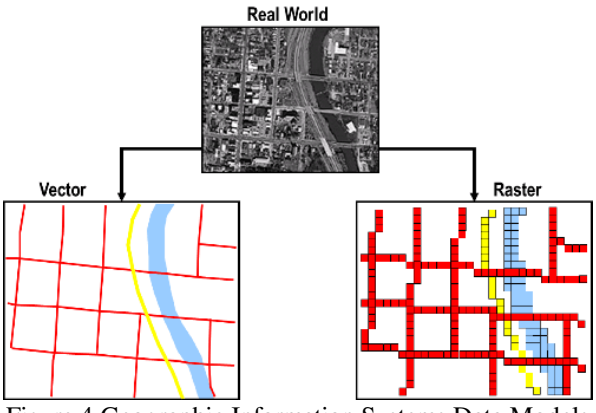

Figure 4 Geographic Information Systems Data Models (Source- Geographic data models)

GIS-T research can be approached from two different, but complementary, directions. While some GIS-T research focuses on issues of how GIS can be further developed and enhanced in order to meet the needs of transportation applications, other GIS-T research investigates the questions of how GIS can be used to facilitate and improve transportation studies. In general, topics related to GIS-T studies can be grouped into three categories:

A. Data Representations: How various components of transport systems are represented as a database, which involves the network and as well as technical and operational characteristics (capacity, speed).
B. Analysis and modelling: How transport methodologies can be used to represent real-world transportation activities.
C. Applications: What types of applications are particularly suitable for the data and analytical capabilities of GIS-T.

V. LIST OF APPLICATIONS OF GIS IN TRANSPORTATION

A. *Highway Maintenance:*

Study of satellite images suggest the vital area which might be experiencing challenges. Various maps also are availed by means of GIS digitally, Information approximately motorway structures can be feed into GIS databases and accessed from any location.

B. *Accident Analysis:*

CCTV in maximum towns and cities, as well as satellites imaging services, is easy to integrate with GIS. Location addressing is used to raise the alarm to accident emergency responders to provide assist. GIS can act as a supply of a report within the occasion of an accident.

C. *Traffic Modeling:*

GIS has provided extraordinary solutions on traffic management for the exceptional large avenue networks to be had in towns and cities. This has proved to ease congestion by using as best the first- rate designs of road, rail and air are built.

D. *Route Planning:*

Road and rail engineers need to navigate avenue or rail routes via the shortest and maximum efficient paths. Efficient, relaxed, and shorter paths should, therefore. All such tasks for infrastructure is done by GIS. It`s additionally easier to come with path designs and fashions with the usage of GIS.

E. *Transport Safety Management:*

Junctions may have integration with GIS for higher signaling of drivers and those trying to crossroads or maybe railway crossing factors. Places taken into consideration to be black spots and prone to injuries also are studied the usage of GIS to decide the reasons of accidents. This is for that reason very useful to any country.

VI. GIS-T ANALYSIS AND MODELING

GIS-T applications have benefited from many of the standard GIS functions (query, geocoding, buffer, overlay, etc.) to support data management, analysis, and visualization needs. Like many other fields, transportation has developed its own **unique analysis methods and models**. Examples include:

- Shortest path and routing algorithms (e.g. traveling salesperson problems, vehicle routing problem).
- Spatial interaction models (e.g. gravity model).
- Network flow problems (e.g. minimum cost flow problem, maximum flow problem, network flow equilibrium models).
- Facility location problems (e.g. p-median problem, set covering problem, maximal covering problem, p-centers problem).
- Travel demand models (e.g. the four-step trip generation, trip distribution, modal split, traffic assignment models, and activity-based travel demand models).
- Land use-transportation interaction models.

While the basic transportation analysis strategies (e.g. Shortest route locating) can be found in maximum industrial GIS software program, other transportation analysis procedures and models (e.g. Journey demand models) available only best selectively in some business software packages. Fortunately, the thing GIS layout approach adopted by GIS software program corporations offers a better environment for knowledgeable GIS-T users to broaden their own custom evaluation strategies and models.

It is critical for both GIS-T practitioners and researchers to have a radical understanding of transportation analysis techniques and models. For GIS-T practitioners, such expertise can assist them examine special GIS software products and choose the only that best meets their needs. It can also assist them select suitable analysis features to be had in a GIS package deal and well interpret the analysis outcomes. GIS-T researchers, alternatively, can observe their knowledge to assist improve the design and evaluation talents of GIS-T. Due to the increasing availability of tracking records that includes both spatial and temporal elements, the improvement of spatio-temporal GIS analysis functions to assist higher apprehend the dynamic movement and routing patterns has attracted enormous research attention.

VII. CASE STUDY

DEVELOPMENT OF NAGDA UNDER AMRUT MISSION

A. Introduction

Nagda is a mid-size metropolis in Malwa place of Madhya Pradesh. Major towns that are close to Nagda are Ujjain, Indore, and Ratlam. It is situated on the bank of river Chambal and world's biggest manufacturer of spun-dyed specialty fiber. Moreover, India's largest caustic soda unit, Grasim's unit is in Nagda. Addition to this, there are numerous other plant life – a Thermal Power Plant, Chemical Plant and others which make Nagda a clearly industrial metropolis. Apart being

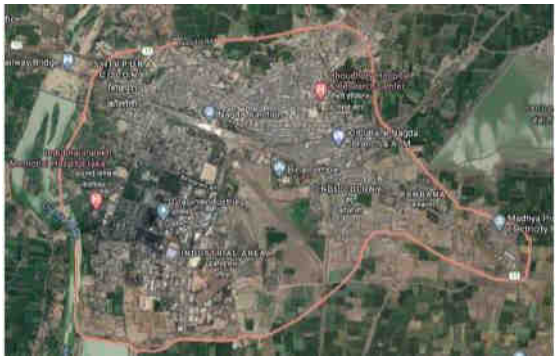

Figure 5 Satellite Image of Nagda [Source - Google Earth]

Nagda is a major ISO granted Railway Junction at the Delhi–Mumbai railway line. It is precisely 694 km from both Delhi and Mumbai. Currently there is no public shipping like AICTSL OR BRTS. Auto Rickshaw is a magic provider for all small distance tour. Devi Ahilya Bai Holkar International Airport, The nearest airport is positioned in Indore approximately a hundred and ten km from the town.

B. Travel Demand Planning

As in any transportation making plans examine, transportation planning in Nagda employs travel call for modelling method primarily based on production and enchantment of journey between activity areas. Trip Distribution Models are used to examine the regional travel traits. Since activities are primarily based on a community of roads and projects, GIS is used in illustrating and manipulating the evaluation of outcomes. GIS is used in modeling activities for long and brief range planning network preservation and updating.

C. Network Maintenance and updating

Nagda's Municipality has adopted various GIS engines (software) no matter carriers considering they function a so-known as open system, GIS via localized database. Due to its compatibility, this absolutely enabled various making plans departments to use it. In GIS, a hyperlinks attribute table, which contains links, characterized is attached to the network map. an commercial metropolis, it also holds historic sizeable values.

Using the GIS functionality of displaying the community attribute table at the side of a graphic display, link attributes may be corrected and updated. In addition, effects of tour call for evaluation are attached and stored within the network attribute tables, which include a link's modeled volume, speed, and impedance. As needed, colored maps of the roadway network displaying the exclusive kinds of information illustrating spatial relationships, temporal modifications in travel needs, or locating centers based totally on magnificence, range of lanes, congestion and speed.

D. Dynamic Segmentation and Networking

In order to determine the spatial attributes of undertaking proposed for inclusion within the short range planning (SRP), GIS is used to develop a map of projects, which highlights every group of tasks, through type. Any of the 3 major GIS packages could have dynamic segmentation capability to generate a route for arc sections helped in identifying initiatives where the undertaking limits does now not cease at a node. This solved the trouble of getting a limited ability in depicting projects correctly on the street network. Dynamic segmentation additionally permits for representing overlap projects, which in part or completely proportion the same street section.

E. Buffer Analysis

Using GIS, Buffers are created round each venture representing the impact area. In GIS, the links placed within the venture's effect region (buffer) can be captured, then, travel timesaving can be calculated from the difference in time, before and after the projects construction. This manner involves incorporating the travel demand for analysis facts into the attribute file, which is transferred from GIS to a records base software (i.e., Access, Oracle etc.) to undertake the calculations required. The advantages of GIS on this technique is that it allowed for generating the buffers required for each person projects and identity of the extraordinary roads located within the impact vicinity. Figure 5 indicates the road network for the town of Nagda.

F. Deficiency Analysis

The deficiency evaluation method is utilized to focus on streets where call for exceeds ability. GIS is utilized in identifying deficient centers. Incorporating the link volumes on account of the travel demand forecasting into the network attribute table in GIS. Using GIS statistics functionality, the connection between the link's potential and the forecasted volume can be calculated. Links are then coloured based upon the severity of call for to capacity ratio and offered on maps. These maps can be the premise for identifying roadways that require improvement to house destiny call for.

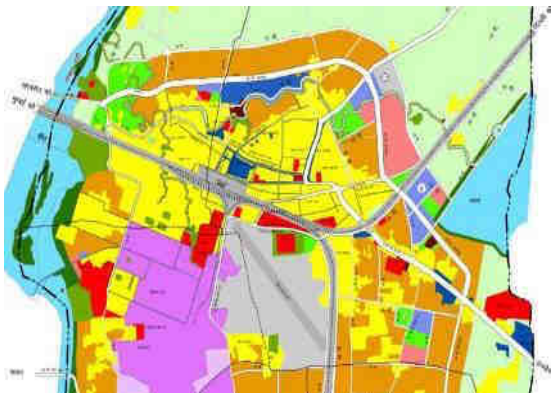

Figure 6 Transportation network for Nagda with Landuse [source: TNCP, Bhopal]

Figure 7 Open Street Map, Nagda

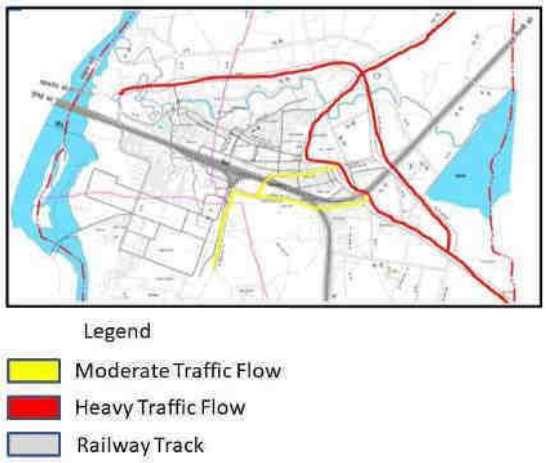

Figure 8 Observation of Traffic flow at Nagda [source: TNCP, Bhopal]

From the above figure (figure 5) it was evident that GIS in its tracking road Improving communication of GIS-T programs and exchanging information about what is happening in the GIS-T sector. deficiencies led to the conclusion that the major highway Unhel road and Ujjain bypass recorded the heaviest traffic. This was based on the observed data, which was linked to a database that enabled the researcher to manipulate it based on the road capacities. Grasim road indicated a more moderate to heavy road deficiency. The rest of the roads were mainly on the tolerable side.

CONCLUSION

The deployment of GIS applications in transportation planning has been taking its way in the transportation all over India, particularly in AMRUT cities. GIS packages have been used in all AMRUT cities municipality and its sub-municipalities. From the case study of Nagda the conclusion leads to the observation of traffic flow of the Town and as per the observed data which region should focused for traffic modelling, route planning, maintenance and safety measures.

Nagda employs travel call for modelling method primarily based on production and enchantment of journey between activity areas. Trip Distribution Models are used to examine the regional travel traits, Using GIS, Buffers are created round each venture representing the impact area. It was evident that GIS in its tracking road Improving communication of GIS-T programs and exchanging information about what is happening in the GIS-T sector.

AMRUT Mission is a great platform for development of infrastructure of cities on GIS platform and GIS application do have major role in the transportation planning process in India. GIS not only display these transport structures throughout creation however also gives surveillance and visualization of site visitors after they may be constructed.

These abilities of GIS permit transit groups to geo- reference their transportation routes, stops, time factors, and other features to a digital avenue centreline report, and hold all these records in synch.

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