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Application of GIS in Transit Planning - A Case Study of Kakinada City

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Abstract*— *In today's highly dynamic and complex world, information has become a critical resource for effective and efficient management of different organisations. Information technology in its various forms is enabling organisation to churn raw data into meaningful information for effective decision-making. In this era of information technology GIS has emerged as a versatile tool.

GIS is a particular coordinated arrangement of hardware, programming and technique designed to help capture, management, control, investigation and show of spatially referenced information for tackling complex arranging and the board issues. It has been utilized for coordination of spatially and non spatial information. It very well may be connected to different services that are reliant on network like water supply, Power supply, sewage, and so on. So it could be of extraordinary assistance for transportation, engineering and arranging additionally a nation's transportation framework speaks to improvement of the nation. And yet, profoundly created nations are facing higher issues of transportation management and spending lots of currency and exertion for tackling those issues.

Developing traffic congestion, the need to save nature and the issues of road security are the primary explanations behind numerous urban communities worldwide to consider new activities in public transit systems. The complexities of structure and working the transport system proficiency and securely have out-stripped the capacity of past experience and professional judgment alone to give arrangements. In the event that a nation is to fulfill the transport infrastructure prerequisite in consonance to its formative pace, decisions must be founded on a progressively solid, updated, relevant, effectively available and affordable data. Better data does not guarantee exact decision making capability but its absence definitely precludes it. The purpose of GIS to a diverse range of troubles in transportation engineering is now well recognized.

The main aim is to provide good Transit facilities to the citizens which could maintain a healthy transit system in a economic way. There can be lot of advancements in the system but it have to be carried in stages according to the availability of resources and system should be updated according to the situations.

The main objective is

•To assess the ampleness transport routs and transport stops for the residents of the district. This is controlled by creatingbuffer zones around the sides of the streets on account of the transport routes and around given points on account of transport stops.

•To prescribe change plans to specific routes or stops relying upon the degree of adequacy in the two facilites. It is pointed that the level of a land-use cover inside certain cushion zones in the area can help in deciding the acknowledgment or the dismissal of two suppositions identified with such an adequacy.

For the study area Kakinada which was located in East Godavari dist. of Andhrapradesh. The city falls under co-ordinate system 16°57'N Latitude and 82°15'E Longitude.

Key words: GIS, Transit Planning, Kakinada City, Information Technology, Transportation Engineering,

I. INTRODUCTION

A. *General :*

A nation's transportation organization represents growth of the nation. But at the same time, highly developed nations are facing upper troubles of transportation management and expenditure lots of currency and attempt for solving those issues. Increasing traffic congestion, the need to conserve the environment and the troubles of road protection are the main reasons for many cities universal to consider new initiative in community transit systems.

The complexities of construction and in service the transport system effectiveness and safely have out-stripped the ability of past experience and trained judgment alone to provide solutions. If a nation is to satisfy the transport transportation condition in consonance to its developmental pace, decisions must be based on a more dependable, efficient, relevant, simply accessible and affordable data.

The purpose of GIS to a diverse range of troubles in transportation engineering is now well conventional.

Because of the varying nature of GIS and the rapid growth of associated discipline, many definitions of this technology exist. Burrough has distinct GIS as an organised group of computer hardware, programming, geographic data and personnel designed to professionally capture, store, update, manipulate, analyse and display all forms of geographically referenced data. It is a useful definition because it addresses functionality as well as components. Traffic and transportation problems in medium sized cities of many developing countries have become grave matters of concern to the governments. Along with the growing population concentration, the rapid increase in the heterogeneous motor traffic and provision of limited transport infrastructure facilities have become the prime reasons for these problems.

While the problems of larger metropolitan cities are at least taken note of, those of medium sized are not even recorded. A strategic planning of transport systems will alleviate these problems to a greater extent. Transportation planning process consists of analysis of interaction between supply in the form of existing facilities and the demand in the form of traffic load. It also involves forecasting for the future and evaluation of the alternatives arrived at the planning stage.

Information about land use, demographic and economic characteristics, existing travel facilities and travel characteristics is required at various stage of transportation planning process. Transportation planning deals with large amounts of data, which are inherently spatial in nature. The process is data intensive and causes overwhelming resource strain of map and data manipulation. Also the information will be collected and maintained by a variety of public and private agencies and hence, it is very difficult to get the necessary data in time. Tools that facilitate easy storage, maintenance and retrieval of large volumes of graphic/non-graphic data and that permit simultaneous sharing of data by many users will be highly useful for transportation planning.

The major concern of the authorities is efficient operation and management of road network. This requires frequent decision making to tackle various types of problems, which are not always structured. The information on variables such as traffic flow and accident particulars on individual links, total travel, zonal details such as population, employment, etc. are required in decision making process. The data retrieval will be quicker and easier if they are maintained in digital form rather than as records, graphs and pictures on papers. GIS is one of the fastest increasing technologies of present moment. It has emerged as prevailing and difficult means to manage vast amounts of geographic data. It provides a machine by which data on position, spatial communication and geographic association of various conveniences can be assessed and viewed in moments. It provides an chance to effectively view and right to use geographic data and thus to get better choice making process.

B. *Scope:*

The efficiency of Public transit system depends upon selection of proper route.
The two main reasons for undertaking the present study are rapid growth in population and urban sprawl leading to increase of traffic count.

- Ensure the transport system is accessible to all.
- Improve the safety and security of its users.
- Improve the efficiency and cost-effectiveness of the transportation of persons and goods.
- Increase ridership through high-quality, frequent and reliable transit service
- Enhance connections with the region's system of transit ways and regular route bus service.
- Catalyze transit-oriented development along a key commercial corridor.
- Enhance the attractiveness and quality of the urban environment.

The scope of the work is to use the latest techniques of GIS and Remote Sensing to select a optimum route for developing Public transit system in urban area like Kakinada.

C. *Objectives*

This research has the following three main objectives:

- To draw accurate maps showing existing bus routes and bus stops in the study area.
- To evaluate the adequacy bus routes and bus stops for the residents of the region. This is resolute by generating buffer zones around the sides of the roads in the case of the means of transportation routes and approximately given points in the case of transportation stops.

To recommend adjustment schemes to certain routes or stops depending on the level of sufficiency in both amenities. It is aimed that the percentage of a land-use cover within certain buffer zones in the area can help in formative the acceptance or the rejection of two assumptions related to such a competence.

- Relieve traffic congestion and minimize travel times.
- Improve the movement of freight and services.
- Maximize investments in the transportation system from all sources.

II. LITERATURE REVIEW

Planning could be defined as a systematic approach used to analyse and answer social, physical, and economic problems of certain areas. In other words, it is a problem-solving field that deals with factors influencing the quality of life at scales ranging from small localities to large regions. Therefore, planning agencies usually employ several professionally trained planners specialised in different fields including land use, hydrology, housing, economic development, transportation, geographic information system (GIS), and remote sensing. These planners attempt to apply methods of data analysis to explore solutions for community problems and urban issues. In fact, urban planning is one of the main applications of GIS. Urban planners use GIS both as a spatial database and as an analysis and modelling tool. The applications of GIS vary according to different stages, levels, sectors, and functions of urban planning. According to Yeh (1999), the increase in user-friendliness and functions of GIS software and marked decrease in the prices of GIS hardware resulted in GIS becoming an operational and affordable information system for planning. Yeh adds that the main constraints in the use of GIS in urban planning today are not technical issues, but the availability of data, organisational change, and staffing. In an earlier work for him, Yeh (1991) mentioned that GIS is increasingly accessible to planners and is now an important tool for urban planning in developed and developing countries alike. Han (1991) agrees that GIS is one of the formalised

computer - based information systems capable of integrating data from various sources to provide the information necessary for effective decision - making in urban planning. As a toolbox, GIS allows planners to perform spatial analysis using geoprocessing functions such as map overlay, connectivity measurement, and buffering (Berry 1987).Urban planners use GIS for general administration, development (building control, and plan making. The first two of these tasks can be regarded as routine operations usually undertaken on a daily basis. Plan making, on the other and, is undertaken less frequently and is regarded as a strategic planning tool. It requires new local and regional plans to be advised (Longley et al. 1999). Mapping provides the most powerful visualisation tools in GIS. It can be used to explore the distribution of socioeconomic and environmental data, and display the results of spatial analysis and modelling exercises. Spatial analysis and modelling are useful for spatial statistical analysis, site selection, land suitability analysis, and land use transport analysis. According to Yeh (1999), the scale of the planning area covered can range from a whole city, to a sub-region of a city, a district, or a street block.

To date, transportation GIS efforts have focussed on specific applications. Comparatively little attention has been given to the integrative aspect of improving consistency and reducing database redundancy for separate transit applications. In highway applications, guidance in integration is provided by Fletcher's (1987) examples of overlaying linear pavement and other data such as traffic and accident counts. TenEyck, et al. (1989) shows how highway shoulder data can be used with run-off-road accidents to identify problem areas, which can be integrated with proposed expenditures to see whether the problem's will be remedy.

III. STUDY AREA

About Kakinada

Kakinada is a city and a municipal corporation in the Indian state of Andhra Pradesh. It is located 465 kilometres (289 mi) east of the state capital, Hyderabad. It is also the headquarters of East Godavari district. It is nicknamed 'Fertilizer City' (owing to the large concentration of fertiliser plants), 'Pensioner's Paradise' and 'Second Madras'. The city had an urban population of 312,255 in 2011, making it the fourth largest city by area and the sixth largest city by population in Andhra Pradesh. Its urban/metropolitan population is 442,936 of which 217,573 are males and 225,363 are females. The sex ratio of Kakinada city is 1046 per 1000 males. It is spread over an area of 90 km. Kakinada is part of a Special Economic Zone and a proposed 'Petroleum, Chemical and Petrochemical Investment Region (PCPIR)'. It is a hub to all the deep sea exploratory activity in the region due to its deep-water sea port and its proximity to the gas fields.

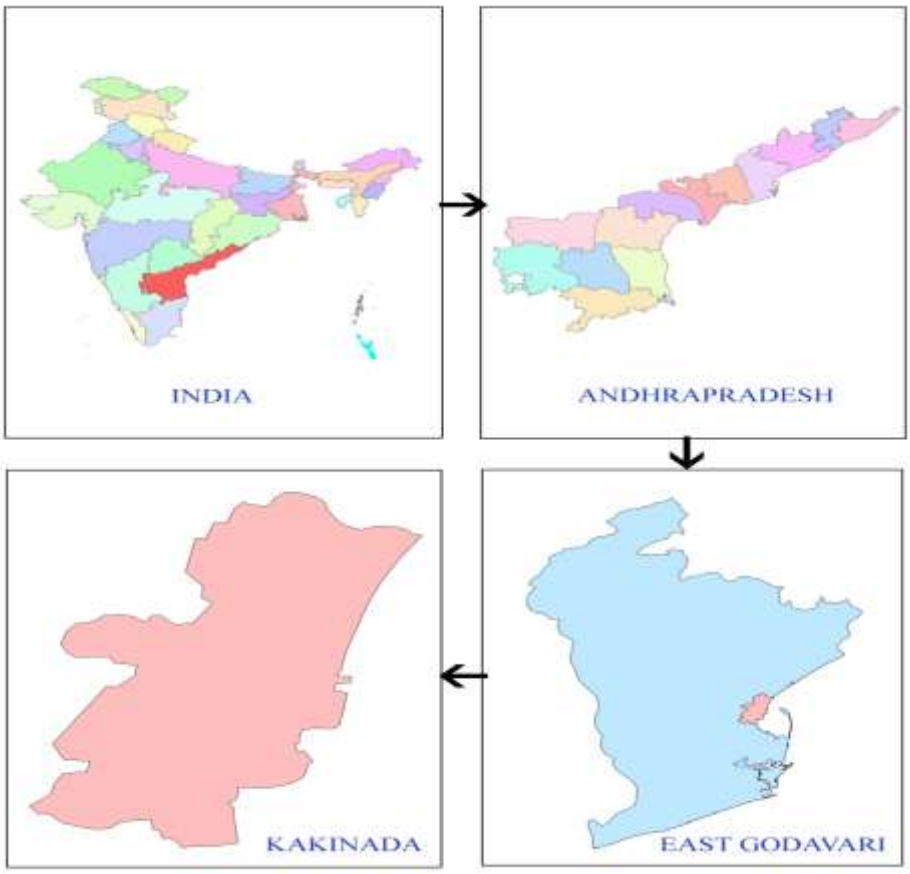


Figure: 3.1 MAP SHOWING THE STUDY AREA

V. METHODOLOGY

The aim of this project is to analyse the present transit situation in the case study area of Kakinada city, India and evaluate the problems that arise due to short comings of the transit system. On the basis of the analysis and related

literature reviews, a model will be proposed that could be able to improve the transit situation. The proposed suggestions for amendments in the system through GIS based model would reduce the traffic problems to some extent.
The methodology includes the collection of information about the transit situations in Kakinada city and preparing a database about the transit situations of the case study area. Analysis of the present traffic situation and recognize the problems faced in the system. This study will include a discussion and a critical analysis of the models. The study analysis will help to learn about the different transit problems their analysis and the way GIS has been used to deal with transit management in different situations. On the basis of the present situation analysis, the data availability of the case study area and the study analysis, the framing of guidelines for the work to be proposed in dealing with transit management planning for the case study area will be carried out. By this method some guidelines for the model will be organized which would be the baseline for the proposed model. In the proposed model the transit management issues are considered to solve some of the present situation problems like private transit system like Autos and Jeeps, traffic problems. Finally the model will be implemented on Kakinada city's case study area data for the analysis and the results will suggest some modification in the existing system which is expected to reduce the traffic problem to a certain extent.
The methodology adopted in this project is put forth through a conceptual model. This would make it more comprehensible to have an idea of the direction flow of the methodology adopted.

A. Conceptual Model

The figure 3.1 is of the conceptual model which demonstrates the methodology adopted for the use of GIS in transit planning in this project. The flow of the model indicates the different steps carried in the methodology adopted for the transit planning proposal. This model was quite helpful to frame the methodology and the flow of this model also suggested the chapters to be included in this project.
The city information is available in four different medium. The information from all these mediums has to be brought on a common platform where they can be linked together with each other. As the information is about the same location, they can be correlated. This will form a complete set of data with both spatial and non spatial information. This would fulfil the basic principle of GIS to relate the information spatially.
There are four means from where the data is available, which are stated bellow;

- The maps containing the spatial information.
- The spatial data, which gives the information about the location of different articles. This spatial information was correlated and later incorporated on the maps. The information was about the location of Educational institutions, Hospitals, Bus stops and other building locations.
- The third is the attribute information. This forms the attribute data giving the information about the spatial elements.

The other information source was through interview, questionnaires and online source.

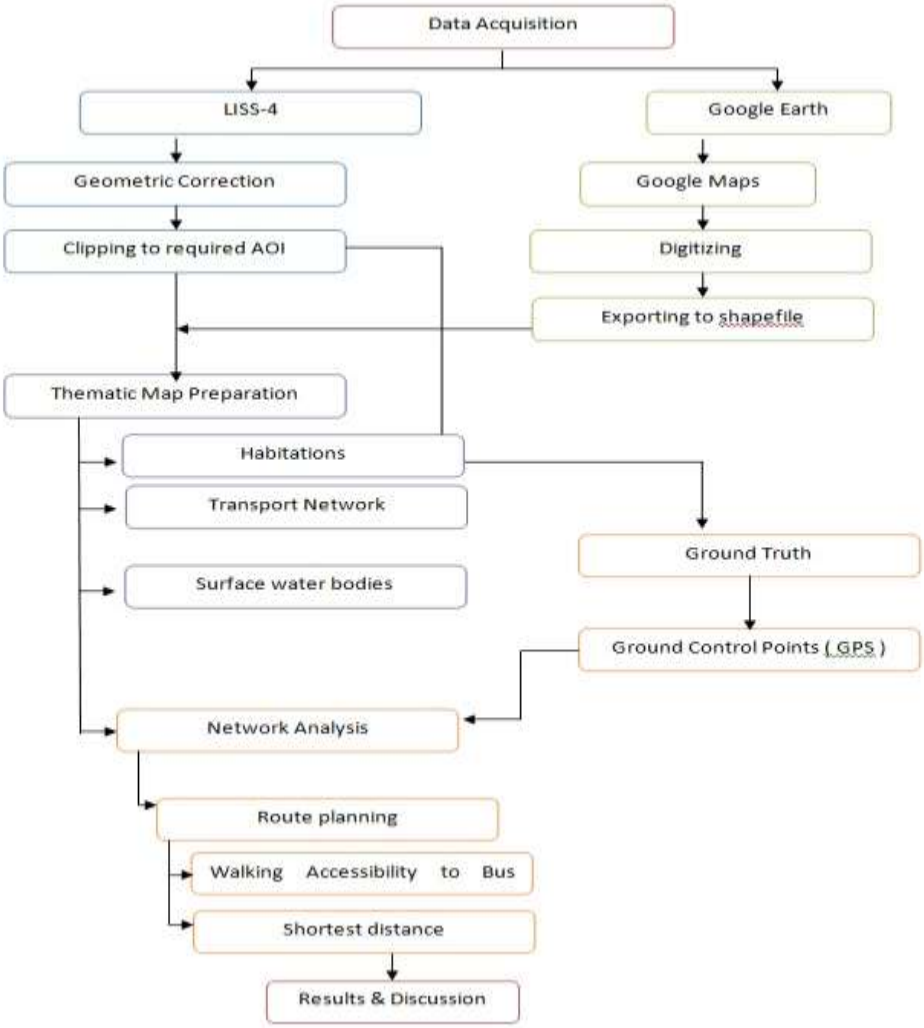


Figure 4.1 Conceptual Model

A. Determining Walking Accessibility to Bus Stops

Pedestrian accessibility is an important factor in the determination of the alignment of a transit route and the locations of bus stops. On-board surveys in Orange County have consistently shown that 80 to 90 percent of bus riders walk to and from their bus stops. The calculation of accessibility requires the identification of the "catchment area" around each busstop – that is, the area from which potential riders would be willing to walk to and from the stop. GIS tools can be used to identify catchment areas in several ways. The selection of a particular approach is determined largely by the availability and accuracy of the necessary spatial data. This section presents three ways of determining catchment areas around bus stops.

B. Route-Buffer Catchment Areas

The simplest approach to building transit catchment areas is to create a buffer around an entire route. The buffer is centred on the route of interest and is defined by the maximum distance that riders find convenient to walk to and from the system – typically one-quarter mile or so. This method is commonly used to describe fixed-routeservice areas for federal reporting purposes. The approach implicitly assumes that all locations within the buffer are accessible to the route. However, this assumption may overestimate accessibility because theroute is only accessible at bus stops. Nevertheless, this approach can be useful when bus stop locations are not available in the GIS. The approach is commonly used, for example, to examine the general accessibility of alternative future transit routes for which bus stop locations are not yet known.

i. Stop-Buffer Catchment Areas

The second approach to building catchment areas is to create a buffer around each individual stop served by a route. This approach improves the accuracy of resulting measures of accessibility to the route but requires the availability of a bus stop layer that has coordinate locations for each stop. The results of this approach for the same route used to illustrate the use of a route-level buffer. While the stop-level approach clearly improves the accuracy of the analysis, it implicitly assumes that all locations within each buffer are within the defined walking distance of the bus stop. The geometry and connectivity of the street system, however, may result in actual walking distances that are much further that the distance implied by the buffer.

ii. Network-Based Catchment Areas

The third approach to building catchment areas is to identify all links in the street network that can be reached from a bus stop by walking along the network for less than the specified maximum walking distance. This approach requires network analysis tools and a spatially accurate street network that identifies facilities that can be used by pedestrians – streets, roads, and pedestrian ways in contrast to freeways and expressways. Several methods can be used to exclude facilities not available to pedestrians. These facilities can be removed entirely from the layer that describes the streets- and highways system. Alternatively, the not-walkable facilities can be excluded from the selected set before any network operation is performed. Finally, these facilities may be assigned artificially long distances that would prevent their inclusion in any shortest path to and from a bus stop .The addition of pedestrian-only facilities may be important to an accurate portrayal of possible walk paths to and from bus stops. Pathways in residential areas and pedestrian connections in commercial areas can play important roles in providing access to bus stops. Depending on the location and importance of these facilities, their addition to the street network may be important to the accuracy of the results. Most GIS software has network analysis capabilities that can be used to create network-based catchment areas. The user specifies the origin points (stop locations) and maximum walk distance. The network tools then determine the walk network around each origin point (bus stop) that lies within the user-specified distance, the results of this analysis for the same route focuses on three of the stops on that route, contrasting the results from the buffer-based approach and the network-based approach. Because the network-based approach is able to recognize disconnects in the street network, it is able to identify the walk-accessible service area for each bus stop with much better accuracy.

V. MODEL ANALYSIS

A. Model

Proposal of new optimum routes and bus stops through Geographical Information Systems.

B. Model analysis

1. **Transportation & Methodologies:** Transportation is not a discipline, excluding a field of inquiry and purpose. Two common traits of transportation studies, regardless of disciplinary affiliation, are a heavy reliance on empirical data and the intensive use of data analytic techniques, ranging from simple descriptive measures to more complex modelling structures. In a quantity of respects, transport geography stand out from lots of extra fields of human geography by the natural world and purpose of its quantitative investigation. In fact, transport geography was one of the chief forces in the quantitative revolution that help to redefine natural features in the 1960s with the use of inferential figures, abstract model and new theory. Although this perspective provided much needed rigor, it also favoured a disconnection between empirical and theoretical approaches. Like in economics, the quantitative revolution led to a mechanistic perspective where concordance to reality became somewhat secondary; realities were made to fit into models. Even if up to date transport geography has a more diversified move toward, the quantitative measurement still plays an key part in the regulation. Thus, in addition to providing a conceptual background to the analysis of movements of freight, people and information, transport geography is much an applied science. The main goal of method aims to improve the efficiency of movements by identifying their spatial constraints. These constraints can be capability, price, time, environmental impact, but more often in grouping. It is consequently possible to identify relevant strategies and policies and provide some scenarios about their possible consequences. There are a variety of ways of classify the methods that are used by transport geographers:

- Whether they are subjective or quantitative.
- Whether they manage infrastructures (for example terminals) or streams.
- Whether they give interjection or extrapolation.
- Whether the system gives depiction, clarification or streamlining.

According to the level of data aggregation, the nature of the assumptions or the complexity of the calculations.

2**. Transport- Connected Methods**: A primary assembly of methods concern those directly linked to the study of transportation since most draw their origins from transport setting up. The methods primarily used in transport geography consist of:

- **Network analysis** (also referred to as graph theory), which is used to study transport network forms and structures, particularly how they change in time. For example, one could use network analysis to study the evolution of the hub-and-spoke configuration of airline services.
- Transport geographers also participate a key role in studying land use - transport communications. Numerical models have been developed, which, over time, have become increasingly complex.
- First, a diverse set of techniques is used in the urban transportation modelling exercise, the purpose of which is to understand and predict urban spatial patterns.
- Following, traffic survey that are used to gather empirical data about movements such as their routing and occurrence.

3. **Multidisciplinary Methods:** comprise the whole variety of methods that were not exclusively developed for transportation studies, but are readily appropriate to its study. They are labelled as multidisciplinary since they can be applied to a wide range of issues irrespective of the discipline.

Geographic Information Systems (GIS), which are an outgrowth of digital cartography, provide a set of tools for storing, retrieving, analyzing and displaying spatial data from the real world. GIS technology has been helpful to some large-scale transportation growth and manufacturing applications.

- A number of methods are used to gather main data (e.g. questionnaires and interviews) while others are used to analyze data. Some of the analytic techniques are straightforward to implement and interpret graphs (e.g. scattergrams, distance-decay curves) and tables (e.g. origin-destination matrices) are two examples. Others are more complex, such as inferential statistics like the t-test, analysis of variance, regression and chi-square.
- Increasingly, transportation studies are concerned with impacts and public policy issues. They rely more on qualitative information such as policy statements, rules and regulations.
- The growth and purpose of methods to transport studies in general and transport geography in particular has been all the time more difficult, particularly as improvements in data technologies made available more commanding analytical tools. For instance, a commercial geographic information system package has analytical and modelling capabilities well beyond of what is undertaken by most researchers, analysts or policy makers. Future developments are therefore more likely to focus on empirical data analysis using known methods but with more extensive datasets. This will lead to more comprehensive and consequential examination of real world transport phenomenon and help improved connect theoretical understanding and real world applications.

C. Specific Requirements for Transit GIS (T-GIS)

Transit GIS requires specific data sets in addition tothose used for general GIS. The following list showsboth the basic data and transit-related data requiredfor a GIS.

Street-centreline file: This layer should include street names, address ranges, jurisdictional data, and other attribute data. The street centre line file serves as amap reference layer, a database to geocode bus stops and trip origins-destinations, a base layer for building transit routes, and provides a source for networks used to determine shortest paths, walk networks, and accessibility measures. The street network is also used for non-GIS purposes, including transit scheduling and trip itinerary planning.

Bus stop inventory: This is a layer of points or coordinate positions representing the location of bus stops. This layer generally contains attribute data, such as unique stop identifiers, stop names or descriptions, and can contain such other data as the presence of bus shelters and maintenance schedules. Departments throughout Transit agencies use bus stop location data for planning, scheduling, customer information, operations, maintenance and other purposes. Passenger count data, associated with stop locations, also can be viewed and analyzed within GIS.

Bus route inventory: A route layer built on top of the street network may be used for many different purposes, especially if it is enriched with such attribute data as headways, capacity or travel speeds. Passenger count data can be summarized using a bus route layer todisplay and analyze travel patterns, monitor system performance, develop load profiles, validate demand model results and other purposes. Other GIS data essential for transit planning include census land-use and employment data. Some data, including those for street networks, and employment, maybe purchased from vendors. Most census data and other socioeconomic information are free from the concerned departments of Transportation Statistics. Specific GIS software modules and extensions that perform network analysis are useful for transit planning. A network analysis module and/or extension can assist in finding efficient transit routes between origins and destinations; building walk paths around bus stops tomeasure transit accessibility; and determining the closest transit facilities to major employment and shopping centers.

VI. DATA COLLECTION

A. Data collection methodology

Data collection is an important work and it is the back bone of the project. Appropriate data is necessary for a proper analysis and this leads to derive accurate results. The database of the case study area is prepared on the basis of the information collected from different sources. The information of different types and forms has to be transferred into the GIS database. In this project the information was collected from different sources and was integrated to form a database of the case study area. The information gathered was quite helpful in the preparation of data. There were also some inadequacies in the information which were not sufficient enough to form a complete data. There was also requirement of some information which was not available and this was a limitation in the data availability. Some information was not sufficient to produce a good data format which was a limitation in the data collection

B. City and case study area maps

Maps were collected from NIRD. The maps were available in the form satellite images. The Kakinada city map was available from Google Earth/Maps and had the information of city boundary, different areas, important landmarks, major roads, railway line and airport. Then the raster images were digitized to enter the spatial information in vector form. Different information was spatially located on the maps in point, line and polygon features. The case study area detailed raster map with vector data information in different features is seen in figure. The information about the schools, hospitals, offices and marriage halls was collected by GPS survey and the information from the local source like the area residents.

C. Limitations of the data

The data information was collected from different sources and tried to incorporate in the GIS data base. There were some limitations in the data; it was related to both data type and data availability. All these limitations are discussed below. The maps available from the municipal corporation were old enough and do not have the information about the later date and changes.

The land use data of the hospital, clinics and nursing homes is available in a point feature. The point feature only demonstrates the location by a point and does not give the exact area of the land use. It would have been more convenient to have the boundary and area of the hospitals to have a precise analysis for waste bin proximity.
There can be an analysis of the quantity and the type of waste generated in an area on the basis of population density, land occupancy and type of settlement. This could help in analysing the waste generation situation in a precise manner. But as there is no availability of detailed information of the population distribution, the quantity of waste generation cannot be related to the area density.

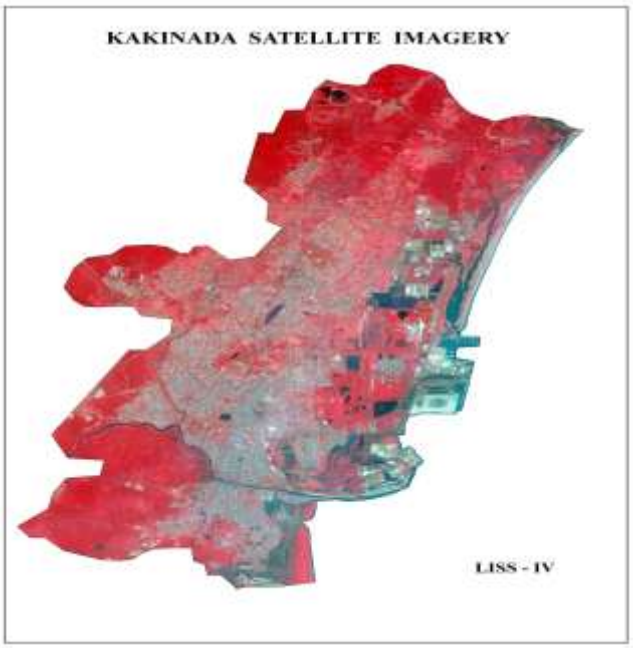


Figure 6.3 LISS IV imagery of Kakinada

VI. MODEL IMPLEMENTATION ON STUDY AREA DATA AND RESULTS

A. Model implementation on case study data and results

This chapter is a discussion of the implementation of GIS workflow model on the case study area data and the results of the analysis. This model is implemented on the data using GIS software ArcGIS10.1

1. Capturing data

First we capture the data like road network, water bodies, railway tracks on the topographic map or satellite image of our study area using ArcGIS based on their features. The following figures shows the data captured.

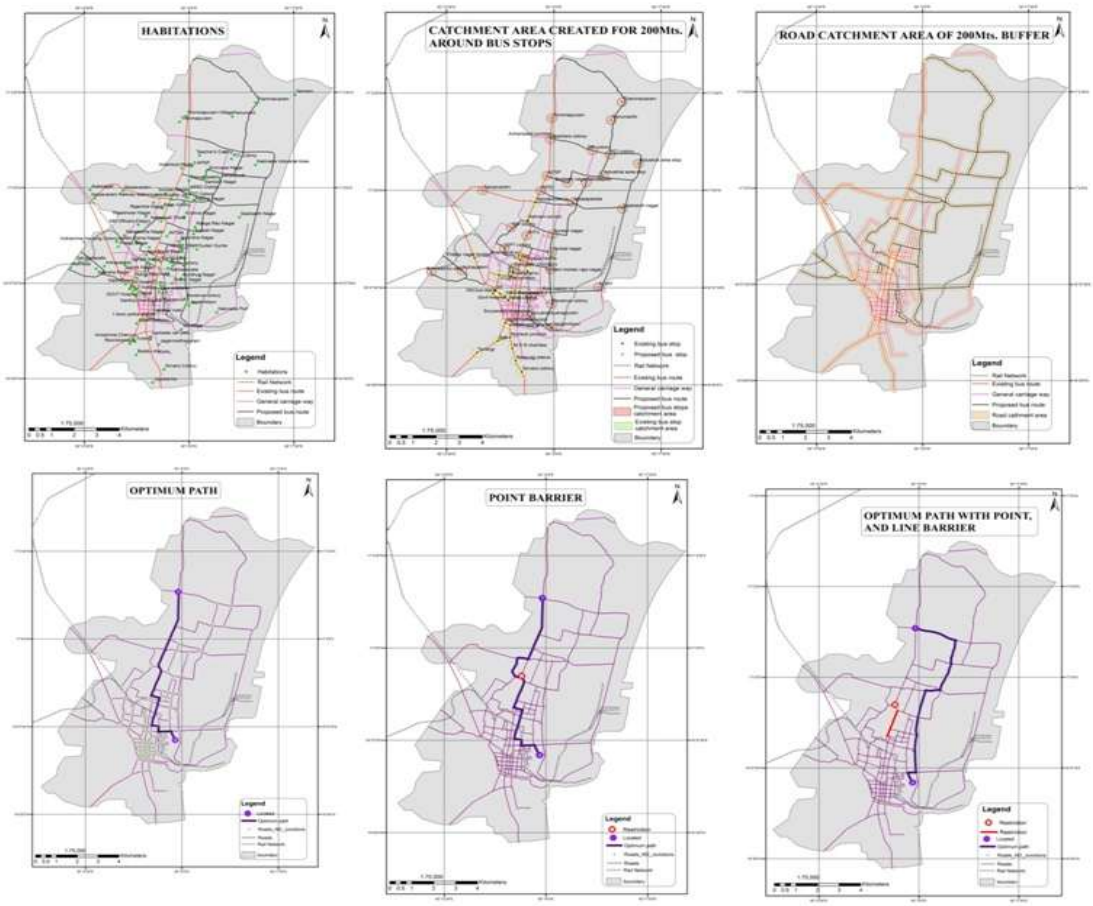


Figure 7.3 shows the Transit network captured

VII. CONCLUSION

There are several problems that can be measured for upcoming studies. The important question it to first takes those ones which can be practically potential to put into operation in the region with the contemplation of the system constrains. Here are some upcoming study suggestions which can be adopted as a after that move to the proposed model for the study region.

- Study the statistics of Road areas for planning transportation in a more precise manner.
- Analysis of further requirement of road extensions and for implementation of new transit system
- Study of improvement in the system for updating and maintaining the transit system.
- Route planning for public transit system.
- To plan an alternate route.
- Route planning for cargos and heavy goods vehicles by alternate routing into the city.

The main aim is to provide good Transit facilities to the citizens which could maintain a healthy transit system in a economic way. There can be lot of advancements in the system but it have to be carried in stages according to the availability of resources and system should be updated according to the situations.

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