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Optimal Route Analysis For The Transportation of Solid Waste Using Remote Sensing and Gis: A Model Study

SS.Asadi[1], Y. Sree Ramulu[2] M. V. Raju [3]and P.J.Ratnakar[4]

1.Associte Professor, Dept. of. Civil Engineering, KL University, Green fields, Vaddeswaram-522502,Guntur(D.t),A.P,India,Email:asadienviron.asadi@gmail.com

2.Professor,Dept.of.CivilEngineering,KLUniversity,Greenfields,Vaddeswaram522502 ,Guntur(D.t),A.P,India.

3.AssistantProfessor,Dept.of.CivilEngineering,VignanUniversity,Vadllamudi,Guntur(D.t).

4. Assistant Professor, Dept. of. Geology, Bundelkhand university, Jhansi, U.P

Abstract

Urban congestion patterns have become ubiquitous and complex. Traditional and static approaches are no longer adequate for analyzing network flows and conducting minimum cost routing. Careful selection of routes is required for different purposes especially when population and traffic are at risk. One such purpose is shipping solid waste, which places public at risk. Due to urbanization, large quantities of waste are being generated and this needs an efficient transportation route for its disposal. The present study gives a GIS based decision support tool for optimal route analysis for transportation of solid waste generated in Hyderabad. The GIS tool provides effective decision support through its database management capabilities, graphical user interfaces and cartographic visualization. The present study offers optimal routes for solid waste transportation and an option to function on a desktop personal computer. The objectives of this project are to create a spatial digital database consisting Road network maps with the help of IRS-ID, PAN & LISS-III merged data and SOI toposheets, to create database consisting of traffic volume, vehicle density and details of solid waste and to evolve an optimal transportation route maps for efficient, safe and economic disposal of solid waste. The final optimal route is obtained using arc view network analyst extension available in arc view GIS. A decision support system is developed using GIS and VB 6.0 as a combination. This decision support system gives information of the present study by simply clicking the options present, as it is user friendly. The project results in giving optimal routes from the three transfer stations of Hyderabad to the dumping sites. A decrease in traffic density with less number of stops and turnings in these optimal routes resulted in more speed, less travel time and less cost making the routes efficient, effective and economic.

Key wards: Road network maps, Network Analysis, Solid Waste disposal site, Population Density Map

Introduction

In India, cities are growing in an uncontrolled manner resulting a lot of civic problems. Many cities have grown haphazardly and ill-thought manners and they have given way to filth, slum, overcrowding, homelessness, awful traffic, pollution and garbage, which are deteriorating human standards in cities. Of all above civic problems, garbage disposal system is worst in many Indian cities. Inhabitants of Indian cities are generating plenty of garbage by adapting western country's way of life and consuming packed goods. Even market centers, commercial complexes, factories, companies, private and public institutions are producing the garbage at a higher level in all cities. Hyderabad is one of such cities that generate huge solid wastes. Hence, the detailed study of garbage and its transportation is very essential to prevent major casualties in and around Hyderabad city.

Solid waste collection in Hyderabad

There are 3850 notified garbage collection centers where garbage is collected in Rcc bins, steel tubs, garbage houses or steel dumper placer bins. Modern dumper placer bins are provided at 1900 locations and in the balance 1950 locations Rcc bins are provided. The total storage capacity of these bins is 2200MT. All the collection centers are attended everyday.Doorstep collection arrangement from bulk garbage generators. Under the principle of users pay, beneficiaries' pay, and polluters' pay, MCH has introduced the scheme of collecting user charges from bulk garbage generators in the city. 1700 establishments like hotels, restaurants,function halls, hospitals, markets, and commercial complexes etc., generating bulk garbage are identified and classified into 12 categories for levying user charges. During the year 2003-2004, 20 transport work packages are proposed to be launched for providing doorstep collection arrangement to these establishments and collecting user charges to the tune of Rs.2 crores.

Transfer stations and Transportation in Hyderabad

The garbage is deposited at notified centers as follows:

- The garbage from Rcc bins are manually transferred by workers into tipper trucks or mini compactor trucks of the corporation, which transport the garbage to the nearest transfer station.
- The Dumper placer vehicles mechanically lift the full steel bins after placing an empty bin at the notified centers and proceed to the nearest transfer station or landfill site.
- At present 55% is handled manually and 45% mechanically.
- There are 102 Dumper placer trucks with a carrying capacity of 2.5MTs each, 45 Big Tippers (10MT), 79 Small tipper trucks (3.5MTs), in MCH.

The transfer station is a transit point in the movement of garbage to the landfill site or solid Waste processing plant. Here the garbage is brought in small Dumper placer

bins and Tippers. The contents are transferred directly into large 10 tones Big Tipper vehicles through a specially designed hopper. These big Tipper trucks in turn take the garbage to the landfill site or MSW processing plant for the final disposal. At present there are 3 transfer stations as stated earlier. The fleet of corporation SWM vehicle are parked and serviced at 3 operational depots located at Chaderghat (South), Kavadiguda (East) and Khairatabad (West).There are full-fledged workshops at these places to attend to the repairs and keep the fleet operational at all times.

Description of Study Area

The Hyderabad city is divided into 11 zones with 7 circles, which are further divided into 35wards in this 7wards under secunderabad cantonment board. Hyderabad city and its surroundings are considered for the study. It is located at 78°22'30''-78°32'30''E longitude and 17°18'30''-17°28'30''N latitude. A buffer of 50 kms from each of the four directions of the city is considered. The study area as a whole lies within 78°-79°E longitude and 17°-18°N latitude covering the parts of the districts namely Nalgonda, Hyderabad, Mahabubnagar, RangaReddy and Medak. Due to its vast urbanization the city as a whole is considered to generate 2200MTs of solid waste of which 65% is contributed by the residential sector. A detailed study of solid waste collection for the city is made. The twin cities have a 3000km of road network maintained by Muncipal Corporation of Hyderabad apart from 85km of roads maintained by roads and buildings department of government of Andhra Pradesh. National Highway 7 & 9 passes through the city.The solid waste being collected is first taken to the nearest transfer stations, which are located in the respective wards. Imliban transfer station, Lower Tankbund transfer station and Yousufguda transfer station are the three transfer stations, which are located in the city. There is one and only one dumping site located at Jawahar nagar in Kapra. Hence three sites are proposed in the surrounding areas of Hyderabad. These include:

- The space between Konukunta, Ireddy Pally and Kothapally villages. The site is nearly three to four kilometers apart from each village. It is 18 km from Dhulpalli forest department and 25 km far from Kukatpally. The site is situated in the Northwest direction of the city (between 78°15'-78°30'E lon and 17°30'-17°45'N lat). It can serve the north and also the west parts of the city.
- The space between Chevella and Malkapur villages, 3 km apart from each. It is 17 km from Rajendra nagar and 20 km far from Nehru Zoological Park. It is situated in the southwest side of the city (between 78°0'-78°15'E lon and 17°15'-17°30' N lat). It may be taken as a site to serve the Western part of the city.
- The space between Chippalipalli and Phulammidi villages and two and three kilometers far the villages respectively. It is at a distance of 7 kms from Mysaram village, 20 km from Shamshabad and 33 km from Charminar. It may be taken as a site to serve the Southern part of the city (between 78°15'-78°30'E lon and 17°0'-17°15'N lat).

These are considered as the disposal sites and the optimal route between the collection and dumping sites is worked out.

Study Objectives

1. To create spatial digital database consisting of road network maps with the help of IRS-ID, PAN & LISS-III merged data and SOI toposheets and ground data on the ARC/INFO GIS platform.
2. Creation of database consisting of traffic volume, vehicle density and details of waste like amount, transporting mode.
3. To evolve an optimal transportation route map for the efficient, safe and economic disposal of solid waste.
4. To create a decision support system using GIS and VB software to function on a desktop personal computer.

Methodology

Data Collection

This includes the collection of Remote Sensing data, SOI Toposheets and the Collateral data/Field data.

Satellite Data:

IRS-ID PAN+LISS-III Satellite imagery obtained from National Remote Sensing Centre, Balanagar, Hyderabad. 56K/1-56K/16 The Survey of India toposheets used for the study are obtained from Survey of India.

Field Data

The field data required for the present study is obtained from different sources.

1) Population data: The population data of the study area i.e. the population of different places described and the statistics obtained from statistics department.
2) Solid waste collection points data: The solid waste collection points for the Hyderabad city are obtained from 35 ward offices and from the 3 transfer stations namely IBT, TBT and YZT. The ward wise details are collected and further pointed on the road network map and the attribute information is attached.
3) Solid waste disposal points data: The solid waste disposal points in and around Hyderabad are obtained from MCH office, Liberty, Hyderabad.

Solid Waste Disposal Points of Study Area Is

1. Autonagar(45 acres)- Closed,2. Gandhamguda(20 acres)- Closed,3. Jawaharnagar (30 acres)- Operational,4. Jiyaguda(30 acres)- Under Proposal,5. Site b/w Konukunta, Ireddypalli Kothapalli - Proposed Site,6. Site b/w Chevella & Malkapur- Proposed Site,7. Site b/w Phumamidi & Chippalipalli- Proposed Site

Transportation Data

The transportation data includes the type and the no. of vehicles used, transfer station details and vehicle location (starting points), the existing routes from each transfer stations, type and length of roads, traffic volume and traffic density data.

Type and Number of Vehicles For Transfer and Disposal of Solid Waste

1. Dumper Placer Trucks (2.5MT)-120, **2.** Small Tipper Trucks (3.5 MT)- 70, **3.** 10 Tones Capacity Tippers-45, **4.** Private Contractor Tipper Trucks-119

Database Creation

- Scanning is done by moving an electronic detector across the map surface and a digital image of the map is obtained.
- Digitizing of all scanned maps using automated digitizing process by AUTOCAD. It is a process of converting the spatial features on a map into a digital format. Point, line and area features are converted into x, y coordinates.
- Editing of the digitized data and detection and correction of errors in digital data so that it is ready for spatial analysis on GIS platform. For this ARC/INFO GIS software (developed by ESRI, Redlands, California) is used. It is a vector-based GIS package, capable of handling both spatial and non-spatial data.
- Linking of attribute data to spatial features in Arc info.
- Data storage and retrieval subs tern.
- Thematic data layers and final output in arc view.
- Decision support system using VB.

Data Analysis

This includes format conversion, data medium conversion, spatial measurements, reclassification, buffering, overlay and modeling surfaces. In the present study buffer analysis and network analysis are made.

Buffer Analysis

BUFFER creates new output coverage by generating buffer zones around input coverage features. Input coverage features can be polygons, lines or points. Output coverage features will always be polygons. In the present study:

- The solid waste collection and details of the entire Hyderabad district are studied.
- A buffer is created around Hyderabad with a radius of 50km.
- The proposed dumping sites for this collected waste fall within this buffer serving all the corners of the district.
- The information of the dumping sites and the collection points is provided.
- And the optimal route between the collection points and the dumping sites is worked out.

Network Analysis with GIS

Analyzing collection vehicle routing and optimization in a road network environment while considering economic and equitable objectives can be complex. GIS allows us to create and store as many layers of data or maps as we want and provides various possibilities to integrate tremendous amounts of data and map overlays into a single output to aid in decision making. The Network Analyst can find out the best route for a given network that was build, which is an extended property of ARC VIEW GIS. The database tables also contain explicit identification numbers that relate them to a particular feature. Whenever the coordinate information for a network is modified, perhaps by the addition of new features, the attribute file in the Relational Database Management System (RDBMS) is automatically updated.

ARC VIEW Network Analyst

The Arc View Network Analyst (AVNA) extension module allows the user to solve 3 categories of network analysis problems, Find Best Route, Find Closest Facility and Find Service Area. If you need to conduct more complex analyses than these 3 default options available, you can do this using Avenue scripts.

Find Best Route problems involve finding the "least cost impedance" path on the network between two or more stops. Find Closest Facility pertains to finding the distances from an event to the nearest facilities, or vice versa, finding the distance from a facility to one or more events. Find Service Area determines the area that a particular facility can serve within a given time or cost frame.

Performing Network Analysis using analyst

To perform a network analysis, a road theme must be present in your View window:

Make the View window active, View > Add Theme > Select slcroads.shp Repeat this for the following themes: facilities.shp, events.shp, stops.shp

The first time you perform a network analysis on a line theme; AVNA will build the topology, create a cost matrix and then run the analysis. In a large network, this may take some time. The next time you run an analysis on the same network, the topology is then already present, and the analysis runs much quicker. However, as soon as you edit the theme attribute table, AVNA will have to rebuild the topology again before running any analysis.

Route

Find Best Route:

With the slcroads.shp theme active,

Network > Find Best Route

AVNA now adds a route theme to your view and presents you with a new dialog box.

You now have two options to add the stops for which you want to calculate a route, either by interactively selecting stops graphically from the view, or by loading a point theme that holds the stops. First, let's try to select them graphically.

Selecting Stops Interactively

Click the Add Location icon in the menu bar: 

Then click in the view to select stops. These are added to the dialog box as you click them. You can change the order of stops by highlighting (clicking) them, and then use the arrow buttons; you can also delete stops by clicking the delete "X" button. In addition you can use the check boxes to choose whether you want AVNA to find the best order of stops, and/or whether you want to return to the origin (the first stop in the list). Properties allow you to choose the shortest path based on shortest distance (default) or least cost (minutes or other cost units).

Just add a couple of stops, then click the Solve icon:  .

AVNA will now build the topology and run the analysis. Be patient! When done, AVNA will add a display the route in your window.

Click Directions.

This gives you turn-by-turn directions for the entire route.

Click Done.

With the dialog box still open, check the Find best order box, and then click the Solve icon again. With the dialog box still open, click Properties, select Minutes as your Cost field, click OK, and click the Find Solve icon. We will see a changed route. If you want to save the different alternatives as different routes, you need to save them separately:

Make the calculated route active in the View window.

Theme > Convert to Shape file > Select a name and a folder > Accept to add the theme to the view.

When done running and saving the different alternatives you want to display, delete the default route theme:

Make the default route theme active,

Edit > Delete Theme

Selecting Stops From A Stops Theme

Make the road theme active,

Network > Find Best Route > Load Stops > Select stops.shp.

Try the same variations as before.

Setting Restrictions

If you select one (or more) arc(s) prior to solve, this prohibits travel on this arc. This is an easy way to model restrictions without editing the attribute table.

Setting up a Road Network

Unfortunately, you cannot expect the network to be fully prepared for you every time you do a network analysis. There's a lot of work behind the scenes before you can

actually perform a network analysis. This includes setting the travel cost for each arc, defining directions and one-way streets, managing restricted turns and most important, address matching. First, add the network road theme to your view. The roads look the same as before, but they lack much of the necessary network information. You can still perform a network analysis with just this line theme present. However, the default cost then is equal to distance traveled. There are no directional restrictions (you may go the wrong way down a one way street, or use the wrong side on the freeway, and turn wherever you want). Routing by address is also more difficult, albeit possible, since you can always select your stops graphically at the approximate position, if you have enough local knowledge to know where you are in the view.

Results

Road Network Map

A Road Network Map is prepared using the SOI toposheets (56K series). A clear road network is further obtained by updating it with satellite image (IRS-1D) since the toposheets are very old and were prepared long back. Different types of roads like National Highways, State Highways, and major district roads, metalled and unmetalled roads are digitized. The core issue *network analysis* is based on this map. The major roads passing through the buffer considered include NH-9 to Mumbai, NH-7 to Chennai and various other roads connecting the settlements, landforms. The road lengths of different types of roads like National Highway, State Highway, District Highway, metalled roads and unmetalled roads are calculated using the Arc View software and a map showing the different road lengths in the study area is prepared. different types of roads and their lengths in the study area is observed that 249.145km of National Highway runs along the study area and State Highway (SH)- 285.639 km, District Highway (DH)- 277.629 km, Metalled Roads-803.329 km, Unmetalled Roads-1186.674, Cart Track-3303.163, Foot Path-642.016

Attribute Data file

Attribute data are those properties of a spatial entity that need to be handled in GIS, but are not themselves spatial. Attribute values associated identifiers may be attached to graphic entities directly on input, it is not efficient to enter large numbers of complex attributes interactively. The data are therefore either stored separately from spatial information in GIS in the case of relational databases, or are input along with spatial description with the object-oriented databases. Attribute data may come from many different sources such as paper records, existing databases, spreadsheets, etc. They may be input into GIS database either manually or by importing the data using a standard transfer format such as TXT, CSV, and ASCII, where relational databases are used as an identifier is included in the attribute record to link the spatial and attribute data together.

Population Density Map

The population density is calculated with population and area parameters and thus a map is prepared for the obtained values. The total population in the study area is obtained by referring the census data. (source: Census Bureau, Hyderabad) and a map is prepared in Arc View. The population density is calculated for each of the district falling in the study area. The percentage of population that is affected during to the transfer of solid waste is also taken into consideration for optimum route selection.

Table 1: Population density details of buffer taken

S No.	District	Total Population	Total Area	Population density
1	Rangareddy	6540421	5144.08	1271.44
2	Nalgonda	790278	4179.8	189.07
3	Medak	1627873	5486	296.73
4	Mahbubnagar	351201	1438.5	244.13
5	Hyderabad	3612427	162.58	22219.38

The solid waste collection points are obtained from the ward offices and the respective transfer stations. The collection points for the Hyderabad city are gathered and are pointed on the Hyderabad road network map circle wise. The transfer stations i.e. IBT, TBT, YZT are also pointed. Hyderabad is dived into 7 circles and is facilitated with 3 transfer stations.

Table 2: Population density in different circles of Hyderabad

S No	Circle No.	Wards falling in circle	Population (2001)	Area Sq.Km	Population Density
1.	1	16,17,18,22,23	901226	31.02	29053.06
2.	2	14,15,19,20,21	490703	14.91	32933.08
3.	3	1,2,3	571733	17.98	31798.27
4.	4	9,10,11,12,13	568163	28.12	20204.94
5.	5	6,7,8	552697	45.36	12184.67
6.	6	4,5	118306	4.93	23997.16
7.	7	24,25,26,27,28,29, 30,31,32,33,34,35	409599	20.26	20271.12

Table 3: Details of Solid waste of Municipal Corporation of Hyderabad

S. No	Circle	Ward	No. of Dumpers	Amount of Solid Waste	Nearest Transfer Station
1	**1**	16,17,18,22,23	61,68,20,15,21	122,136,40,30,42	IBT
2	**2**	14,15,19,20,21	38,40,36,36,36	76,80,72,72,72	IBT
3	**3**	1,2,3	48,29,40	96,58,80	TBT

4	**4**	9,10,11,12,13	13,21,30,16,23	26,42,60,32,46	YZT
5	**5**	6,7,8	33,31,137	66,62,274	YZT
6	**6**	4,5	11,13	22,26	IBT
7	**7**	24,25,26,27,28, 29,30,32,33,34, 35	34,11,12,13,35 ,34,22,22,35,3 2,22,23	68,22,24,26,70,68, 44,44,70,64,44,46	TBT

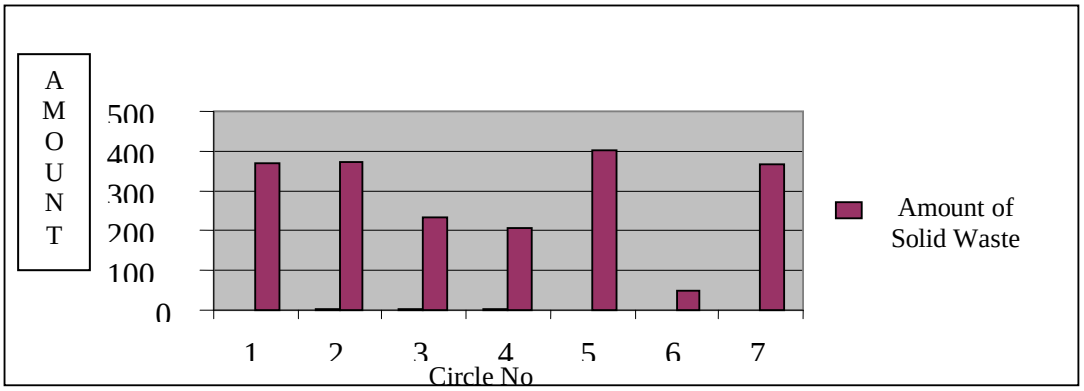


Figure 1: Solid waste in Different circles

Solid Waste Disposal Points

The collected waste is disposed in the dumping yards. But unfortunately the city of Hyderabad is facilitated with only one dumping site at jawahar nagar, Kapra municipality. It is the one and only one dumping station that is operational at present. Hence three dumping sites are proposed to the north, west and south of the city. They are

1) Site b/w Konukunta, Ireddypalli Kothapalli to the north of Hyderabad
2) Site b/w Chevella & Malkapur to the west of Hyderabad
3) Site b/w Phumamidi & Chippalipalli to the south of Hyderabad

Solid waste Details:

The amount of solid waste that is being generated in different wards of the 7 circles, the number of dumper steel bins in each ward and the nearest transfer station to that ward are shown in table The daily lifting points from MCH are collected and are presented in tables. The solid waste collection points map of Hyderabad is shown in fig. This map is also linked with the database in Arc View.

Table 4: Solid waste collection points of Circles in Hyderabad

Circle No.	**Collection Points**
Circle 1	Malakpet Market, Chandana Brothers, Venkateswara Temple, Central Jail, Saidabad P.S, Saidabad Colony, Singareni Colony, Madannapet, M.V.S.R. Engg.College, I.S.Sadan, Santoshnagar Colony, Kundanbagh, Rain Bazar, Edi Bazar, Kummarwadi, Riasat nagar, Lalithanagar, Uppuguda, Raksha, Poolbagh, Hafeezbabanagar(N), Hafeezbabanagar(S), Chandrayanagutta, Keshavgiri, Bandalaguda, Janagammet, Vetapalli, Rajanna Bowli, Aliabad(S), Aliabad(N), Laldarwaza(S), Laldarwaza(N), Bhavaninagar, Gaulipura, SultanShahi, Talabkatta, Talabchenchalam, Alijakotia, Mughalpura, MeccaMasjid, Charminar, Pattargatti, Dabirpura nala, Chanchalguda, Imliban, Salarjung Museum, Madina Hotel, Meerchowk, Puranapool, Bahadur pura, Kanchan Bagh, Zoo Park, Shaheen Hotel
Circle 2	Falaknuma Palace, Jahanumma, NawabSaheb Kunta, Tadbund, Chandulalbaradari, Shalibanda, Himatpura, Fathedarwaz, Dudhbowli, Kamatipura, DeviBagh, KabutharKhana, Hussaini Alam, PetlaBurz, Osmania Hospital, BegumBazar, Afzalgunj, Veternary Hospital, Dhoolpet, SabjiMandi, Rampur, GowligudaKhaman, Goshamahal Stadium, Mojamjahi Market, Pochamma Temple, Goshamahal, Mangalhat(E), Veternary Hospital, SitaramBagh, Mallepalli, Anwarul College
Circle 3	Osmania Mediacl college, Women's College, SultanBazar, Barkatpura, Lingampally, Kachiguda, Ramkote, Narayanaguda, Old MLA Quarters, Hyderguda, Himayatnagar, GaganMahal, Ashoknagar, Nehrunagar, LowerTankbund Road, Indira Park, Gandhinagar, Bakaram, Kavadiguda, Bholakpur, Zamistanpur, Azamabad, Ramnagar, Dayara, Adikmet, Chikkadpally, Vidyanagar, Vidyanagar Ext, Amberpet, BaghAmberpet, Nallakunta, Tilaknagra, AmberpetPolicelines, Amberpet Extn, Golnaka
Circle 4	MasabTank, ChintalBasthi, Ahmednagar, Santhinagar, Sarojinidevi eye Hospt, Venkateswara Temple, Humayunnagar, Vijayanagar Colony, BazarGhat, Mehdipatnam, Retibowli, Akbarpura, Tolichowki, Shaikpet, Golconda MilitaryArea, Golconda Fort, IbrahimBagh, Gudimalkapur, Muradnagar, SyedAliguda, Dattatreyanagar, Ramsinghpur, Kharvan, Jiyaguda Dargah

Circle 5	Lumbini Park, Necklace Road, Khairatabad, Near Railway Track, Rajbhavan Road, NIMS, Somajiguda, Panjagutta, Banjara Hills Road No.1, Banjara Hills Road No.11, Banjara Hills Road No.9, Banjara Hills Road No.10, Banjara Hills Road No.7, Banjara Hills Road No.8, Banjara Hills Road No.4, Banjara Hills Road No.6, Banjaran Hills Road No.5, Banjara Hills Road No.2, Banjara Hills Road No.3, Yellareddyguda, Ameerpet, Srinagar Colony, Sarathi Studio, S. R. Nagar, Vengala Raonagar, Kalyannagar, Balkampet, Opp. T. B. Hospital, Rythu Bazar Opp, FCI Godown Main Road, Sanathnagar, Sultannagar, Yousufguda Electrical Transmitting Station, Yousufguda Policelines, Yousufguda, Jubli Hills Road No.54, Jubli Hills Road No.10, Jubli Hills Road No.14, Jubli Hills Road No.44, Journalist Colony, Film nagar, Apollo, Hakimpet, T.B. Hospital,
Circle 6	Secretariat, BirlaMandir, MCH, Hillfort, Baseerbagh, L.B.Stadium, SBH, Nampally, Abids, Boggulakunta, Esamia Bazar
Circle 7	Fathenagar, MayuriMarg, Begumpet, Brahmanawada, Prakashamnagar, Pattigadda, Prenderghat Road, Ramgopalpet, Kalasiguda, Jamai Osmania, Budhnagar, GeneralBazar, Sivajinagar, MahankaliTemple, Old Gandhi Hospital, Monda Market, Old Boiguda, James Street, Ranigunj, Boiguda, Padmaraonagar, Parsigutta, Walker Town, Namalagunddu, Warasiguda, Sitaphalmandi, Manikeshwarnagar, Tarnaka, Chintal, Lalapet, Lalaguda(N), Lalaguda(S), Tukaram Gate, Railway Quarters, Mettuguda, Chilkalguda, Rezimental Bazar, East Maredpally, West Maredpally, Addagutta, Srinivasnagar

Traffic Volume

Traffic counts were made for different junctions and links (stretch of road) in the city. Some of the major findings of the study are stated in the following tables:

Table 5: Junctions (16Hrs Traffic Count) having more than one lakh vehicles from all directions (Source: From HATS (Hyderabad Area Transportation Study of Huda.))

S No.	Name	No. of Legs	16Hrs Traffic
1	Green land juction	3	292898
2	M.J.Market Road	4	189926
3	Ambedkar statu Juction	4	184247
4	Vishveshwarayya Juction	5	162738
5	Ameerpet Juction	4	140751

This indicates a bottleneck at the Green Lands Junction through which the largest number of vehicles pass for want of alternative routes.

Tables 6: Links with traffic volume more than one lakh vehicles per day

S No.	Name	Vehicle/Day
1	Nalgonda x Road-Chandergahat	162189
2	Afzalginj-M.J.Market	130871
3	Khairtabad-Lakdikapool	130780
4	HotalAshoka-Ravindrabharathi	121228
5	Khairtabad-Eeeaammanzil	111293

Tables 7: Links with traffic volume between 75000 to 100000 vehicles per day

S No.	Name	Vehicle/Day
1	Hotal Ashok-Ayodhya Hotal (on way)	96910
2	YMCA-Parade Grounds link	95593
3	Sec.Reservation Compl.Bhoiguda	93946
4	Ambedkar Statute-Hotel Viceroy	90824
5	Dilsukhnagar-Chaitanyapuri	90521

This shows the traffic volumes on major roads, which need to be relived by creating parallel roads, strengthening rail based commuting and better traffic management to restrict private vehicles. Strengthening and creating a network of Ring and Radial roads can divert much of the traffic on these roads.

Table 8: Links with highest Truck traffic

S No.	Name of Link	Volume in Veh./Day	% of total Volume
1	Vanasthalipuram-L B Nagar	7787	22.3
2	Miyapur-Lingampally	5779	22.5
3	BHEL-Patancheruvu	5686	20.1
4	Santh nagar	5609	11.1
5	Attapur	5525	19

Optimal Routes Maps

The Road network map prepared is dealt with the ArcView network analyst (an extension of arcview). The best route between the transfer stations and the dumping sites is given. Further the traffic volume between the source and the sink is calculated. The present routes followed by the trucks from the transfer stations to the dumping site are no doubt the routes with shortest distance but it takes more time to reach the dumping site from the transfer station. This is due to increase in traffic density and more number of signal points in the city. The details of traffic volume are clearly depicted in table no.s 4.9, 4.10, 4.11, 4.12, which show that the traffic density is more at the junctions that are near to the transfer stations. With the increase in the traffic density the speed decreases and the travel time increases. The optimal routes found out from the transfer stations to the proposed dumping sites differ by 5km with that of

the present distances but there is a decrease in traffic density as there are very less number of stops and turnings compared to the existing. Hence more speed and less travel time are obtained and the fuel charges will also be less. Moreover the truck travel in this route doesn't affect the public and it doesn't disturb the prevailing traffic. The optimal routes from the three transfer stations of Hyderabad (IBT, TBT, and YZT) to the three proposed dumping sites are found. The existing routes are from the three transfer stations are shown in below figures. The optimal routes from each of the transfer station to all the dumping sites proposed are shown in below figures. From these the best route for each transfer station is obtained with minimization of time and cost. These best / optimal routes from IBT, TBT and YZT are shown in below figures

The below figure shows an optimal route from IBT to the proposed dumping site (site b/w Chippalipalli and Phulmamidi). Of the three dumping sites, the site between Chippalipalli and Phulmamidi is the nearest and optimal. The route goes through touching the following places Dabirpura, Sivaramballi, Shamshabad, Hamidullah nagar, Nagawaram, Kalwakol, Kolla, Parandla, and Chippalipalli.

The below figure shows an optimal route from TBT to the proposed dumping site (site b/w Chippalipalli and Phulmamidi). The route goes through touching the following places Kachiguda, Dabirpura, Sivaramballi, Shamshabad, Hamidullahnagar, Nagawaram, Kalwakol, Kolla, Parandla, Chippalipalli.The below figure shows an optimal route from YZT to the proposed dumping site (site b/w Kothapalli, Ireddypalli and Kanukunta). The route goes through touching the following places Moosapet, Kukatpalli, Madinagudem, Borampet, Gundla Pochampalli, Dundigal, Bontapalli, Gummadidala, and Kanukunta.

Decision Support System

The attribute data (data collected through field work) and the spatial data (maps obtained) are together used to form an information system using VB. This is a user-friendly system and the end user can get the information, make a decision by mere clicking the options. It is designed using VB in ID Environment and the designed system can function on a desktop computer. This decision support system consists of the login page and Home page from which different windows open. The design of these pages is discussed below.

The system is designed in Integrated Development Environment (IDE). IDE is a term commonly used in the programming world to describe the interface and environment that is used to create the application we need. The Visual Basic IDE is made up of a number of components like:

- Menu bar
- Tool bar
- Project Explorer
- Properties Window
- Form layout Window
- Toolbox
- Form Designer
- Object Browser

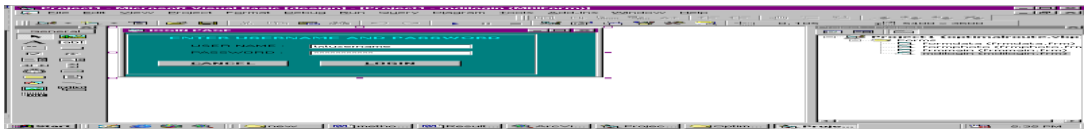
Of these, form is the most basic object in which application is developed. A form is a window that contains application code and has other objects placed on it to create the user interface. A form may fill the entire screen or have other forms contained within it, or it may be a custom dialog box. Visual Basic initially includes a default form, *Form1* file in each new project. You can change the form's name and caption to identify the purpose of the form. Every form object has its own properties, events and methods associated with it.

In the present work a login page is designed in the same manner with the object *Form*. This page helps to get into the system's Home page, displayed in form pattern by giving the password set earlier while writing the code.

Design (Login page)

The login page is designed with username, password, cancel and login buttons. Then the properties of each object are set. The code for each is written in the text editor.

The login page designed is as shown in figure below



The code for the above page that is to be written in the text editor is given below.

```
Private Sub cmdcancel_Click()
 'To close the login window
Unload Me
End Sub
Private Sub cmdlogin_Click()
 'Calling the procedure:logincheck to check the entered username and password is correect or not
Call logincheck
End Sub
Private Sub MDIForm_Activate()
 'When the user open the login page cursor will go to username box
txtusername.SetFocus
End Sub
Private Sub MDIForm_Load()
 'To clear the username and password field when the form open
txtusername.Text = ""
 txtpassword.Text = ""
End Sub
Private Sub txtpassword_KeyPress(KeyAscii As Integer)
 'Calling the procedure:logincheck to check the entered username and password is correect or not
If KeyAscii = 13 Then
Call logincheck
End If
```

```
End Sub
Private Sub txtusername_KeyPress(KeyAscii As Integer)
' MsgBox ("Ketascii=" & KeyAscii)
‘When user press ENTER after entering username the cursor goes to the password field.
If KeyAscii = 13 Then
txtpassword.SetFocus
End If
End Sub
Public Sub logincheck()
 ‘To check the user name and password is correct or not
If L Case (txtusername. Text) = "jntu" And L Case (txtpassword.Text) = "jntu" Then
frmmain. Show
Unload Me
ElseIf L Case (txtusername.Text) = "jntu" And LCase(txtpassword.Text) <> "jntu" Then
MsgBox "ENTER CORRECT PASSWORD"
txtpassword.SetFocus
ElseIf LCase(txtusername.Text) <> "jntu" And LCase(txtpassword.Text) = "jntu" Then
MsgBox "ENTER CORRECT USERNAME"
txtusername.SetFocus
ElseIf txtusername.Text = "" And txtpassword.Text = "" Then
MsgBox "ENTER USERNAME AND PASSWORD THEN PRESS ENTER"
txtusername.SetFocus
ElseIf txtusername.Text = "" And txtpassword.Text <> "" Then
MsgBox "ENTER USERNAME"
txtusername.SetFocus
ElseIf txtusername.Text <> "" And txtpassword.Text = "" Then
MsgBox "ENTER PASSWORD"
txtpassword.SetFocus
Else
MsgBox "ENTER CORRECT USER NAME AND PASSWORD"
txtusername.SetFocus
End If
End Sub
```

The same process is followed by the remaining i.e. designing the form, setting the properties of the objects present in the property window of the form and writing the code in the respective text editor. Then it is executed using the run option.

Design of Home page

The home page is titled ‘Optimal route analysis for the transportation of solid waste.’ It’s designed with a menu bar with the following menus: File, Thematic Maps, Existing routes, proposed routes, optimal routes and Miscellaneous. Each of these is further designed with menu items as shown in the table below.

Table 9: Descriptions of Menu

Menu Name	Sub Menu	Function
File	Exit	Exits from the application
Thematic Maps	Base Map Drainage Map LU/LC Map Road Network Map Other Maps	Displays the Base map Displays the drainage map Displays the LU/LC map Displays the road network Displays other maps like population density and satellite image
Existing Routes	Route from IBT Route from TBT Route from YZT	Shows the existing route from IBT Shows the existing route from TBT Shows the existing route from YZT
Proposed Routes	Route from IBT Route from TBT Route from YZT	Shows the proposed routes from IBT Shows the proposed routes from TBT Shows the proposed routes from YZT
Optimal Routes	Route from IBT Route from TBT Route from YZT	Displays the Optimal route from IBT Displays the Optimal route from TBT Displays the Optimal route from YZT
Miscellaneous	Photo gallery Database-Collection points	Displays the Various photos Displays the collection points of each transfer station

Table 10: The database are designed along with the buttons and these are described as follows.

Button Name	Function
Go To Home	Takes back to the home page
Exit	Exits from the application
Go To Gallery	Takes back to the photo gallery
Get Collection Points	Displays the collection points of the transfer station selected in the data grid

For each of the described windows the code is written in the text editor and tested by running. The working features are described below.

Working of Login page

After filling the correct username and password if the user clicks the LOGIN button then the home page is displayed otherwise an error message ‘enter correct password ‘ is displayed.

Working of Home page

The home page consists of many menu items. By clicking the menu items in the *thematic maps* menu the corresponding maps are displayed. For example: on clicking the road network map the road network map of the study area is displayed in figure.

The detailed menu list is shown in figure. Similarly by clicking the options in the menus '*existing routes', 'proposed routes' and 'optimal routes'* the corresponding maps are displayed. The *miscellaneous* menu contains the items 'photo gallery' and 'database-collection points', which displays the photos and the collection points of the respective transfer stations collected in the due course of field survey.

In the photo gallery the button GO TO HOME takes back to the home page. In the database collection points window the transfer station is chosen and its respective collection points are displayed in the data grid named 'collection points' on clicking the 'GET THE COLLECTION POINTS' button. This way the system works and it is easy to use as it has desktop functioning ability. The project is run outside VB environment by using the option 'make', which will enable to run the project anywhere provided the set path satisfies the code limitations.

Conclusions

In early times the transportation and disposal of human and other wastes produced in the city did not pose significant problem, as the amount of waste generated and the distance between the point of generation and disposal was less. But as the population increased, more land was occupied for residential and commercial purposes. As a result the dumpsites had to be relocated to far off places in order to reduce its impact on the public health, which in turn requires provision of better transportation facilities for the transfer of wastes to the dumpsites. Therefore optimization of route or selection of shortest route to the dumpsite considering the transportation costs including the fuel efficiency is very much essential. Remote sensing and GIS can be effectively used to address the objective of finding the optimal route between the given origin and destination. It can be used to find the routes involving the shortest distances as well as shortest travel time thereby reducing impact of waste on public health and extent of air pollution caused during the transportation of the waste. The present study thus develops a decision support system for optimal route analysis for the transportation of solid waste. This optimal route is obtained with minimization of distance, minimization of time and cost and presents a working and easy to use solid waste routing. For this Arc view GIS's network analyst is used. The network analyst of Arc View GIS may further be used in different studies like capacitated networks in which, Cost is minimized for a given flow between source and sink, flow is maximized between the source and sink at a given cost this is mainly to maximize the profit. The decision support system designed using Visual Basic for the present study is user-friendly and only simple applications of it are used. Further, it promises more professional and web applications like querying, report generating, adding and updating of database with skilled programming. Availing the latest sensor capabilities of Remote sensing technology and the advantages of GIS tool the best possible optimal route is designed and developed for the effective transportation of solid waste. The decision support system developed in this work can be applied for other metropolitan cities as well.

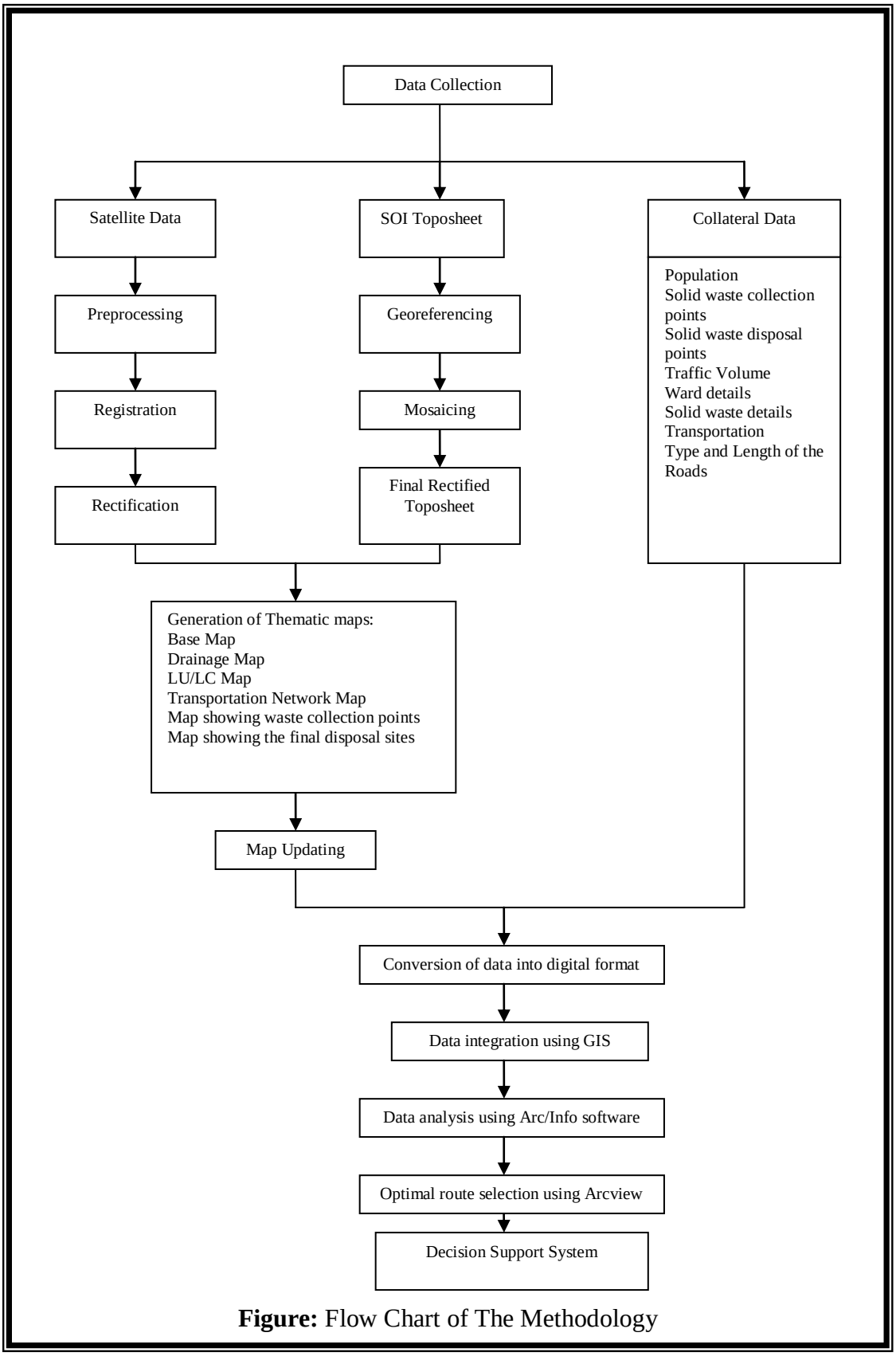


Figure: Flow Chart of The Methodology

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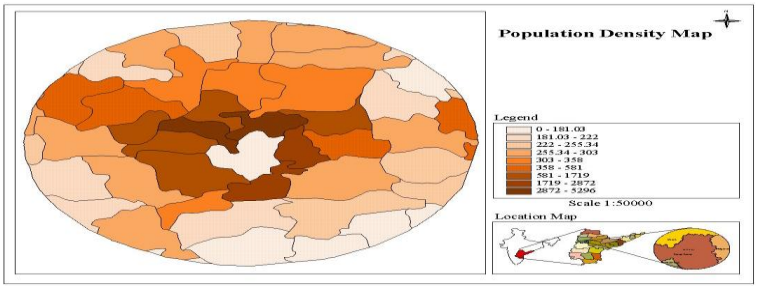
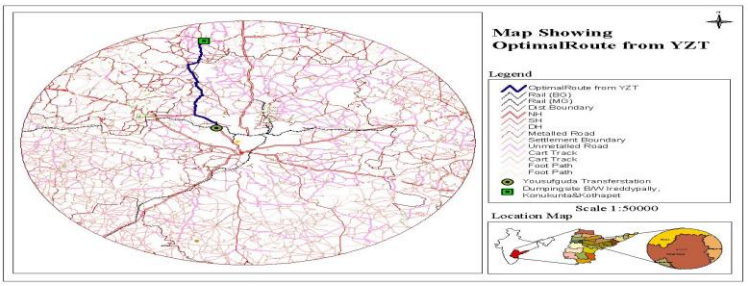
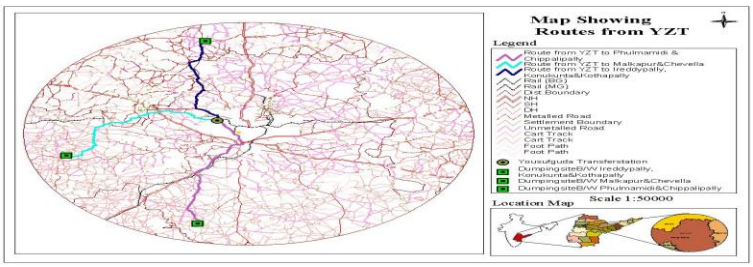
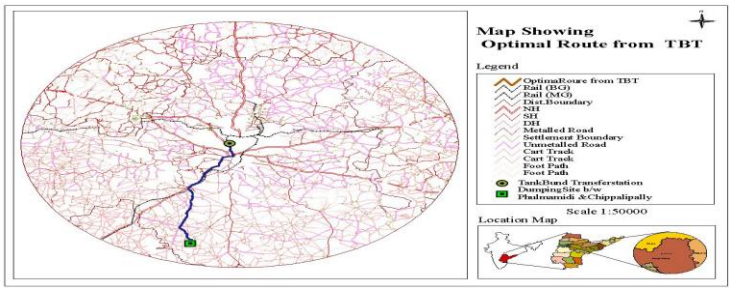
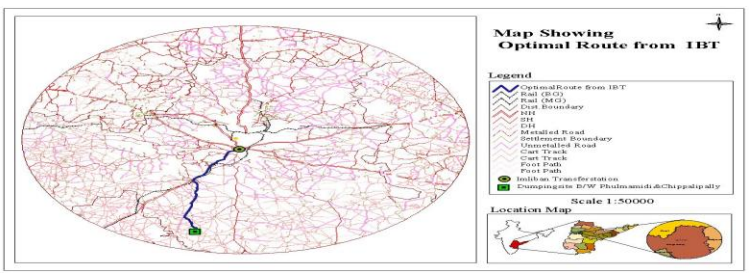
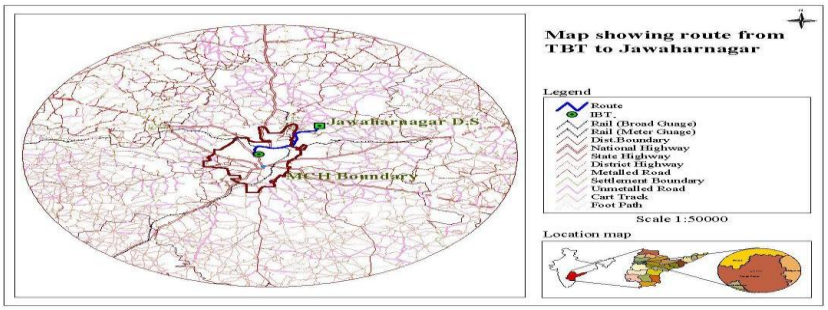

Population Density Map
Legend
0 - 181.03
181.03 - 222
222 - 255.34
255.34 - 303
303 - 358
358 - 581
581 - 1719
1719 - 2872
2872 - 5296
Scale 1:50000
Location Map

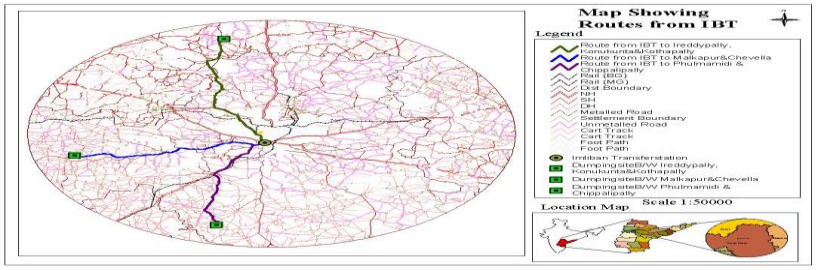

Map Showing
OptimalRoute from YZT
Legend
Scale 1:50000
Location Map

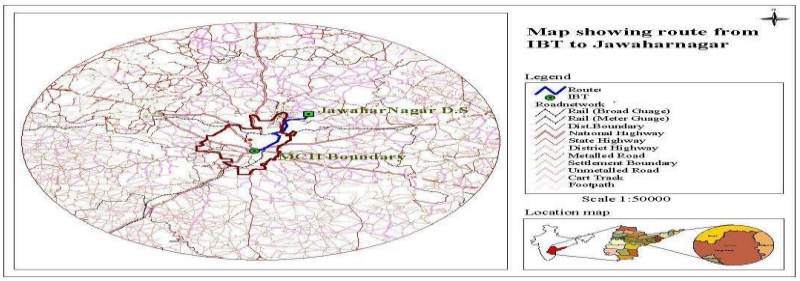

Map Showing
Routes from YZT
Legend
Scale 1:50000
Location Map

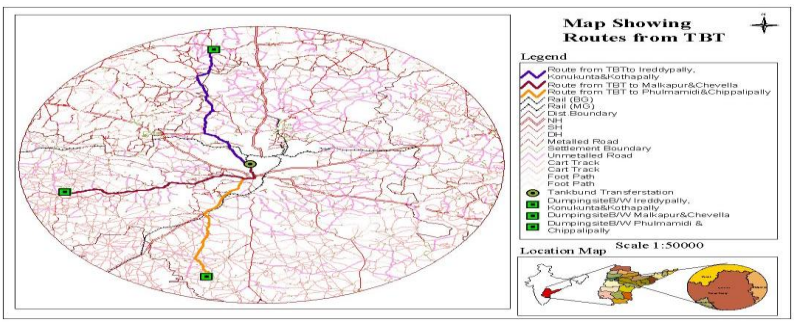

Map Showing
Optimal Route from TBT
Legend
Scale 1:50000
Location Map

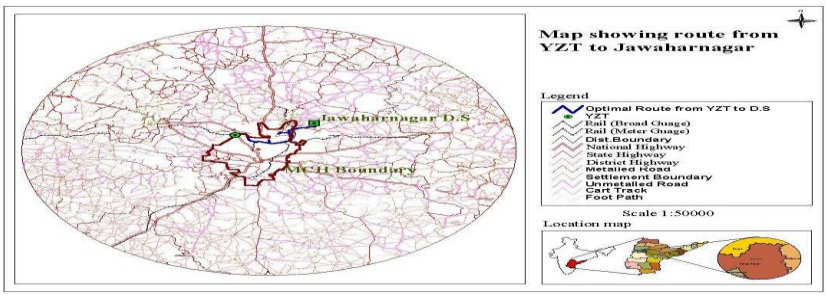

Map Showing
Optimal Route from IBT
Legend
Scale 1:50000
Location Map


Map showing route from TBT to Jawaharnagar
Legend
Route
IBT
Rail (Broad Guage)
Rail (Meter Guage)
Dist.Boundary
National Highway
State Highway
District Highway
Metalled Road
Settlement Boundary
Unmetalled Road
Cart Track
Foot Path
Scale 1:50000
Location map
Jawaharnagar D.S
MCH Boundary


Map Showing Routes from IBT
Legend
Route from IBT to Ireddypally, Konuluntal&Kothapally
Route from IBT to Malkapur&Chevella
Route from IBT to Phulmamidi & Chippalipally
Rail (BG)
Rail (MG)
Dist Boundary
NH
SH
DH
Metalled Road
Settlement Boundary
Unmetalled Road
Cart Track
Cart Track
Foot Path
Foot Path
Imlibun Transferstation
DumpingsiteB/W Ireddypally, Konuluntal&Kothapally
DumpingsiteB/W Malkapur&Chevella
DumpingsiteB/W Phulmamidi & Chippalipally
Scale 1:50000
Location Map


Map showing route from IBT to Jawaharnagar
Legend
Route
IBT
Roadnetwork
Rail (Broad Guage)
Rail (Meter Guage)
Dist.Boundary
National Highway
State Highway
District Highway
Metalled Road
Settlement Boundary
Unmetalled Road
Cart Track
Footpath
Scale 1:50000
Location map
JawaharNagar D.S
MCH Boundary


Map Showing Routes from TBT
Legend
Route from TBTto Ireddypally, Konuluntal&Kothapally
Route from TBT to Malkapur&Chevella
Route from TBT to Phulmamidi&Chippalipally
Rail (BG)
Rail (MG)
Dist Boundary
NH
SH
DH
Metalled Road
Settlement Boundary
Unmetalled Road
Cart Track
Cart Track
Foot Path
Foot Path
Tankbund Transferstation
DumpingsiteB/W Ireddypally, Konuluntal&Kothapally
DumpingsiteB/W Malkapur&Chevella
DumpingsiteB/W Phulmamidi & Chippalipally
Scale 1:50000
Location Map


Map showing route from YZT to Jawaharnagar
Legend
Optimal Route from YZT to D.S
YZT
Rail (Broad Guage)
Rail (Meter Guage)
Dist.Boundary
National Highway
State Highway
District Highway
Metalled Road
Settlement Boundary
Unmetalled Road
Cart Track
Foot Path
Scale 1:50000
Location map
Jawaharnagar D.S
MCH Boundary