

# GIS Based Route Optimization for Solid Waste Management: A Case Study of Surat City

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**Abstract**— In a municipal solid waste management system, collection/hauling costs, which consist of 85 % of total disposal expenditure, can be decreased by optimizing routes. Geographic information systems (GIS) can be valuable tools in the environmental planner's toolbox, saving time, money and headaches when planning collection routes. To use route optimization process, data related in present spending, truck type and capacity, solid waste production, number of inhabitants and Global Positioning System (GPS) receiver data for each route is collected and all the data are analyzed with each other. For two wards of the south zone of Surat city, a shortest path model can be used in order to optimize solid waste collection/hauling processes, as minimum cost can be aimed. The ArcGIS software as an optimization tool is used for that purpose. After performing routes by the software, the optimized routes are compared with the present routes.

**Key words:** Municipal Solid Waste Collection Data, GIS Technology, Arc GIS Software, Route Optimization, Comparison of Present and Proposed Scenario

## I. INTRODUCTION

In present time solid waste management is a worldwide ecological issue. In India this issue is not considered important. There is a high measure of misfortune regarding ecological corruption, wellbeing dangers and misfortune because of direct transfer of waste. There ought to be suitable getting ready for legitimate solid waste management by method for examination of the waste circumstance of the region. The development in the urban populace and movement has lead in an expanded solid waste era. Waste management includes a considerable measure of troubles amid operation and among these; waste accumulation is the most troublesome because of the high costs that are included. During the time spent solid waste management, more consideration ought to be paid towards accumulation as it requires 60-70% of the aggregate expense.

There is a recognizable measure of transfer of waste without appropriate isolation which prompts both economy and environment sufferings. Waste diminishment and reuse of items are both strategies for anticipation. This anticipates manages the arranging of solid waste management for streamlining of courses, gathering and transfer of solid waste. This study can be gainful to the wellbeing experts, arrangement creators and society. Information required for SWM in the Municipal Corporation region gathered, and issues in the framework are recognized. A GIS ideal steering model in light of the parameters, for example, waste era limit, street system and the sorts of street, stockpiling containers and accumulation vehicles, and so forth., is produced and used to follow the base cost/separation proficient gathering ways for transporting

the strong squanders to the exchange stations and from that point landfill.

### A. Use of ArcGIS Software in Route Optimization

GIS is an instrument for working with geological framework. GIS is a structure, constituted by a capable arrangement of instruments and advances resolved to secure, store, oversee, change, break down and imagine geo-referenced spatial information. Each record or occasion alluded to an incomplete bit of earth's surface is a case of geo-referenced data.

GIS is a database framework in which a large portion of the information are spatially filed and whereupon an arrangement of system is worked to answer inquiries about spatial substances in database. It is an effective device for gathering, putting away, recovering, changing and showing spatial information from this present reality.

GIS is another innovation which have contributed a considerable measure in less time range to the waste administration society. The GIS controls information in the PC to produce options and to take the best results.

Segments of Geographical Information System:

- Data (geographic data model and structures)
- Organizational structure and work strategies
- Software parts
- Hardware parts
  - Computer
  - Digitizer
  - Plotter
  - Printer
  - CD/DVD reader/ writer

### B. Need of the Study

Due to increased generation rate of municipal solid waste by increased population, higher community living standard and higher economic growth.

The existing situation is not satisfactory as municipal solid waste is not collected with 100% efficiency. There is a high amount of loss in terms of environmental degradation, health hazards and loss due to direct disposal of waste.

In the process of solid waste management, more attention needs to be paid towards collection as it itself requires 60-70% of the total cost.

### C. Objectives of the Study

To determine the optimum route for solid waste management for two wards of the South zone of Surat city. To compare the travel distance, fuel and time elapsed between the proposed optimum route and the existing run routes for the vehicles used for solid waste management.

## II. METHODOLOGY

### A. Description of Study Area

Surat covers 326.515 sq. km of zone out of which South zone (Udhna) covers 61.764 sq. km i.e. 18 % of the city range. Surat had a populace of 4.6 million at the 2011 statistics, out of which south zone had a populace of about 7 lakh. It is the eighth biggest city and ninth biggest metropolitan range of India. The city enrolled an annualized GDP development rate of 11.5 % over the seven monetary years somewhere around 2001 and 2008. The city has 2.97 million web clients which are around 65% of aggregate populace. Surat has a thickness of 13680 persons/sq. km out of which south zone has a thickness of 12311.04 persons/sq. km. surat has a ghetto populace of 481658 out of which south zone has a ghetto populace of 76025.

In Surat City (in year 2015), 1575 MT MSW is produced for each day. Out of them, 1499.44 MT/day waste was gathered (Average of 01/04/13 to 31/03/14) by Surat Municipal Corporation (SMC). (Source: www.suratmunicipal.gov.in).

There are 7 zones in the Surat city, to be specific North, East, West, South, Central, South-East and South-west. Every zone has various wards; out of which south zone have 10 wards.

South zone have 10 wards and each ward have 10-12 collection container spots. The waste is collected and transported to transfer stations of Bhestan and Anjana and then to solid waste dumping site Khajod. At transfer stations of Bhestan 50 MT/day and at Anjana approx. 40 MT/day Solid wastes is transferred through container vehicles. Time schedule is from 6 am to 2 pm for collection vehicles. Fuel is consumed form 18 to 23 litre/day and travel distance is from 70 to 90 km/day.

In these study two words, namely Vadod-Unn and Bhestan are studied from south zone of surat city.

### B. Description of Data collection and Spatial Database

To productively deal with the civil strong waste framework, point of interest spatial data is required. This data is identified with the land foundation of the territory under scrutiny, and additionally to spatial information identified with waste accumulation methodology. It contain study region limit, populace thickness, satellite picture, street system, area limit time timetable of waste receptacle.

Data	Source
Study area boundary	SMC corporation
Population density	Census 2011
Satellite image	Google earth and ArcGIS
Road network	SMC corporation and ArcGIS
Location of waste bin	SMC corporation
Capacities of bin	SMC corporation
Time schedule for the collection process	SMC corporation
Existing collection routes	SMC corporation
Vehicle fuel consumption	SMC corporation

Table 1: Data Collection and Their Source

For the advancement of the gathering procedure a spatial geodatabase was built, in a standard business GIS environment (ArcGIS). This guarantees similarity with

accessible information from region and numerous system defeats.

Spatial data	Details	Geometry
Road network	Main road and internal road	Line
Present waste bin	All type of waste bin present	Point
Land use	Residential, industrial, commercial, slum	Polygon

Table 2: Spatial Database- Type of Data and Its Geometry

### C. Digitization

The different definite improvement arrangements of Udhna (South Zone) at a size of 1:5000 were examined. The filtered pictures are then digitized utilizing Arc View GIS 10.1. The raster picture showed on the PC screen is changed over into vector representation. This procedure is known as heads up digitizing. The digitized documents will be in the .shp position.

### D. Geo-Processing Wizard

The Geo processing Wizard offers six Geo processing choices to make or increase highlight topics containing break down, union, cut, converge, union, allocate information by area. Combine procedure will make one topic that contains the components of two or more subjects. The new subject will contain the fields of one of the information topics. The alternative „Merge topics together“ was utilized to join the three individual shape documents together.

### E. Adding Attribute

Non spatial information, for example, street name, speed limit, number of containers and travel time in every street are included.

The digitized streets were recognized utilizing every city map and their names were allotted.

The pace furthest reaches of the gathering vehicle is thought to be 5, 10 or 12 km/hr relying on the width and volume of movement in every street.

The quantity of receptacles gathered in every fragment of the street amid the day and night movements of the compactor are accounted.

The accumulation time is summed up with the run time of the vehicle to get the aggregate travel time.

### F. Route Generation

After every one of the information were given as information, the ideal course was created utilizing Network Analyst, an augmentation of Arc View GIS 10.1.

#### 1) Network Analyst

The Arc View Network Analyst is an augmentation item intended to utilize arranges all the more productively. It can tackle basic system issues on any subject containing lines that associate. System Analyst can,

- 1) Find effective travel courses.
- 2) Figure out which office or vehicle is nearest.
- 3) Produce travel headings.
- 4) Discover an administration range around a sit.

G. Methodology Used

GIS give an intense setting to import, oversee and investigations spatially based information. Technique is actualizing in two stages.

- 1) Spatial database of study region.
- 2) Optimization of courses, least time, and separation.

H. Proposed Methodology

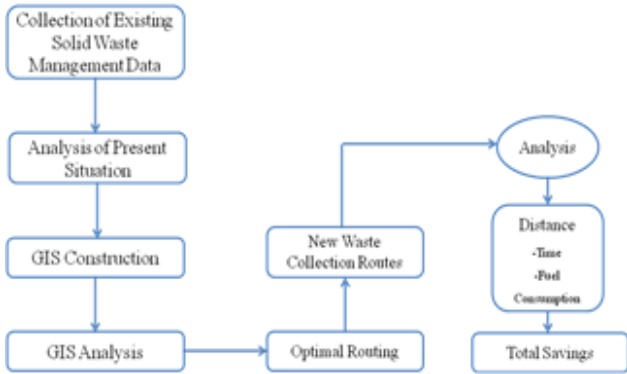


Fig. 1: Methodology of Study

ArcGIS Network Analyst is utilized to gauge interrelations between the dynamic elements, similar to network movement changes in the region under study and to create enhanced arrangements.

It can have the capacity to characterize or change all the required elements for the formation of an underlying situation, and by adjusting these specific parameters, elective situations can be created prompting a few arrangements. At long last, the ideal arrangement is recognized by a capacity that considers different parameters, for instance the briefest separation, street system and in addition social and ecological parameters.

III. RESULTS AND DISCUSSION

Sr. No.	Name	Travel distance (km)		
		Existing	Optimized	Reduction
1	Route_1	3.8	1.2	2.6
2	Route_2	6.6	4.4	2.2
3	Route_3	6.0	4.4	1.6
4	Route_4	5.2	4.6	0.6
5	Route_5	5.8	4.6	1.2
6	Route_6	5.8	3.2	2.6
7	Route_7	4.8	3.2	1.6
8	Route_8	3.8	2.8	1.0
	Total	41.4	28.4	13

Table 3: Comparison of Travel Distance of Vadod-Unn Ward

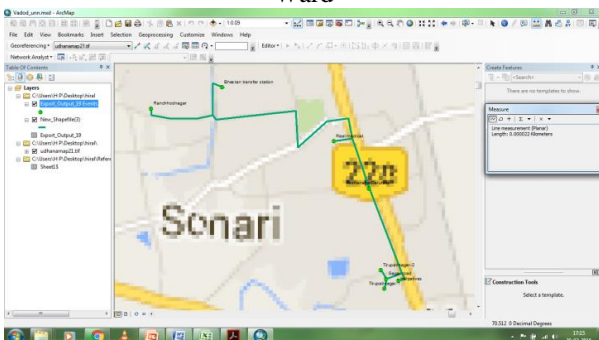


Fig. 2: Optimized Route Map of Vadod-Unn Ward (Source: ArcGIS software)

Sr. No.	Name	Travel distance (km)		
		Existing	Optimized	Reduction
1	Route_1	3.6	2.8	0.8
2	Route_2	3.6	2.8	0.8
3	Route_3	3.4	2.8	0.6
4	Route_4	3.5	2.8	0.7
5	Route_5	3.5	2.6	0.9
6	Route_6	2.9	2.4	0.5
7	Route_7	2.5	2.4	0.1
8	Route_8	1.1	2.2	-1.1
9	Route_9	1.9	2.4	-0.5
	Total	27.0	23.2	3.8

Table 4: Comparison of Travel Distance of Bhestan Ward

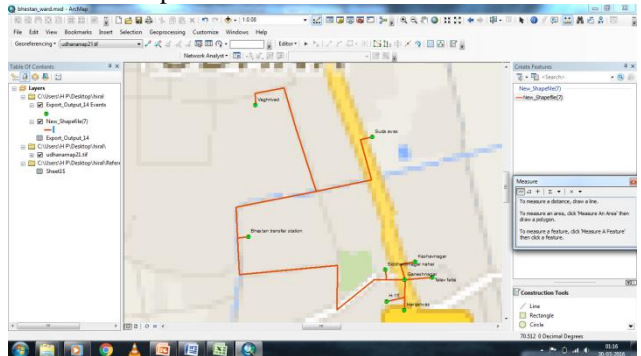


Fig. 3: Optimized Route Map of Bhestan ward (Source: ArcGIS Software)

In this work the solid waste course for vehicle in two wards of the south zone of Surat city is optimized by utilizing Arc map Network Analyst. With the GIS system, ideal course was distinguished which observed to be financially savvy and less tedious when contrasted and the current run course. The course is to acquire by Arc GIS is 16.83 km. also, time and fuel is saved with respect to the travel distance reduction. The product based examinations is rapidly/quick and straightforward when contrasted with manual investigations. So programming examinations likewise is the great choice for this sort of study.

IV. CONCLUSION

In the present study an endeavor has been made to improve the solid waste course for vehicle in two wards of the south zone of Surat city by utilizing Arc view Network Analyst. With the GIS strategy, ideal course was recognized which observed to be financially savvy and less tedious when contrasted and the current run course.

By analyzing and comparing existing and optimized Municipal Solid Waste Collection Routes for the two wards of the South Zone (Udhna) of Surat city, 22.74% of the Route length, time duration and fuel consumption can be minimized by GIS based Route Optimization, without changing the Transfer stations.

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