Title of the project	"GIS Based Route Optimization for Solid Waste Management: A Case Study of Bidar city - Karnataka, India"
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INTRODUCTION

1.1. General:

Solid waste collection is a major section of the process of solid waste management (SWM), and it is estimated to consume up to two-thirds of the entire SWM budget. The functional element of collection includes not only the gathering of solid waste and recyclable materials but also the transport of these materials, after collection, to the location where the collection vehicle is emptied.

The use of "Quantum Geographic systems" (QGIS) is recognised as one of the most promising approaches to analysing MSW collection and transportation systems. The use of QGIS for collection and transportation optimisation can provide economic and environmental gains by reducing travel time, distance, fuel consumption, and pollutant emissions.

1.3 STUDY AREA:

Bidar city is governed by Municipal Corporation which comes under Bidar Metropolitan Region. The Bidar city is located in Karnataka state of India. Bidar is located at 17.9°N 77.5°E,[26] lies at a central position in Deccan, a plateau at an elevation of 2300 ft from the sea level with a total area of around 69.7 km^2. As per provisional reports of Census India, population of Bidar in 2011 is 214,373;

1.8 Objective of the present study:
- Implementation of QGIS software for route Optimisation.
- To create the shortest route for households MSW Collection and Transportation.
- To make the process more economical.

METHODLOGY

Data Collection:

First, we collected the data like the word map, area, population, waste generation per capita, current route, modes of transport, and location of stations.

Some of the data we got from Bidar CMC and some data we had collected by doing surveys like "Road Side Interview" and "Origin-Destination Survey," in which we asked the AutoTipper driver to draw their travel route map in the provided local street map printout.

QGIS Work Flow:

- First, we opened a Google satellite map and located our study area, and then we attached the reference ward map pdf file with the help of the "Freehand Raster Georeferencer" plugin, which allows us to stretch, move, and rotate the raster file as per our requirements.
- Then we created the polygon ".shp" shape file of the ward map by tracing the reference map. By enabling "snapping" from the "snapping tool bar," our work became much easier.
- Then we extracted the road network map with the help of the "OSM Downloader" plugin, which allows us to create the road network map of the area just by selecting an area in the OSM standard map.
- Then we provided the ward map with details like area and population.
- Then we created the route map, which we got from surveying, with the help of the "ORS-Open Route Service" plug-in, which allows us to calculate the time and distance travelled by the vehicle on a particular path.
- With the same plugin, we created the shortest path with time and distance.
- Then we calculated the same for the trash truck, which will transfer the waste from the transfer station to the processing unit.
- After creating all the information, we added the study area map, north arrow, legends, scale bar, titling, and annotations in the print layout.

Collection and analysation of available data:

The data is to be collected from the "Bidar CMC Office" and by doing a "Road Side Survey" or "O-D Survey".

The data that we get from doing this is then analysed, and the results show that

- Bidar Old City has nine wards.
- Each ward has its own auto-tipper for Door-To-Door MSW collection.
- All the auto-tippers start their journey from the Bidar CMC Office.
- Every auto-tipper should dump their collected waste at the transfer station located at "Hyderabad Road, Near Karnataka College, Old City Fort Road Area, Bidar, Karnataka 585401."
- From there, a trash truck fills the dumped waste and transfers it to a processing unit located at "Sultanpur, Bidar, Karnataka 585402."
- Every auto-tipper is provided with a ward road map.
- But the direction is not provided on the map.
- Then we created the current ward map with the direction of vehicle movement with the help of QGIS software.
- After collecting all the data, we analysed the current time for transportation, distance of travel, fuel consumption, and cost of fuel per day, month, and year.
- The current time for nine vehicles in nine wards to collect and transport the MSW with stops every 50m for at least 3 minutes is a total of 27 hours and 14 minutes per day.
- The distance travelled by the vehicles is a total of 79.282km per year.
- Fuel consumption per year is about 1702 litres.
- The cost of fuel per year is 140653.75 rupees.

Analysis of Shortest Route:

The Shorest Route that we had created has the same number of vehicles for each ward, with different routes for circulation in each ward.

- The shortest route takes time for 9 vehicles in 9 wards to collect and transport the MSW with stops every 50m for at least 3 minutes, for a total of 23 hours and 25 minutes per day.
- The distance travelled by the vehicles is a total of 62.506km per day.
- Fuel consumption per year is about 1323 litres.
- The cost of fuel per year is 118763.7 rupees.

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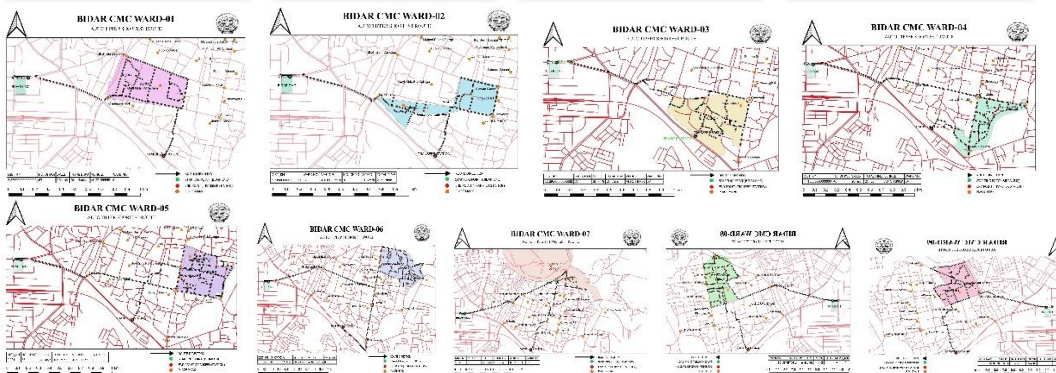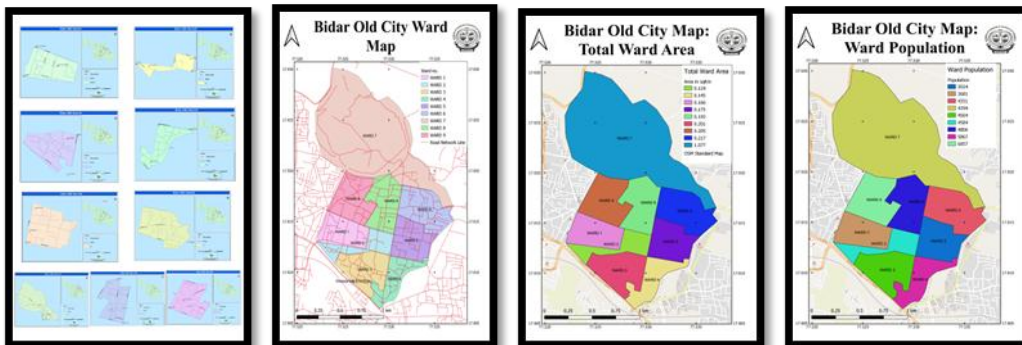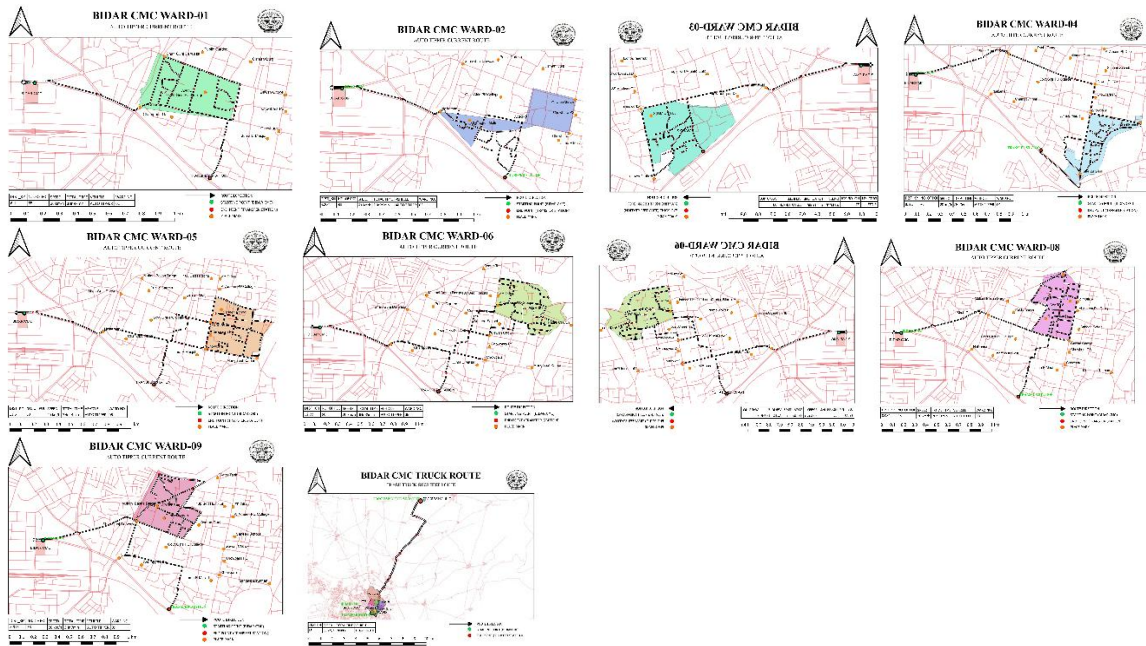
RESULS AND DISCUSSION

In the present work, an effort has been made to design and develop an appropriate collection and transportation plan for the Bidar City Municipality Corporation. Here, a GIS based optimal model is developed and used to trace the least cost. This minimum cost is with respect to a distance-efficient collection path in transferring the MSW to the processing unit. The shortest route is designed for Door-To-Door collection and transportation of MSW to the processing unit.

Implementing QGIS software helps to recreate the shortest route for waste collection and transportation, which is more efficient in comparison to the previous system.

The increase in efficiency in percentage is shown below.

- Total travel distance by 21% per day
- Time by 14% per day.
- Fuel consumption by 22.26% per year.
- Fuel cost by 21.16% per year.

The total savings are shown below:

- Total travel distance by 16.78 km per day
- Each day, subtract 3hr 41min.
- Fuel consumption by 379 litters per year
- Fuel cost by 31890.5 rupees per year.

CONCLUSION:

- Implementation of QGIS software for route optimisation has been very effective, and the work has been done remotely, which is much better than working at site. This can also be implemented for many other works in the MSW management system.
- By creating the shortest route for households MSW collection and transportation, we are able to reduce the overall time distance and fuel consumption, which makes the work more efficient.
- By creating the shortest route for MSW management, we were able to reduce the overall cost of the system, which will reduce the overall budget of municipal solid waste management and make the process more economical.

Thus, the proposed model can be adopted by the concerned authority. Further use of GIS can be adopted as a decision-support tool by the municipal authorities for efficient solid waste management with respect to transportation issues.

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