Optimization of Solid Waste Management Using Geographic Information System (Gis) for Durg City

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Abstract: **A rapid urbanization, surging population numbers, limitations of funding, emerging limitations of both energy and raw materials coupled with different increasing industrial, commercial and Social economic development in a durg city. The Durg city area has given rise to an increased generation of various types of wastes. Among these wastes, managing of solid waste is a major problem faced by the Durg city. The Durg city maintaining daily logs of collection and transport of solid waste is time consuming and difficult as it involves large filed data and statistics. 80% of the total cost of solid waste management is being spent on collection and transportation so there is to a need of proper monitoring of the system. This paper attempts to analyze the proposed status of location of municipal bins along with the various secondary routes followed for the solid waste collection of durg city. Then using Arc GIS 10 , a GIS based urban MSW management system is proposed for the study area by proper optimizing the waste collection and transportation routes and reallocating the bins for efficiency in distance travelled and time taken. Thus Geographical Information System model would reduce the complications in waste management system to some extent and exhibit remedies for the same in the study area.**

Keyword – **MSW Management, GIS Software, Cost Optimization**

I. INTRODUCTION

A Solid waste management is one of the major increasing problems faced by today's world. With the growth in socio economic and industrialization development, the generation of solid waste has also increased.[9]. The large percentage of urban population, due to the greater amount of solid waste production [2]. The Large quantities of waste generation by the cities are one of the serious outcomes of unplanned development. Due to the increasing population and industrialization, large quantities of wastes are being generated in different forms such as Solid, Liquid and Gases etc. Every city produces tones of solid waste daily from the household, hospitals, industries, agricultural fields, market centres etc. The management of this enormous waste in terms of collection, handling and disposal with conventional methods has become increasingly difficult [3]. we have studied on, collection and transport of municipal solid waste is responsible for a large portion of the total waste management costs, in the range of 70-100%.

Existing and New location for collection bins can be confronted with applying the advance geo technology like Geographical Information System (GIS) computerized tool [4]. Geographic Information Systems (GIS) i.e geo information technology have been successfully used in a wide variety of applications such as urban town planning, transportation planning , natural resources protection and management, health sciences related planning , forestry planning, geology structure planning , natural disasters prevention and relief planning , and various aspects of environmental modelling and as well as engineering. Among them, the study of one of the waste management systems, in particular sitting waste management and disposal facilities and optimizing the Waste Collection & Transportation have been a preferential field of GIS applications, from the early onset of the technology [4]. The problem during vehicle routing is a common one: which is each vehicle must travel in the study area and collect all the waste bins, in a way that minimizes the total travel cost: most often distance and time. As the success of these decision making tool process depends largely on the quantity and quality of information that is made available to the decision makers. The use of GIS software modelling tool as a support tool has grown in recent years, due to these technology easily and conveniently waste collected large quantity and geo spatial information of the earth [8]. The route is optimize of the Collection and Transportation making use of these tools work on spatial modelling techniques is used to provide large economic and environmental savings through the ce, is effect to fuel consumption and pollutants emissions. The object of this work is to develop a modified methodology for the optimization of the waste collection and transportation system, based on GIS software technology. The methodology was applied to the Durg city of Municipal Corporation (DMC), based on real field data. The strategy consisted of

1) Analyzing the existing status of MSW collection bins with their locations for zone wise under Durg City.
2) Analyzing the Proposed collection and transportation routes.

3) Optimization of the above waste collection routes in terms of minimum time and distance criteria taken using Network Analyst of Arc GIS 10
4) New approach of location of the waste collection community bins through field survey as well as rescheduling waste collection routes via GIS routing optimization.
5) The above scenarios that is in terms of time and distance taken,
6) The benefits of these proposed strategies were assessed in terms of quantity of waste collected and transported in minimizing the collection time and distance travelled

II. ABOUT THE CITY

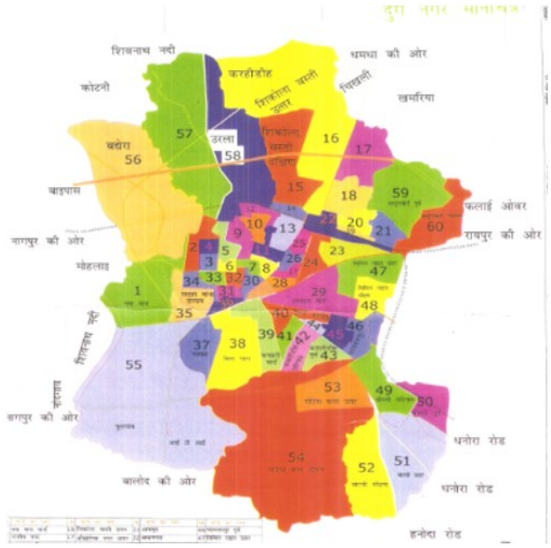

Figure 1: Different Wards of Durg city Municipal Corporation

Table 1: Details of Ward

S.N.	Name of Ward	Population	Area Sq. Km.
1	Nayapara	7547	1.5000
2	Rajiv Nagar	4923	0.3260
3	Mathpara (North)	4161	0.1089
4	Mathpara (South)	3136	0.1073
5	Mararpara	4018	0.2344
6	Thethvar Para	2919	0.0515
7	Killa Mandir	3417	0.1019
8	Takiya Para	5091	0.1350
9	Swami Vivekanand	4595	0.2730
10	Shankar Nagar (West)	4746	0.1213
11	Shankar Nagar (East)	4525	0.1950
12	Mohan Nagar (West)	4486	0.1450
13	Mohan Nagar (East)	4459	0.3556
14	Sikola Bhatha	4192	0.1492
15	Sikola Basti (South)	4645	1.2710
16	Sikola Basti (North)	6078	1.2460
17	Audhogik Nagar (North)	4891	0.9294
18	Audhogik Nagar (South)	6089	0.4880
19	Shahid Bhagat Singh (South)	6599	0.0610
20	Shahid Bhagat Singh (North)	3003	0.2413
21	Titurdin	5352	0.2942
22	Station Para	3581	0.4288
23	Deepak Nagar	4165	0.3688
24	Amdi Mandir	4582	0.2488
25	Gayatri Mandir	3390	0.1249
26	Santrabadi	4002	0.1246
27	Polsaya Para	4118	0.0910
28	Pachri Para	3481	0.1123
29	Asaptal Ward	2581	0.8743
30	Tamer Para	2747	0.1413
31	Aapapura	2918	0.1225
32	Bramhan Para	3915	0.1135
33	Chandi Mandir	3873	0.1159

2.1 City Profile

A Durg city is a major city in Chhattisgarh state, central India east of the Seonath River (Shivnath River) and is part of the Durg-Bhilai urban agglomeration [20]. The Durg city is an agricultural market available and heavily engaged in milling rice and pigeon peas. Durg city are importance as an industrial hub center after the establishment of a large steel plant at Bhilai. Other industries include brass working and bell-metal working, oil pressing, mining and weaving. It is the headquarters of Durg District, is a third largest district of Chhattisgarh.. The Durg municipal corporation was earlier divided into these 60 wards .In the present study, Durg city Municipal Corporation has been chosen for efficient management of MSW[16].

	Ward		
34	Shivpara	4252	0.1917
35	Ramdev Mandir	4872	0.4860
36	Ganjpara	3143	0.1477
37	Aazad Ward	3446	0.6551
38	Milpara	4623	1.0810
39	Kachahri Ward	6805	0.7024
40	Surana College Ward	4168	0.3366
41	Kelabadi	5497	0.2110
42	Kasaridih (West)	6593	0.3110
43	Kasaridih (East)	4683	0.3090
44	Babu guru Ghasidas Ward	4337	0.0695
45	Padamnabhpur (West)	4051	0.2351
46	Padamnabhpur (East)	4921	0.4572
47	Civil Line (North)	4658	0.8383
48	Civil Line (South)	5059	0.4837
49	Borsi (West)	3931	0.8410
50	Borsi (East)	3885	0.7360
51	Borsi (South)	8620	0.6394
52	Borsi (North)	5251	2.1000
53	Potiyakala (North)	7187	0.8880
54	Potiyakala (South)	3614	6.1024
55	Pulgaon	5049	6.0815
56	Baghera	8240	4.0540
57	Urla (East)	5498	2.4000
58	Urla (West)	4198	2.8600
59	Katulbod (East)	5160	1.3913
60	Katulbod (West)	3779	0.8716
			46.6880

III. DATA COLLECTION AND DESCRIPTION

For the efficient management of the municipal solid waste collection and transportation system, detailed spatial information is required. This real information is related to the geographical condition background of the area under investigation as well as to spatial data related to the waste collection and transportation procedure. the study area Durg city Municipal Corporation, a large database of waste management data has been collected and statistically analysed like field data i.e. population, waste generation, number, type and positions of waste bins, the road network and the related traffic , the current routing system of the collection vehicles, and, the geographic borders. Thus, for the new location of bins and optimisation of the collection and transportation routes the following data were generated (data source in the bracket)[4]:

- Study area boundary (Durg Corporation)
- Land use of the study area (toposheet)
- Satellite image of the area (Google Earth)
- Road network of the study area (toposheet)
- Road class information (official toposheet plan, Durg Corporation, field work)
- Existing Location of waste bins (Durg Corporation, field work)
- Capacities of bins (Durg Corporation, field work)
- Time schedule for the collection process (Durg Corporation, field work)
- Proposed Location of waste bins (Durg Corporation, field work)

For this project, the total 164 collection routes for waste collection in Durg Corporation area, 164 routes viz; Collection Route (CR) . CR1 to CR 164 are being chosen for route optimization by GIS. For the project a spatial geo database was designed and implemented using standard commercial GIS software (ESRI, Arc GIS 10). Background spatial data for road network, existing routes, bins and geographical boundary were obtained from Durg city Municipal Corporation. These data were updated with field work and other non spatial data such as road length, road name, road type road width , vehicle average speed, travel time, bin number, bin type , bin capacity, bin collection time are added. Furthermore, spatial attributes of road network were registered. These attributes included traffic rules, traffic marks, and special restrictions (e.g. turn restrictions) in order to model efficiently the real world road network conditions.

Table 2: The Spatial Database- Type of Data and the corresponding Geometry

Spatial Data	Type	Geometry
Zone boundary	Vector	Polygon
Road network	Vector	Line
Waste bins	Vector	Point
Existing run routes	Vector	Line

Road networks attributes/ restriction	Tabular	-
Waste bins attribute	Tabular	-
Population data	Tabular	-
Satellite image	Raster	-

IV. METHODOLOGY

4.1 Spatial Database Development

In order to analyse the spatial data for the optimisation of the waste collection scheme, a spatial database (SDB), within a GIS framework, was constructed. The main sources of the SDB are (a) toposheet, (b) maps digitized in Autodesk 2014 (c) data derived from field work [1].

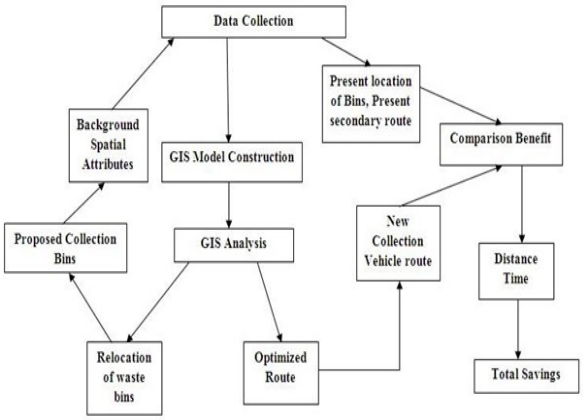

Figure 2: Proposed Methodology

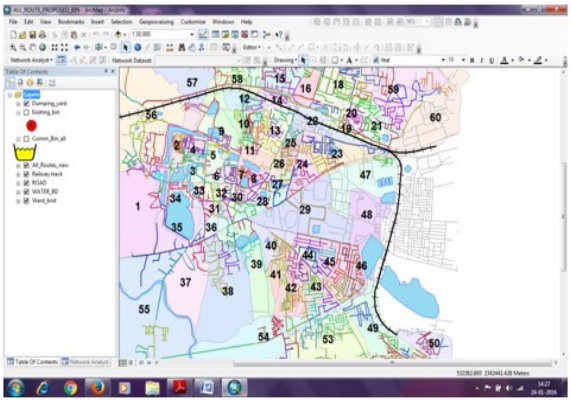

Figure 3: Road Networks of Durg Corporation

4.2 Reallocation of waste collection bins

The next phase of the proposed methodology is related to reallocation of waste collection bins wherever required. This analysis is implemented in a GIS environment with the use of sophisticated spatial analysis functions. The placement of the waste collection bins in their newly proposed positions is based on the following criteria:

First, the number of present bins is determined by field study and data from Durg Corporation. Next, the reallocation of these bins in the study area is performed according to the following rules:

1) Allocate bins wherever open dumps are found

2) Allocate bins on the road network (intersections are preferable);

3) Install new bins near existing bin locations and

4) Allow the placement of more than one bin at the same intersection. The number of the bins sharing the same intersection point is related to the surrounding land use and the population of the covered area.

4.3 Routing- Network Analysis

For the purpose of optimization of routes, the Arc GIS 10, Network Analyst modelling is used. To use it within the context of real transportation data, Network Analyst model includes real problem restrictions, such as one-way roads, prohibited turns (e.g. U-turns), demand at intersections (nodes) and along the roads, etc. These points correspond to pairs of vehicle stops (waste bins). The total travel time for the optimal route is the sum of the travel time for each road segment plus the collection time for the waste collection bins. The final output is an optimal solution in terms of distance and time criteria. For the purpose of optimization of routes, the Arc GIS 10 Network Analyst modelling is used. To use it within the context of real transportation data, Network Analyst model.

V. RESULTS AND DISCUSSION

The method described above was applied to analyse the waste collection scheme for zone A of Durg city Municipal Corporation area. Two different optimisation approaches were considered:

1) Optimization of collection routes CR1 to CR 164 by the developed by GIS model.

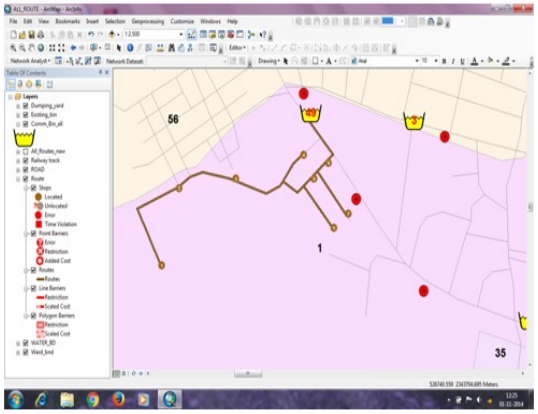

Figure 4: Present Collection Route _01

2) Optimization of Transportation Routes TR1 to TR 25 by the developed by GIS model.

Table No.3 Summary Sheet of All Waste Collection Route

Collection _Route _ No.	Ward Wise Route	Volume of waste	Ward No.	Com. BIN No	Time for Collection	Start Time	End Time	Distance
CR_01	Route_No_01	0.0255	1	49	58 min	07:00	07:58	0.9 km
CR_02	Route_No_02	0.1053		1	17 min	10:30	10:47	0.5 km
CR_03	Route_No_03	0.1383		49	20 min	08:30	08:50	0.5 km
CR_04	Route_No_04	0.0855		1	22 min	09:10	09:32	0.6 km
CR_05	Route_No_05	0.1335		2	51 min	11:10	12:01	0.9 km
CR_06	Route_No_06	0.081		5	34 min	12:20	12:54	0.7 km
CR_07	Route_No_01	0.0513	2	6	44 min	07:00	07:44	1.7 km
CR_08	Route_No_02	0.0615		5	1 hr 1 min	09:00	10:01	1.8 km
CR_09	Route_No_03	0.018		1	25 min	11:10	11:35	0.9 km
CR_10	Route_No_04	0.228		6	12 min	08:10	08:22	0.6 km
CR_11	Route_No_01	0.411	3	7	1 hr 18 min	07:00	08:18	1.6 km
CR_12	Route_No_01	0.369	4	8	10 min	07:00	07:10	0.6 km
CR_13	Route_No_02	0.5955		8	1 hr 49 min	09:00	10:49	2.2 km
CR_14	Route_No_03	0.0465		8	1 hr 54 min	09:30	11:54	1 km
CR_15	Route_No_01	0.8145	5	8	1 hr 43 min	10:10	11:53	1.3 km
CR_16	Route_No_02	0.5055		8	1 hr 8 min	07:00	08:08	0.8 km
CR_17	Route_No_01	0.324	6	9	1 hr 50 min	08:45	10:35	1.8 km
CR_18	Route_No_02	0.0555		7	1 hr 15 min	07:00	08:15	1.4 km
CR_19	Route_No_01	0.483	7	9	1 hr 52 min	07:00	08:52	1.6 km
CR_20	Route_No_02	0.357		10	1 hr 14 min	10:00	11:14	1.2 km
CR_21	Route_No_03	0.5415		9	1 hr 26 min	07:00	08:26	1.5 km
CR_22	Route_No_01	0.3015	8	10	1 hr 12 min	09:30	10:42	1.3 km
CR_23	Route_No_02	0.489		10	2 hr 13 min	07:00	09:13	3.4 km
CR_24	Route_No_01	0.519	9	8	1 hr 22 min	07:00	08:22	1.1 km
CR_25	Route_No_01	0.2835	10	14	1 hr 25 min	09:00	10:25	1.1 km
CR_26	Route_No_02	0.153		12	1 hr 35 min	11:30	13:05	1.5 km
CR_27	Route_No_03	0.528		14	14 min	07:00	07:14	0.4 km
CR_28	Route_No_04	0.507		12	1 hr 5 min	09:00	10:05	1.6 km
CR_29	Route_No_05	0.4065		14	1 hr 11 min	07:00	08:11	1.2 km
CR_30	Route_No_01	0.3015	11	13	46 min	09:00	09:46	0.8 km
CR_31	Route_No_02	0.1395		25	1 hr 22 min	07:00	08:22	1.5 km
CR_32	Route_No_01	0.999	12	14	1 hr 8 min	09:00	10:08	1.3 km
CR_33	Route_No_02	0.372		12	55 min	07:00	07:55	1.3 km
CR_34	Route_No_01	0.282	13	11	1 hr 45 min	07:00	08:45	2.4 km
CR_35	Route_No_02	0.5625		13	2 hr 24 min	07:00	09:24	2.2 km

CR_36	Route_No_03	0.7785		11	1 hr 27 min	10:00	11:27	1.6 km
CR_37	Route_No_04	0.492		13	1 hr 58 min	11:00	12:58	3.5 km
CR_38	Route_No_05	0.4875		15	51 min	09:10	10:01	1.3 km
CR_39	Route_No_01	0.8415	**14**	16	2 hr 9 min	07:00	09:09	3.2 km
CR_40	Route_No_02	0.1815		16	3 hr 20 min	07:00	10:20	3.3 km
CR_41	Route_No_01	0.822	**15**	17	1 hr 37 min	07:00	08:37	3 km
CR_42	Route_No_02	1.3665		17	37 min	10:00	10:37	3.3 km
CR_43	Route_No_01	0.201	**16**	18	43 min	10:00	10:43	1.7 km
CR_44	Route_No_02	0.1215		18	1 hr 22 min	07:00	08:22	4 km
CR_45	Route_No_01	0.417	**17**	18	1 hr 47 min	07:00	08:47	2.8 km
CR_46	Route_No_01	1.0275	**18**	19	2 hr 15 min	09:30	11:45	2.7 km
CR_47	Route_No_02	0.873		19	1 hr 3 min	07:00	08:03	1.7 km
CR_48	Route_No_03	0.009		19	49 min	09:00	09:49	1.2 km
CR_49	Route_No_04	0.3345		18	35 min	10:30	11:05	1.3 km
CR_50	Route_No_05	0.01351		20	1 hr 18 min	07:00	08:18	1.8 km
CR_51	Route_No_01	1.194	**20**	16	25 min	09:00	09:25	1.3 km
CR_52	Route_No_02	0.3375		16	2 hr 50 min	07:00	09:50	3.4 km
CR_53	Route_No_03	0.486		19	57 min	07:00	07:57	1.4 km
CR_54	Route_No_04	0.235		19	1 hr. 59 min	11:00	01:00	2.5 Km
CR_55	Route_No_01	0.2205	**21**	20	1 hr 22 min	10:00	11:22	2.4 km
CR_56	Route_No_02	0.5055		20	2 hr 20 min	09:30	11:50	2.5 km
CR_57	Route_No_03	0.4245		21	49 min	07:00	07:49	2.5 km
CR_58	Route_No_01	0.255	**22**	20	45 min	11:15	12:20	1.2 km
CR_59	Route_No_02	0.117		22	2 hr 59 min	07:00	09:59	1.9 km
CR_60	Route_No_01	0.195	**23**	22	1 hr 16 min	11:00	12:16	1.5 km
CR_61	Route_No_02	0.363		23	2 hr	07:00	09:00	2.7 km
CR_62	Route_No_01	1.3125	**24**	15	2 hr 4 min	07:00	09:04	1.6 km
CR_63	Route_No_02	0.4215		23	2 hr 30 min	10:30	13:00	2.8 km
CR_64	Route_No_03	0.9525		23	1 hr 45 min	10:00	11:45	1.4 km
CR_65	Route_No_04	0.417		23	3 hr 26 min	07:00	10:26	3.6 km
CR_66	Route_No_01	1.1655	**25**	15	1 hr	07:00	08:00	0.9 km
CR_67	Route_No_01	0.858	**26**	26	2 hr 56 min	07:00	09:56	2.5 km
CR_68	Route_No_01	1.2846	**27**	27	1 hr 16 min	11:30	12:46	0.9 km
CR_69	Route_No_02	0.633		27	1 hr 38 min	07:00	08:38	1.2 km
CR_70	Route_No_01	0.6735	**28**	10	56 min	07:00	07:56	0.9 km
CR_71	Route_No_02	0.516		10	1 hr 53 min	09:00	10:54	2.2 km
CR_72	Route_No_03	0.186		27	1 hr 34 min	07:00	08:34	1.2 km
CR_73	Route_No_01	0.5565	**29**	33	1 hr 11 min	09:30	10:41	2.7 km

CR_74	Route_No_01	0.78	**30**	10	2 hr 1 min	07:00	09:01	2 km
CR_75	Route_No_02	0.333		28	2 hr 14 min	10:00	12:14	3 km
CR_76	Route_No_01	0.579	**31**	7	1 hr 32 min	07:00	08:32	1.7 km
CR_77	Route_No_01	0.687	**32**	28	2 hr 5 min	07:00	09:05	1.9 km
CR_78	Route_No_02	0.633		9	1 hr 48 min	10:30	12:19	1.2 km
CR_79	Route_No_01	0.8675	**33**	29	2 hr 20 min	07:00	09:20	1.9 km
CR_80	Route_No_02	0.6705		7	58 min	11:00	11:58	0.8 km
CR_81	Route_No_01	0.1215	**34**	1	1 hr 46 min	07:00	08:46	1.7 km
CR_82	Route_No_02	0.4995		2	1 hr 42 min	10:00	11:42	0.9 km
CR_83	Route_No_01	1.1475	**35**	29	2 hr 28 min	07:00	09:28	2.6 km
CR_84	Route_No_02	0.93		1	35 min	11:00	11:35	0.4 km
CR_85	Route_No_01	0.6	**36**	28	1 hr 42 min	07:00	08:42	1.3 km
CR_86	Route_No_01	0.465	**37**	29	1 hr 30 min	07:00	08:30	2.1 km
CR_87	Route_No_01	1.205	**38**	29	3 hr 30 min	07:00	10:30	3.9 km
CR_88	Route_No_02	0.7185		29	2 hr 7 min	10:30	12:37	1.9 mi
CR_89	Route_No_01	1.32	**39**	31	2 hr 28 min	07:00	09:28	2.9 km
CR_90	Route_No_02	0.5385		28	1 hr 45 min	11:00	12:45	2 km
CR_91	Route_No_03	0.9915		28	1 hr 9 min	07:00	08:09	1.2 km
CR_92	Route_No_01	0.8745	**40**	32	2 hr 44 min	07:00	09:44	2.5 km
CR_93	Route_No_02	0.3735		32	1 hr 36 min	11:10	12:46	2.5 km
CR_94	Route_No_03	0.9075		31	1 hr 18 min	07:00	08:18	1.4 km
CR_95	Route_No_01	1.824	**41**	31	2 hr 17 min	10:00	12:17	2.5 km
CR_96	Route_No_01	0.507	**42**	32	2 hr 50 min	07:00	09:50	2.4 km
CR_97	Route_No_02	0.3315		34	1 hr 53 min	07:00	08:53	2.1 km
CR_98	Route_No_03	0.8775		36	2 hr 58 min	07:00	09:58	2.7 km
CR_99	Route_No_04	0.7245		36	2 hr 43 min	07:00	09:43	3.5 km
CR_100	Route_No_01	0.939	**43**	36	2 hr	07:00	09:00	2.8 km
CR_101	Route_No_02	0.7725		36	1 hr 18 min	10:30	11:48	3.3 km
CR_102	Route_No_03	0.6405		34	2 hr	07:00	09:00	2.1 km
CR_103	Route_No_01	0.42	**44**	32	2 hr	07:00	09:01	2.1 km
CR_104	Route_No_01	0.8565	**45**	33	1 hr 5 min	07:00	08:05	1.4 km
CR_105	Route_No_02	0.438		34	1 hr 3 min	08:45	09:48	1.6 km
CR_106	Route_No_03	0.4125		33	1 hr 57 min	10:45	12:43	2.6 km
CR_107	Route_No_01	0.654	**46**	39	2 hr 13 min	07:00	09:13	3.7 km
CR_108	Route_No_02	0.93		39	1 hr 48 min	11:45	13:33	2 km
CR_109	Route_No_03	0.9255		39	1 hr 15 min	07:00	08:15	1.2 km
CR_110	Route_No_04	0.5265		39	2 hr 13 min	09:00	11:13	3 km
CR_111	Route_No_01	0.261	**47**	24	47 min	07:00	07:47	1.2 km

CR_112	Route_No_01	0.318	**49**	38	1 hr 37 min	07:00	08:37	1.9 km
CR_113	Route_No_02	0.735		40	1 hr 29 min	09:40	11:09	1.8 km
CR_114	Route_No_03	0.324		40	55 min	07:00	07:55	1.1 km
CR_115	Route_No_04	0.468		41	1 hr 22 min	09:00	10:22	1.4 km
CR_116	Route_No_05	0.363		40	59 min	07:00	07:59	1.2 km
CR_117	Route_No_06	0.3585		41	2 hr 49 min	09:30	12:19	4.2 km
CR_118	Route_No_07	0.387		40	56 min	12:30	01:30	2.2 Km
CR_119	Route_No_01	0.4545	**50**	43	7 min	07:00	07:07	0.5 km
CR_120	Route_No_02	0.624		43	2 hr 35 min	07:30	10:05	2.5 km
CR_121	Route_No_03	0.834		42	1 hr 57 min	07:00	08:57	2.2 km
CR_122	Route_No_04	0.171		42	1 hr 21 min	09:30	10:51	1.2 km
CR_123	Route_No_05	1.4709		42	50 min	11:00	11:50	2.8 km
CR_124	Route_No_01	0.0045	**51**	42	1 hr 38 min	07:00	08:38	2.7 km
CR_125	Route_No_02	0.6165		40	1 hr 35 min	09:10	10:45	1.7 km
CR_126	Route_No_03	0.546		42	58 min	07:00	07:58	1.4 km
CR_127	Route_No_04	0.453		40	1 hr 26 min	09:00	10:26	1.7 km
CR_128	Route_No_01	0.7695	**53**	36	1 hr 39 min	07:00	08:39	1.7 km
CR_129	Route_No_02	0.288		36	1 hr	10:00	11:00	2.5 km
CR_130	Route_No_03	0.24		37	24 min	12:00	12:24	1.4 km
CR_131	Route_No_04	0.639		35	32 min	07:00	07:32	2.6 km
CR_132	Route_No_05	0.285		38	1 hr 13 min	08:15	09:28	2.5 km
CR_133	Route_No_06	0.0615		36	1 hr 50 min	10:00	11:50	2.6 km
CR_134	Route_No_01	0.078	**54**	47	14 min	07:00	07:14	1.7 km
CR_135	Route_No_02	0.741		37	32 min	07:40	08:12	1.4 km
CR_136	Route_No_03	0.456		37	2 hr 32 min	09:00	11:32	2.6 km
CR_137	Route_No_04	0.067		38	1 hr 45 min	07:00	08:45	3.4 km
CR_138	Route_No_05	0.1305		38	1 hr 53 min	10:00	11:53	3.6 km
CR_139	Route_No_06	0.1296		37	1 hr.	12:00	01:00	2.7 Km
CR_140	Route_No_01	0.887	**55**	29	1 hr 53 min	07:00	08:53	4.4 km
CR_141	Route_No_02	0.8185		29	1 hr 21 min	10:00	11:21	3.4 km
CR_142	Route_No_03	0.441		47	1 hr 36 min	07:00	08:36	2.9 km
CR_143	Route_No_04	0.486		47	1 hr 16 min	10:00	11:16	3.6 km
CR_144	Route_No_01	0.1215	**56**	49	39 min	07:00	07:39	1.9 km
CR_145	Route_No_02	0.3495		48	42 min	08:30	09:12	1.5 km
CR_146	Route_No_03	0.276		49	24 min	10:30	10:54	1.1 km
CR_147	Route_No_04	0.2655		49	1 hr 34 min	07:00	08:34	1.8 km
CR_148	Route_No_05	0.2865		3	34 min	10:00	10:34	1.2 km
CR_149	Route_No_06	0.132		3	19 min	11:30	11:49	1.2 km

CR_150	Route_No_07	0.69		48	25 min	07:00	07:25	1.7 km
CR_151	Route_No_08	0.2055		48	1 hr 20 min	08:30	09:50	3.8 km
CR_152	Route_No_09	0.054	**57**	17	1 hr 16 min	07:00	08:16	4.5 km
CR_153	Route_No_01	0.084		8	1 hr 7 min	09:30	10:37	3.2 km
CR_154	Route_No_02	0.2985		48	15 min	12:00	12:15	1.5 km
CR_155	Route_No_03	0.3315	**58**	17	39 min	07:00	07:39	2.1 km
CR_156	Route_No_04	0.204		17	29 min	08:20	08:49	2 km
CR_157	Route_No_05	0.069		17	45 min	10:00	10:45	2.4 km
CR_158	Route_No_01	0.3435		46	1 hr 9 min	07:00	08:09	2.5 km
CR_159	Route_No_02	0.4095		44	24 min	08:40	09:04	0.9 km
CR_160	Route_No_03	0.0555	**59**	46	1 hr 6 min	11:00	12:06	2.8 km
CR_161	Route_No_04	0.6405		21	1 hr 54 min	07:00	08:54	3.6 km
CR_162	Route_No_05	0.522		45	1 hr 14 min	11:00	12:14	2.3 km
CR_163	Route_No_06	0.4205		45	1 hr. 51 min	07:00	08:51	2.7 Km
CR_164	Route_No_01	0.4415	**60**	44	24 min	10:30	10:54	0.9 km

Table No.4 Summary Sheet of All Waste Collection Route

Route No.	**Waste Generated in BIN**	**Ward No.**	**Community Bin No.**	**Start Time**	**End Time**	**Distance Covered**	**Time Required For Travelling (Min.)**	**Time Required For Loading(Min.)**	**Time Required For Un-Loading(Min.)**	**Total Time (Min.)**	**Total Distance Covered Km.**
Route _NO_1	2.9655	24	15	1:10	1:50	5.6	40	20	20	80	11.2
Route _NO_2	2.934	5	8	1:10	1:51	5.7	42	20	20	82	11.4
Route _NO_3	2.5545	16	16	1:10	1:52	6.2	44	20	20	84	12.4
Route _NO_4	2.847	15	17	1:10	2:02	7	50	20	20	90	14
Route _NO_5	3.117	8	10	1:10	1:45	4.5	32	20	20	72	9
Route _NO_6	1.9815	32	9	1:10	1:47	4.8	34	20	20	74	9.6
Route _NO_7	2.7115	20	19	1:10	1:56	7.4	52	20	20	92	14.8
Route _NO_8	3.036	46	39	1:10	1:42	3.3	24	20	20	64	6.6
Route _NO_9	3.15	39	28	1:10	1:44	4	28	20	20	68	8
Route _NO_10	3.0264	50	42	1:10	1:46	3.8	32	20	20	72	7.6

Route _NO_11	2.8785	51	40	2:45	2:58	3.2	26	20	20	66	6.4
Route _NO_12	2.3151	02,35	06,05,01,02	2:45	4:01	7.3	54	80	20	154	14.6
Route _NO_13	3.047	59, 21,47	45,44,20,24	3:10	4:03	7.8	58	80	20	158	15.6
Route _NO_14	2.538	21,59, 18	21,46,18	3:15	4:35	9.1	66	60	20	146	18.2
Route _NO_15	2.2521	1,55	49, 03, 47	3:30	4:50	8.1	60	60	20	140	16.2
Route _NO_16	2.7135	56,22, 26	48,22,26	3:10	3:20	10.2	76	60	20	156	20.4
Route _NO_17	2.3565	10,11	14, 25	3:05	4:10	5.4	40	40	20	100	10.8
Route _NO_18	2.748	10,06	12,07	3:10	4:10	6.7	50	40	20	110	13.4
Route _NO_19	2.7055	50,54, 49	43,38,41	3:20	4:20	5.4	44	60	20	124	10.8
Route _NO_20	2.4165	13	11,13	3:05	4:05	5.8	42	40	20	102	11.6
Route _NO_21	6.109	36	29	1:10	1:26	4.6	32	20	20	72	9.2
Route _NO_22	4.0515	39	31	1:10	1:20	2.7	20	20	20	60	5.4
Route _NO_23	4.4325	54	36	1:10	1:18	2.2	16	20	20	56	4.4
Route _NO_24	5.8242	23,29, 54	23,27,37	2:30	2:59	5.4	38	60	20	118	10.8
Route _NO_25	5.4105	45,41, 42	33,32,34	2:30	3:00	5.9	40	60	20	120	11.8

VI. CONCLUSION

In this project GIS technology was used for the development of a methodology, reallocation of waste bins of zone A and for the optimisation of MSW collection and transportation routes. The method uses various geographical data (road network, location of waste bins, land uses etc) in co-operation with advanced spatial analysis GIS tools. Results indicate that the optimal scenario is more efficient in terms of collection and transportation time and distance travelled. The project aims at an efficient designing and developing of a proper storage, collection and disposal system plan for Durg city Municipal Corporation, India. A GIS optimal routing model is developed by considering the parameter like population density, waste generation capacity, road network and transporting waste routes. This model will help to find minimum cost/distance, efficient collection and transportation of solid waste. Durg city Municipal Corporation can use this model as decision support tool for efficient management of moving the solid waste, fuel consumption and work schedule for the worker and vehicle in daily route of life.

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