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Solid Waste Infrastructure Distribution and Accessibility: A case Study of Gulbarga city

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Abstract: *Solid wastes are the large undesirable residue in the form of refuse, garbage, sludge, etc. that are generated through domestic, commercial, industrial and agricultural activities. Solid Waste Handling Infrastructure is the basic life line on which any city thrives. Mere presence of this infrastructure does not guarantee the services until the geographic accessibility ensures availability of Waste Bins at proximity. Hence, infrastructure has to be cross viewed in terms of spatial distribution and spatial accessibility. The research work attempts to demonstrate the application of Geoinformatics in analyzing the distribution of solid waste infrastructure and space-time accessibility of this infrastructure in Gulbarga city, India. The outcome of the research also exhibits the application of Geoinformatics for designing the placing of dust bins to achieve spatial balance of distribution.*

Keywords: *Dust bins, Geoinformatics, Infrastructure distribution, Solid Waste, spatial distribution*

I. Introduction

Solid wastes are refuse, garbage, sludge, slurries that are unwanted heterogeneous materials, residue from domestic , commercial, industrial and agricultural activities[1]. For good health, good environment and aesthetics of any cities, management of solid waste has been vital. Developing countries like India face a major problem in Management of Municipal Solid Waste (MSW). Municipal solid waste management is one of the major problems that city planners face all over the world. The problem is especially severe in most developing country cities where increased urbanization, poor planning and lack of adequate resources contribute to the poor state of municipal solid waste management[2]. The difficulties in providing the desired level of public service in the urban centers are often attributed to the poor financial status of the managing municipal corporations[3]. There are no sufficient infrastructure and resources for the SWM in many Urban Councils of the country, and there are no enough and suitable services to dispose most of the solid waste from households and industries [4].
Solid waste is a serious threat to environmental, social and political structures if it is not managed properly. Unfortunately, solid waste management as a deliverable service is only sufficiently provided to a certain number of people around the globe, and insufficiently to a great number of others. The rapid urban growth has exerted heavy pressures on land and resources contained within the area surrounding cities, and resulted in serious environmental and social problems. Growth of population, increasing urbanisation, rising standards of living due to technological innovations have contributed to an increase both in the quantity and variety of solid wastes generated. The amount of MSW generated per capita is estimated to increase at a rate of 1–1.33% annually[5]. The net waste production increases as population grows, and the per capita generation of waste is also increasing, particularly in developing countries[6]. Solid Waste Management is a combination of several activities that ranges from collection, segregation, routing, transportation, treatment to disposal. For a sustainable living it is important to handle solid waste without polluting the environment[7]. The present state of urbanization in India nevertheless seems concerned about the methodological disposal of solid waste. Bangalore, the capital city of Karnataka has set itself as an example before us about preparedness for growth to handle solid waste. In the situation where there is no education about segregation of waste at source to the citizens, the situation gets much worse. While attempting the solution of this issue, the first priority comes with the collection of waste. This requires a detailed study of existing bin positions and numbers. Based on the number of households in a ward, additional bins are recommended so that spatial balance is kept along number.

II. Study Area

Gulbarga city is one of the largest cities in North Karnataka. The geographic coordinates of the city is 17.33° latitude North and 76.83° longitude east. The city is characterized with hot climate ranging from 22 °C to 40 °C in summers, and cool and dry winters with temperature ranging from 15°C to 33°C. The annual average rainfall of the city is 777mm (IMD). The average number of rainy days is 46, (1971-2000) (http: //www.imd.gov.in.).The city gets more rainfall in the South west monsoon ranging up to 186.6mm.

Convectional rainfall and thunder storms are quite usual phenomena in the in the month of April-May. According to Census 2011, the population of the city is 5,43,147 with 102830 numbers of households. The Male and Female population is 276552 and 266595 respectively with sex ratio of 964.The average literacy rate is 82.20%. The city is governed by the Gulbarga Mahanagar Palike (GMP), which is divided into 55 Administrative Wards and 3 Outgrowths. Gulbarga city covers a spatial spared of 172 km2. The urban area is about 82km².

III. Present Scenario

Total waste generated in the City is projected to be about 197 tons per day (TPD), about 132TPDwaste is collected and disposed and the efficiency of collection and disposal is about 66% [8]. Segregation of waste at sources and Door to Door Collection is not practiced in the City. The Generated waste is either dumped on neighboring open place or the containers bins nearby. There are 201container bins spread across the city out of which there are about 145 container bins of 3m³and 56 container bins of 4.5m³. The sweeping, collection and drain cleaning activity are handled by poura karmikas and hired labours managed by Gulbarga Mahanagar Palike (GMP).

3.2 Collection of Waste

The transportation of waste happens with the twin bin dumper placers, tractor trailers and a compactor. Fig 3 shows the mode of lifting and transporting the waste from the city to landfill site. The waste is transported to the landfill site located at udnoor village which is spread across 28 .19 acres of land. It has been allotted for treatment & disposal of Solid wastes. Fig 2 shows the flow of waste from the source to the landfill site.

3.2.1 Door-to-Door

The major sources of generating waste are household (63%) and commercial waste (21%). Door-to-door Collection is done by collecting waste from household on a tricycle or small truck and dumps it to the nearby Waste Dust Bins. This practice is implemented in all wards of the city.

3.2.2 Road Sweeping

The Gulbarga city is estimated to have total roads of about 986 km in GMP limits spread across all the 58 wards. The street sweeping operations in all the 58 wards are managed by GMP. The GMP manages the street sweeping operations by its poura karmikas and labours hired through manpower supplying agency. The streets of the city are classified into 3 types of roads based on the frequency of sweeping.

Type A- the streets which are swept every day are classified as type "A" Roads. These roads are located in city centres, near bus stand, commercial areas and common areas which need daily sweeping to keep them clean.

Type B- Roads coming under this type are located in not so busy areas like semi residential- commercial areas, school areas, etc. where the locality is not as densely populated like Type A roads and would require sweeping twice a week to keep them clean.

Type C- Roads coming under this type are located in purely residential areas where there is considerably less dirt and people commuting. Commercials centres are very less. These types of roads require sweeping once in a week to keep clean.

The street sweeping work is carried out from 6.00 AM to 12.00 PM in the morning hours. The shift could extend till 1 PM in case of excess waste or inefficient operation of sweepers. Street sweeping happens usually in single shift unless there is a lot of waste generated in a day or there are special occasions in the city.

3.2.3 Transportation of wastes

Transportation of the solid waste generated in the city is being managed by GMP. Primary transportation refers to transporting of waste generated from waste generators to the waste storage depot. Primary transportation of waste is not practiced presently in Gulbarga. There are no intermediate storage depots in Gulbarga except container bins.

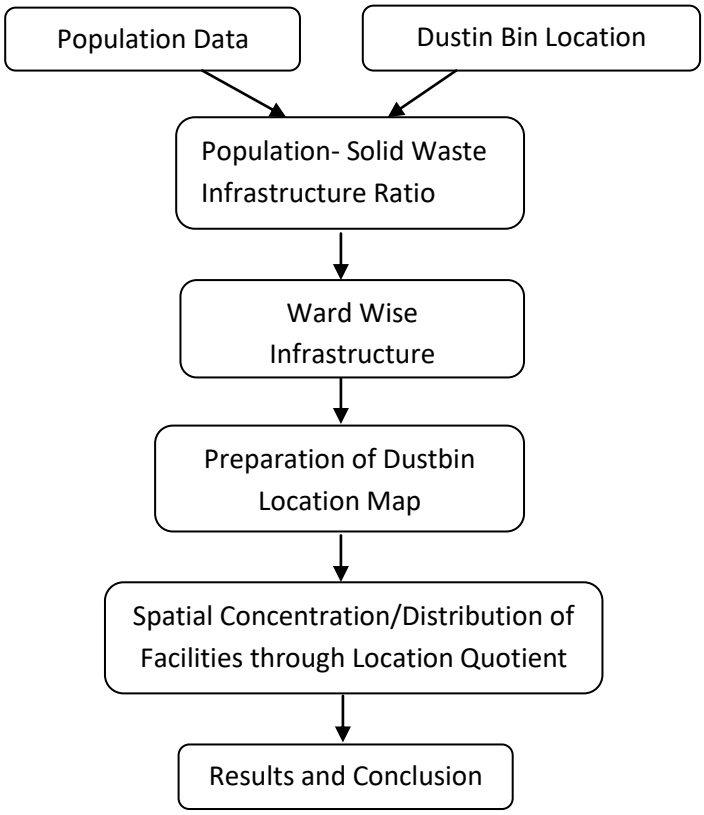
Secondary transportation refers to collection of waste from intermediate storage points like dumper bins and open points to disposal unit. GMP is presently managing the secondary transportation with its vehicles and hired vehicles. Compactor, dumper placers and tractor trailers are used as secondary transportation vehicles.

3.2.4 Processing and disposal of wastes

GMP has set up Municipal Solid Waste disposing site at Udnoor village towards south west of the city. The landfill is located at a distance of about 13 kms from the city center. The waste brought to the depot by compactors, dumper placers and tractors is dumped inside and JCB is deployed to form heaps of the wastes. Bio medical waste generated by Hospitals and clinics is separately collected by the Common Healthcare waste Appropriate Management Plant (CHAMP) facility. It caters to all the healthcare establishments of the Gulbarga

city and independently handles the process of collection, transportation, treatment and disposal of healthcare waste from medical establishments.

IV. Methodology and Results



The different sources of waste generators in the Gulbarga city are shown in fig 4. The Fig 5 represents the spatial position of solid waste collection bins that are distributed across Gulbarga city. Apart from this data, amount of waste generated was also obtained from the City Municipal Corporation. Amalgamating this information with the Census information of number of households and population, the sufficiency of existing bins were worked out. Table 1 shows the ward wise distribution of bins and their population. A total of 203 bins are used to collect the waste from the wards. To calculate the spatial concentration the dust bins, location Quotient method is used.

Location quotient (LQ) is a valuable way of quantifying how concentrated a particular industry, cluster, occupation, or demographic group is in a region as compared to the nation. Location quotients used for comparing a ward's percentage of a particular facility with the percentage of its population. To calculate Location quotient (L.Q.) for a particular facility 'i' in a particular ward, the following formula is used

$$L.Q = (ni / p) / (Ni / P)$$

Where,
ni= Number of facility i in the given ward, p= Population of the given ward.
Ni= Number of facility i in the Gulbarga City, P= Total Population of Gulbarga City.
i= facility type, in this case number of Bins.
If L.Q >1, Concentration is indicated means the per capita availability of that facility in the ward exceeds that of the city as a whole. L.Q <1, indicates Deficiency and L.Q=1 indicates self-sufficiency
Table 1 shows the result of the location quotient, 4 wards have absence of the Dust Bins and 23 wards are Deficient and 23 wards show excess of bins and 8 wards are self-sufficient.
In order to identify gaps in the distribution the solid waste infrastructure in the Gulbarga city, weightage has been given to the facilities as per their standard and number. The total number of facilities in each ward has been multiplied by the number obtained by dividing the aggregate number of all kinds of facilities by total number of each facility. The individual weighted scores of different facilities of a ward were added together to get total weighted score of each ward (Table 2). The total number of facilities Gulbarga City is taken as 1201.

V. Figures and Tables

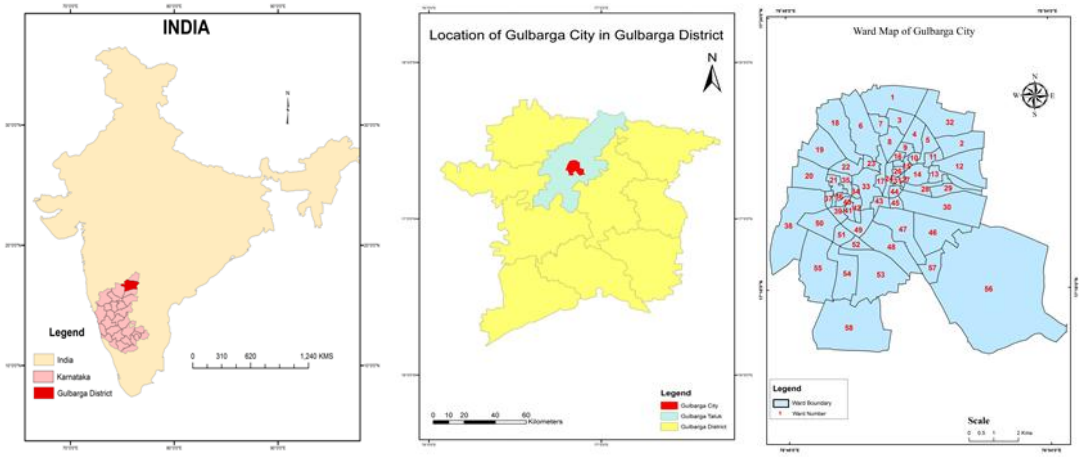


Figure 1: Study Area

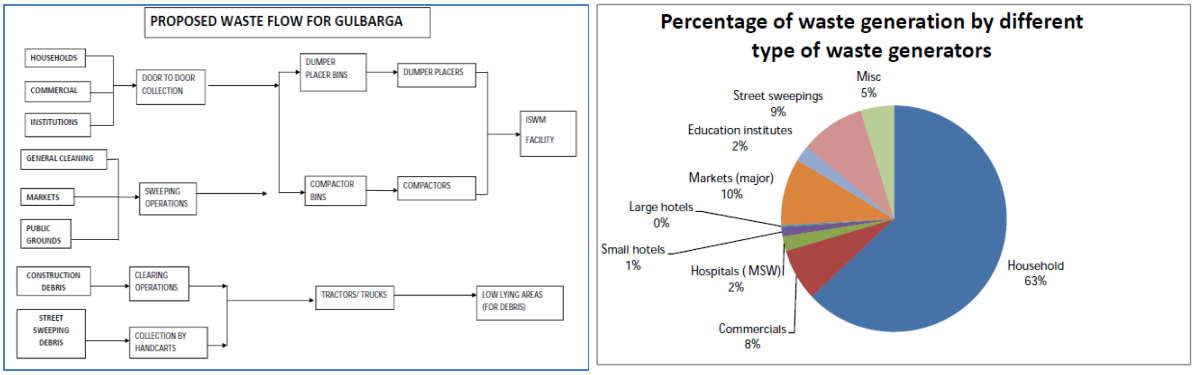


Figure 2: Proposed Waste Flow Diagram and Percentage of generated Chart.

Figure 3: Different methods of Collecting of Garabage .

Sl	Waste generators	No of waste generators	Avg waste per source in kgs	Total waste in Tonnes
1	Household	102830	1.2	123.4
2	Commercial shop	14861	1.6	23.78
3	Hospitals (MSW)	514	5.1	2.62
4	Small hotels	530	4.1	2.17
5	Large hotels	53	11	0.58
6	Markets (major)	15	1230	18.45
7	street sweepings			
	Type A	202.47	29	5.87
	Type B	645.31	9.1	5.87
	Type C	138.78	4.1	0.57
8	Educational institutes	682	6.4	4.36
9	Miscellaneous waste	5%		9.38
	TOTAL			**197.06**

Figure 4: Solid Waste Generators in Gulbarga City

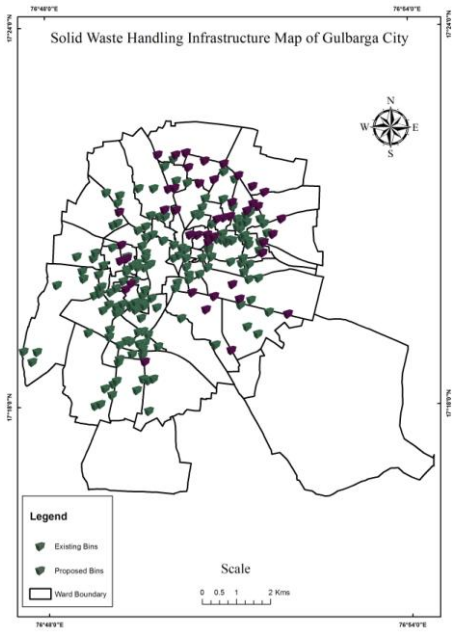


Figure 5: Ward Wise Location of DustBin

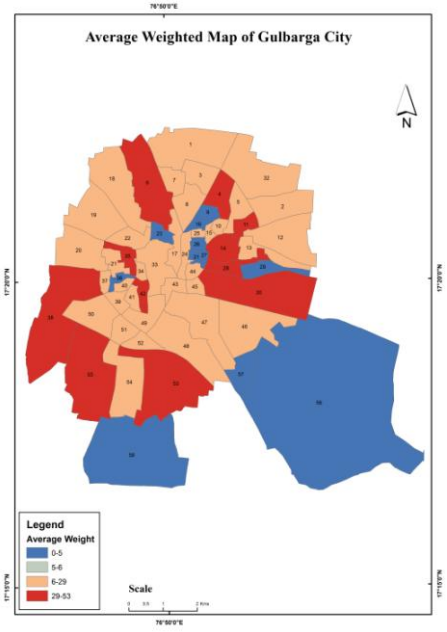


Figure 6: Average Weighted Map

Table 1: Ward Wise Analysis of DustBins and Location Quotient of Bins

Ward number	No of Bins	Population	Number of HH	% of Population	% of Bins	L.Q of Bins
1	5	12621	2305	2.32	2.46	1.06
2	2	12634	2088	2.33	0.99	0.42
3	3	7971	1662	1.47	1.48	1.01
4	6	14468	2305	2.66	2.96	1.11
5	4	7592	1283	1.40	1.97	1.41
6	7	6613	1388	1.22	3.45	2.83
7	3	8047	1563	1.48	1.48	1.00
8	4	7249	1517	1.33	1.97	1.48
9	1	3097	597	0.57	0.49	0.86
10	2	5202	873	0.96	0.99	1.03
11	6	10278	1732	1.89	2.96	1.56
12	5	6946	1183	1.28	2.46	1.93
13	4	17133	2833	3.15	1.97	0.62
14	9	14145	2357	2.60	4.43	1.70
15	2	7982	1484	1.47	0.99	0.67
16	1	5318	953	0.98	0.49	0.50
17	4	7061	1391	1.30	1.97	1.52
18	3	13365	2574	2.46	1.48	0.60
19	4	8039	1680	1.48	1.97	1.33
20	4	16355	2811	3.01	1.97	0.65
21	2	10589	1955	1.95	0.99	0.51
22	3	15446	3176	2.84	1.48	0.52
23	1	19993	3985	3.68	0.49	0.13
24	4	10075	1838	1.85	1.97	1.06
25	2	9333	1518	1.72	0.99	0.57

26	1	5708	875	1.05	0.49	0.47
27	1	6544	1193	1.20	0.49	0.41
28	6	9636	1724	1.77	2.96	1.67
29	1	13918	2624	2.56	0.49	0.19
30	7	12596	2608	2.32	3.45	1.49
31	1	5048	1003	0.93	0.49	0.53
32	3	11095	2025	2.04	1.48	0.72
33	5	8027	1591	1.48	2.46	1.67
34	3	5006	1089	0.92	1.48	1.60
35	6	8445	1647	1.55	2.96	1.90
36	0	11703	2316	2.15	0.00	0.00
37	2	7531	1307	1.39	0.99	0.71
38	9	16218	3235	2.99	4.43	1.48
39	5	7164	1298	1.32	2.46	1.87
40	2	9275	1790	1.71	0.99	0.58
41	5	6964	1263	1.28	2.46	1.92
42	6	8180	1747	1.51	2.96	1.96
43	2	4870	1003	0.90	0.99	1.10
44	2	7703	1503	1.42	0.99	0.69
45	2	12339	2266	2.27	0.99	0.43
46	5	10393	2068	1.91	2.46	1.29
47	2	5989	1163	1.10	0.99	0.89
48	2	4847	955	0.89	0.99	1.10
49	4	6808	1395	1.25	1.97	1.57
50	5	12175	2446	2.24	2.46	1.10
51	3	4268	923	0.79	1.48	1.88
52	5	8695	1766	1.60	2.46	1.54
53	6	10736	2008	1.98	2.96	1.50
54	5	16820	3356	3.10	2.46	0.80
55	6	17334	3731	3.19	2.96	0.93
56	0	6262	1202	1.15	0.00	0.00
57	0	434	91	0.08	0.00	0.00
58	0	2864	568	0.53	0.00	0.00
Total	203	543147	102830	100.00	100.00	

Table 2: Weighted Score of Wards

Ward number	No of Bins	Avg Weighted Score	Ward number	No of Bins	Avg Weighted Score
1	5	29.58	31	1	5.92
2	2	11.83	32	3	17.75
3	3	17.75	33	5	29.58
4	6	35.50	34	3	17.75
5	4	23.67	35	6	35.50
6	7	41.41	36	0	0.00
7	3	17.75	37	2	11.83
8	4	23.67	38	9	53.25
9	1	5.92	39	5	29.58
10	2	11.83	40	2	11.83
11	6	35.50	41	5	29.58
12	5	29.58	42	6	35.50
13	4	23.67	43	2	11.83
14	9	53.25	44	2	11.83
15	2	11.83	45	2	11.83
16	1	5.92	46	5	29.58
17	4	23.67	47	2	11.83
18	3	17.75	48	2	11.83
19	4	23.67	49	4	23.67
20	4	23.67	50	5	29.58
21	2	11.83	51	3	17.75
22	3	17.75	52	5	29.58
23	1	5.92	53	6	35.50
24	4	23.67	54	5	29.58
25	2	11.83	55	6	35.50
26	1	5.92	56	0	0.00
27	1	5.92	57	0	0.00
28	6	35.50	58	0	0.00
29	1	5.92	31	1	5.92
30	7	41.41	32	3	17.75

VI. Conclusion

During the development process of any city, where to place a facility becomes more important for the functional capabilities and reach of service. Fig 6. Shows the Average Weighted Map that is prepared using the weighted scores. Wards in blue shade represent no dust bins and wards in brown shade indicate low number of dust bins and whereas wards in Red shade represent more number of bins. Ward numbers 9,16,23,26,27,29,31,36,56,57 and 58 needs more attention and allocate new Dust bins, and ward numbers 4,6,11,14,28,30,35,38,42,53 and 55 have adequate number of bins whereas remaining 36 wards in brown shade which occupy the core area of the city need more number of bins. There is a clear disparity in the distribution of Dust bins in the city. The results show that improvement is a needed in the existing system to meet the requirement of solid waste handling in the city.

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