Comparative Study on Waste Generation Maps of Two Municipal Areas of West Bengal, India

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1. INTRODUCTION

Municipal solid waste management (MSWM) is an integral part of urban environmental planning. The characteristics and quantity of MSW arising from domestic, commercial and industrial activities in a region is not only the result of growing population, rising standards of living and technology development, but also due to the abundance and type of the region's natural resources. The collection, transport, treatment and disposal of solid wastes, particularly wastes generated in medium and large urban centres, have become a relatively difficult problem to solve. More than 90% of the MSW generated in India is directly disposed on land in an unsatisfactory manner .The problem is already acute in cities and towns as disposal facilities have not been able to keep pace with the quantum of wastes generated. It is common to find large heaps of garbage lying in a disorganized manner in every nook and corner in large cities. Salt lake (Bidhan Nagar) is one of India's plan cities and like other large cities faces similar problems of poor solid waste management. The objective of this paper is to analyze some of the strengths and deficiencies in the current MSW management (MSWM) system in Salt Lake and propose feasible solutions with the application of GIS and Image Processing (IP). A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. The IP based technique is proposed for better perceptive approach towards implementation of a feasible solution in MSWM.

Solid waste management is a statutory function and (Bidhan Nagar) Municipal Corporation is responsible for the management of MSW generated in the city. The city is divided into 88 block and all operations of solid waste management (SWM) in this area are performed under four heads – sweeping , collection, transportation and disposal. Major sources of MSW in the Bidhan Nagar Municipal Corporation area are residential areas, commercial/market areas, offices and institutions. Salt lake city generates approximately 200.578 ton/ d of MSW daily. Bidhan Nagar Municipal Corporation has estimated the amount of MSW generated from various sources in the city as shown in table I.

Table I. *Sources and Quantity of Solid Waste.*

Sources Of Waste	Weight(Kg)
House	110085
Market	34450
Play Ground	75
Park	1452
Institution	7342
Office	7824
Shopping Mall	2707
Hospital	2155
Bhavan/Complex	32879
Factory	1600
Total	200578

Sources: Bidhan Nagar Municipality Corporation (2011)

Relevant information from different areas of Chandannagar City was collected for constructing database. After collecting information GIS application was implemented. Chandannagar Municipal Corporation is responsible for collection of solid waste which is produced day by day from different areas of Chandannagar. It is noted that there are five borough and 33 wards in Chandannagar. There are 35,630 houses in this area which was considered in our study. There are

several sources for solid waste generation in this city which are as follows:

1. Markets
2. Play Ground/ Parks
3. Domestic Buildings/ Houses
4. Houses containing shops
5. Institutions
6. Offices/Bhawans/Complex
7. Hospitals

Following are the statistical information of producing solid waste (in kg) per day from different sectors depicted in Table 1 and Table 2 gives the details of seven wards which were densely populated:

Table: 1.

Area	borough	ward	house hold	Populatio	Market	Hospital
22.03 km^2	5	33	35630	162187	7	2

Table 2.

Serial No	Ward Number	Number of Market	Population
1	6	1	4688
2	8	1	7632
3	18	1	5453
4	21	1	5919
5	23	1	4202
6	30	1	4994
7	31	1	3321

It transpires from the above two tables:

a) Garbage production from house is higher in ward number 8 among all wards as this ward is densely populated

b) As seven wards are rich in market thus production of garbage from these wards are higher than rest of area

c) Seven wards having market and two wards having hospitals produce higher amount of garbage than rest of wards

2. CURRENT SWM SITUATION OF THE STUDY AREA

In Salt Lake area, waste collection is inadequate, in which a large percentage about 10% remains either in the places where it originates or staying longer in the collection points leading to a number of environmental and health hazards e.g. dust, smell, smokes from burning etc. Furthermore, the mounds of waste stored become breeding grounds for disease carrying flies, cockroaches, mosquitoes and rats and thus creating health risks. Due to climatic factors like high temperature and humidity along with high organic matter content, MSW decomposes rapidly resulting in unhygienic conditions. Hence in most areas, collection has to be done on a daily basis. Currently, different collection methods are being used in Bidhan Nagar Municipal Corporation and include: house-to-house collection (primary collection), and collection from roadside storage areas (3-sided enclosures). The remaining waste is disposed on vacant land and in canals.

Salt Lake City is divided into 88 blocks. For better SWM 6-8 sweepers are provided in each block. A broom, a scraper and a small bin and a tri cycle bar is provided to each sweeper. 4 members for sweeping 2 members for market sweeping and 2 member for house to house collection are working for waste collection. After the collection the waste they just disposed into the community bins. Wastes produced in the house are called household wastes. It is classified as dry waste, wet waste and hazardous wastes. Plastic, packing materials, and pieces of glass are not bio-degradable, that is, they do not decay or decompose. They are called dry waste. The left over vegetables, unconsumed food, fruits, flowers, meat, and bones are bio- degradable and are known as wet wastes. Used battery cells, paint boxes, chemicals, pesticides, used syringes, unused and outdated medicines and so on are called hazardous wastes. But Bidhan Nagar Municipal Corporation is not taking any steps for segregation or classified as dry waste, wet waste and hazardous wastes. Also they are not organising awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials. Bidhan Nagar Municipal Corporation has provided 45 storage places in the form of large masonry storage enclosures, and dumpers for temporary storage of MSW, which is collected from the city during secondary collection. Large masonry storage enclosures are open spaces enclosed on three sides with a masonry wall of about 1.2–1.8 m height, with capacities ranging from 30 to 60 m^3 and located in congested areas with narrow winding streets. Waste is brought to these depots in handcarts during primary collection while trucks can drive into these areas and pick-up waste from here for disposal to the landfill site. These large storage enclosures can also be thought of as transfer stations even though they are not formally designed for compaction, nor do they have equipment for separation or processing. A part from absence or improper locations for transfer

stations for solid waste collection, the routing system for trucks in Salt Lake has a lot to be desired. Some areas of the city are extremely difficult to access by refuse collection trucks, waste is transported to a collection point. In those situations, the trucks make one trip or two instead of three times a week as per requirements. Thus, much waste remains uncollected. Bidhan Nagar Municipal Corporation aims to provide daily collection, but overflowing bins are common features throughout the city, despite the excess storage capacity. A major factor responsible for this problem is the frequency of collection. In practice, the collection frequency is less than the design requirement (daily); in many cases collection is on a weekly basis. Another major factor is the location of the bins. These locations are decided without considering vehicle accessibility, population density or rate of waste generation in the local service area. The waste dumped in Muller very area does not undergo any treatment; hence a threat to the environment and pose health risks to the inhabitants. For this reason, the biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of waste. In Salt Lake, the disposal site of Muller very is located in sector- V at an average distance of 5 km from the collection points. Bulldozers at the disposal area are used to spread and level the garbage. There is no restriction for non-biodegradable, inert waste and other waste that are not suitable either environment and pose health risks to the inhabitants. For this reason, the selection of sites where to dispose the waste has to be done scientifically with a number of feasibility studies.

Chandannagor Municipal Corporation is responsible for collecting the garbage from different areas of Chandannagar. Municipal Authority is collecting this garbage in regular manner. There are numbers of big dust bins in several areas of the city and several wards share each big dust bins. Garbage is accumulated in this bin from adjacent areas. In each block three sweepers are working. For garbage collection procedure, 250 persons are involved. They are involving in sweeping the roads and collecting the garbage and transferring the waste into the bins. The collection of waste from these dust bins is frequently done where numbers of sweepers involved are more. The collected garbage is carried by small cart, tractors or trucks which are dedicated for collection purpose.

Collected garbage is transported to the disposal areas in specific manner. It starts from small dumper and ends into big dust bins. Among the collected garbage, both degradable and non-degradable wastes are present. It is alarming that several plastic products are dumped into the dust bins. Several types of vehicles are used for transporting garbage to disposal sites which are as follows:

i) Tri cycle cart

ii) Tractor

Three tri cycle carts are provided in each ward for collection of garbage from door to door. But in market area extra two tri cycle carts are provided. There are 22 tractors which are used for transporting garbage from different areas. The tractors carrying waste are not covered or partially covered during the journey and waste tends to spill on the roads. The loading and unloading of waste is done through manual as well as mechanical system. Normally the collected garbage is disposed without treatment and recycling. So till now there is no recycling procedure of garbage according to the normal specification i.e. Municipal Solid Waste (Management & Handling) Rules 2000 of solid waste treatment

3. METHODOLOGY

Primary and secondary data were collected to propose options for better solid waste management for Salt Lake city & Chandannagar Municipal areas. Random questionnaire survey was conducted at the study area with collecting Geographic Position System (GPS) of existing waste bins, containers and illegal disposal sites using GPS device. Secondary information about solid waste management associating other relevant information, like demographic and socio-economic data from various governmental and non-governmental sources were collected to decide the viable option for waste management. Spatial data were generated using collected GPS data and high resolution satellite images of the study area. Thematic maps were prepared for every relevant feature in GIS platform with digitization of collected secondary data. The geo-referencing and geo-processing were conducted to define all the dataset in Salt Lake Municipality area projection and to set the specific dataset boundary. Concurrent GIS software (ArcGIS 9.2) with its network analyst extension was used to generate the waste generation map of these municipal areas. These maps are as follows:
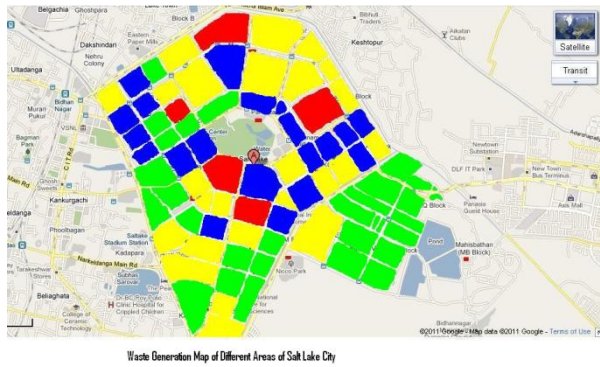
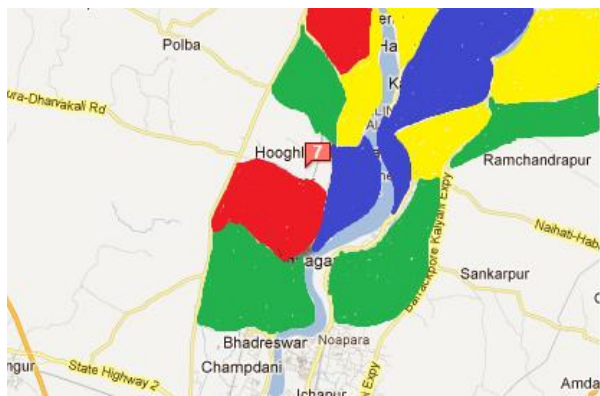**Fig 1.** *Waste Generation Map of Bidhan Nagar (Salt Lake) Municipal Area*

Fig 2. *Waste generation map of Chandannagar Municipal Area*

Where,

Serial Number	Color Code	Significance
1	Green	0-1500 Kg Waste Produced Daily in this Block
2	Yellow	1501- 3000 Kg Waste Produced Daily in this Block
3	Blue	3001- 4500 Kg Waste Produced Daily in this Block
4	Red	>4500 Kg Waste Produced Daily in this Block

4. APPLICATION OF IP BASED TECHNIQUE

From the above waste generation map, following questions may be raised:

- Can we retrieve waste generation information from this map automatically?

- Can we classify the region into subparts on the basis of waste generation?

To give the answers of above questions, IP based application may be effective. In this case, Image segmentation can be considered because it can identify the regions of interest in a scene or annotate the data. We classify the existing segmentation algorithm into region-based segmentation, data clustering, and edge-base

segmentation. All of them expand each region pixel by pixel based on their pixel value or quantized value so that each cluster has high positional relation. But among all segmentation method the edge-based segmentation process is considered in our study. This type of the segmentations generally applies edge detection or the concept of edge. The typical one is the watershed algorithm, but it always has the over-segmentation problem, so that the use of markers was proposed to improve the watershed algorithm by smoothing and selecting markers. We have developed the code in MATLAB programming interface under Windows operating system.

The main goal of watershed segmentation algorithm is to find the "watershed lines" in an image in order to separate the distinct regions. To imagine the pixel values of an image is a 3D topographic chart, where *x* and *y* denote the coordinate of plane, and *z* denotes the pixel value. The algorithm starts to pour water in the topographic chart from the lowest basin to the highest peak. In the process, we may detect some peaks disjoined the catchment basins, called as "dam". The watershed segmentation has proven to be a powerful and fast technique for both contour detection and region-based segmentation. In principal, watershed segmentation depends on ridges to perform a proper segmentation, a property which is often filled in contour detection where the boundaries of the objects are expressed as ridges. For region-based segmentation it is possible to convert the edges of the objects into ridges by calculating an edge map of the image.

We have applied the watershed algorithm on binary image data and the derived segmentation information is superimposed on previous image and the resulted image is shown below:
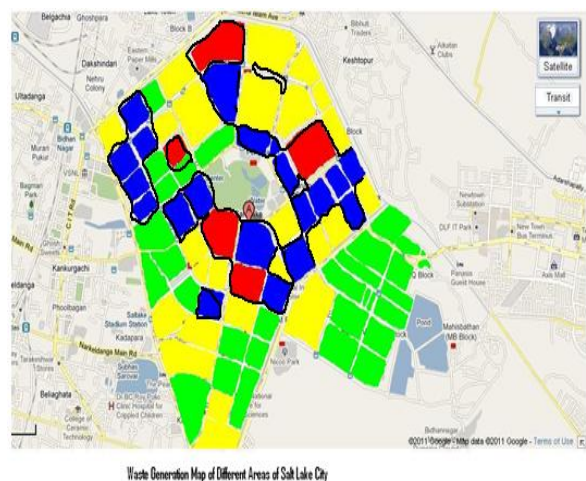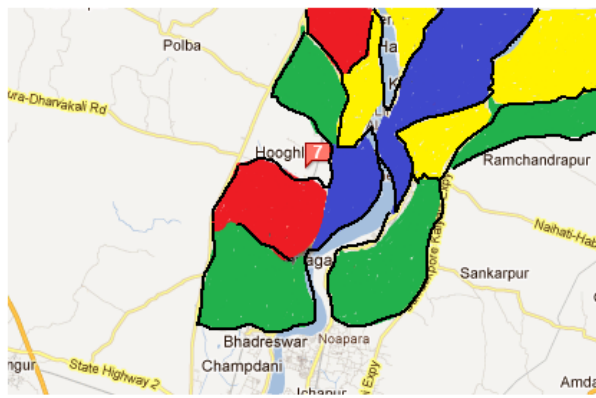

Fig 3. *Segmentation result of Waste generation area of Bidhannagar Municipal Area*

Fig 4. *Segmentation result of Waste generation area of Chandannagar Municipal Area*

From this segmented image we can see that the region where garbage production is huge is more or less clearly segmented. From the above two figures (Fig 3 & 4) of segmented images of two municipal areas derived by IP based study, following can be wrapping up explicitly:

- Ward wise garbage production is much more higher at Salt Lake Municipality than Chandannagar Municipality

- The garbage production areas are not properly segmented in Salt Lake Municipal area but it is not true for Chandannagar Municipal area.

5. CONCLUSION

In the conclusion it has been discussed about the reformation in the concepts of the data management and the analysis carried with the help of GIS. Once the waste management department is aware of the total function of the GIS system, it will get acquainted with its effectiveness. Then there will be an entire record of all the things related to the waste management and suitable logistic management and spatial planning can be achieved. This can be done with the help of both GIS and Image analysis on the different layers for practical implementations. By applying the functions like overlaying, applying buffer for proximity analysis or by applying queries through a structured query language (SQL) the required information can be extracted.

• Demographic map can be used to know the more waste generating areas.

• The category of waste like domestic, industrial, commercial etc can be found out easily with the help of the land use map.

• Existing location of the waste bins and the street maps will provide the proximity of the bins to the waste collection service routes. In case of any inconveniency for the waste collecting crew the bins can be re located.

• A map showing the current waste generated and the waste generated in different wards, sectors and along the roads, streets and junctions. The segmentation approach helps to isolate those areas where waste generation is maximum.

These above enlisted points are said to be an important exercise to begin with. The points overall covers many waste management issues, but they are very generalize and require a lot of data and proper analysis using the GIS software. There will be a requirement to develop several models to apply all those points on the real time data.

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