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Application of GIS in Solid Waste Management for Coimbatore City

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Abstract- Solid waste management is the one of the major problem faced by today's world. There is an increase in commercial, residential and infrastructure development due to the population growth and it leads to negative impact on the environment. Urban solid waste management is considered as one of the most tedious environmental problems facing by municipal authorities in developing countries. Rapid urbanization coupled with increasing industrial, commercial and economic development, have given rise to an increased generation of various types of waste. The amount of waste generation rates is coupled with socio-economic development, degree of industrialisation and climate. Generally, the greater the economic growth and higher the percentage of urban population, the greater amount of solid waste is produced. In recent years, the management of solid waste continues to be one of the major issues facing municipal planners due to increased population levels. Planners are thus forced to consider alternate and available means of disposal, especially by minimizing damage to the ecosystem and human population. GIS has proved to be a boon to such planners by visualizing the real solid waste situations and facilitating route analysis through mapping. Based on the above focus, the present study focuses mapping the waste generation of Coimbatore urban area and on suggesting convenient and administratively transparent solutions to the waste disposal problem.

Coimbatore urban is located in the extreme west of Tamil Nadu. The area covers 105.6 Sq. km with a population of 1026219. The total waste generated from the study area is 749 tonnes. Solid waste generation data and population data were collected from each ward (total number of wards are 72) and linked to the Coimbatore urban map through GIS. Analysis through maps was performed to identify the areas with increased solid waste generation on comparison with the local population.

Index Terms- Solid Waste Management, GIS, Thematic mapping, Population distribution, Waste generation.

I. INTRODUCTION

The rapid growth of population and urbanization decreases the non renewable resources and disposal of effluent and toxic waste indiscriminately, are the major environmental issues posing threats to the existence of human being (Allen et al; 1997). The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses (Jilani et al). There has been a significant increase in solid waste generation in India over the years from 100 gm per person per day in small towns to 500 grams per persons per day in large towns. Presently most of the municipal solid waste in India is being disposed unscientifically (Akolkar, A.B; 2005). Generally municipal solid waste is collected and deposited in sanitary landfill, such unscientific disposal attract birds, rodents and fleas to the waste dumping site and create unhygienic conditions (Suchitra, et al). The degradation of the solid waste results in the emission of carbon dioxide (CO2), methane (CH4) and other trace gases.

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 (Obirih-Opareh & Post, 2002; Mato, 1999; Doan, 1998; Mwanthi et al., 1997). There is a considerable amount of disposal of waste without proper segregation, leading to both economic and environment loss. There is a tremendous amount of loss in terms of environmental degradation, health hazards and economic descend due to direct disposal of waste. It is better to segregate the waste at the initial stages of generation rather than going for a later option, which is inconvenient and expensive. There has to be appropriate planning for proper waste management by means of analysis of the waste situation of the area.

The environment is heading towards a potential risk due to unsustainable waste disposal. It is a sensitive issue, which concerns about serious environmental problems in today's world. The present situation of direct dumping of the waste without proper inspection and separation leaves a serious impact of environmental pollution causing a tremendous growth in health related problems. Domestic, industrial and other wastes, whether they are low or medium level wastes, they are causing environmental pollution and have become perennial problems for mankind.

Most urban areas in the country are plagued by acute problems related to solid waste management. It is estimated that about 100000 metric tones (MT) of solid waste is generated everyday in the country. Per capita waste generation in major cities ranges from 0.12 kg to 0.6 kg as per the data from National Environmental Engineering Research Institute (NEERI). The collection efficiency ranges from 50 to 90% only, leaving the balance unattended. It is estimated that the urban local bodies spend about Rs. 500 to Rs. 1500 per tone on solid waste for collection, transportation, treatment and disposal. About 60 to 70% of this amount is spent on collection, 20 to 30% on transportation and less than 5% on final disposal of waste.

Therefore waste collection must be regarded as an important issue in order to increase the efficiency of waste management.
The population of urban India was 285 million as per 2001 census, which accounts for 27 per percent of the total population. The TATA Energy Research Institute has estimated that the waste generation will exceed 260 million tons by 2047 which speaks volumes of the problems that urban areas are going to face in coming decades in managing their waste.

Corporation carries out detailed study of the existing situation of solid waste management in Coimbatore. Municipal Corporation does not do any treatment or scientific disposal of waste. Private sector has come forward and set up a very small plant, which takes care of only 3% of city's waste. Thus 97% of the waste is not treated at all and disposed of unscientifically at the landfill. The situation of landfill is pathetic. The entire waste, which is over 700 MTs a day, is disposed of haphazardly at the landfill. The waste is neither spread nor covered. It is allowed to decay on site. Over 500000 MTs of waste is disposed of at Vellalore landfill unscientifically during many years. This project used to identify the waste generation pattern for Coimbatore corporation limit.

II. GIS

A Geographic Information System (GIS) is a computer tool for capturing, storing, querying, analyzing and displaying spatial data from the real world for a particular set of purposes. This technique is used to generate optimal route for collecting solid waste. GIS is a tool that not only reduces time and cost of the site selection, but also provide a digital data bank for future monitoring program of the site. Therefore, objective of the present study are to estimate the ward wise per capita solid waste generation and to prepare a distribution map of waste generation in the urban limit of Coimbatore.

III. STUDY AREA

Coimbatore known as 'The Manchester of South India' is the district head quarters of Coimbatore district. It is the second largest city in Tamil Nadu and houses numerous textile mills and small scale engineering units. In the year 1866, Coimbatore was constituted as a Municipal Town with an area of 10.88 sq. kms. The Coimbatore Corporation was upgraded from special grade Municipality to corporation in the year 1981 and spreads over an area of 105.60 sq. kms.

A. Population density

The density of population is increasing from year to year and the area has remained unchanged. The collected average population data have been used to calculate the population density of the area, based on population/total area (sq. km). Using the above, a population distribution map is prepared thematically to identify areas based on population. Natural break classifier is used to classify the population into six classes.

IV. METHODOLOGY

An inventory questionnaire seeking available data on solid waste generation, collection, treatment and disposal was prepared and used to collect information from officials of Coimbatore Corporation. The data thus obtained were compiled and processed to assess the adequacy of data for strategic planning of solid waste management.

A. Data Entry

The spatial data and attribute data is entered into a data base to create maps and analysis by Arc view GIS 3.2a software. This includes photos, ward boundaries, quantity of waste, etc.

B. Mapping Technique

The Coimbatore Corporation map was obtained from the District Town Planning office. The details were identified using the geographical coordinates. The map was scanned using the HP Precision scan jet 5200c at 600dpi and the scanned images were stored as JPEG files, which were edited wherever necessary, using MS Photo Editor. Scanning results in the conversion of the image into an array of pixels, thereby producing an image in the raster format. A raster file is an image in a series of dots called pixels or picture element that are arranged in rows and columns in a matrix format.

The raster images were opened in Arc view GIS 3.2a as a raster layer using JPEG interchange format. Later this image was projected using projection of geographic latitude and longitude. Registration and Transformation was done to convert the image to real world coordinates. There are two types of transformation techniques, where the first one involves the X and Y co-ordinates recorded in Notepad or dbase being opened in Arc View. The option "Add Table" presents in Arc View adds the X, Y coordinates in the Notepad or dbase to the map, out of which the points were created. The created points were coordinated to that of the raster layer.

Similar features to that of the points were identified in the raster layer and a source point was selected in the raster map. Using that, the destination point was given to the text / dbf map. The raster later was thus assigned the real world coordinated or the ground control points of the study area. On completion of the transformation with the above method, over the raster layer, a new layer is digitized with special points. The digitized layer is transformed using the method similar to the first method.

Once the map is transformed, the line tool was used to digitize the map. Digitizing is a method to convert raster layer to vector. A specific tool like point, line or polygon was selected and digitized over the map. Automatically, an Attribute table with records for each polygon was created by the platform. Each line was given an ID and additional fields were added to enter records such as average waste generation per day, method of collection etc., the entire layer was saved as a shape file.

C. Thematic Mapping

Thematic maps show the distribution pattern of a particular theme objective. Thematic mapping involves data classification methods, which is known as the most common method for manipulation. Generally, six data classification methods are available: equal interval, equal area, standard deviation, means, natural break and user defined. Equal interval uses a constant

class interval in classification. Equal frequency also called as quantile, divides the total number of data values by the number of classes and ensures that each class contains the same number of data values. Equal area divides the map area by the number of classes and ensures that each class contains the equal proportions of area. Mean and standard deviation sets the class breaks at the units of standard deviation above and below the mean. The method of natural breaks uses a computing algorithm to minimize the difference between data values in the same class and to maximize difference between classes. For the present study, natural break classification techniques was used to classify the waste generation for thematic mapping.

V. RESULTS

The city is decentralized into four administrative zones, namely North, South, East and West. Each zone is headed by an assistant commissioner who is delegated with adequate powers to discharge his functions effectively. Each zone consists of 18 wards. The ward administration is being supervised by junior engineers and sanitary inspectors who are also delegated with some powers to discharge his functions at the ward level. The distribution of wards in Coimbatore urban is shown in Map 1. The ward number of Coimbatore Corporation is shown in the map.

A Thematic map of population density was prepared for the ward wise population density for Coimbatore Corporation as shown in Map 2. To arrive at the population density values, the formula was adopted

Population Density = No of persons / Area of ward (sq.km)

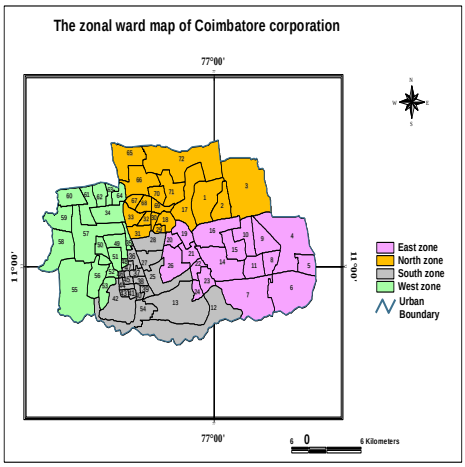
The Arc view calculator was used to obtain the population density value, which was attributed in the existing table. The population density values were further used for thematic mapping.

More than 50% of the wards (41 wards) are identified with density between 9934 -28727 persons per sq.km. These wards are identified are the potential wards for development and high growth rate is attributed to these wards. About 20 wards are observed with densities ranging upto 9933 Persons/sq.km. Low densities wards are attributed to location along the corporation periphery, presence of water bodies, hillocks, Industrial units or educational institutes

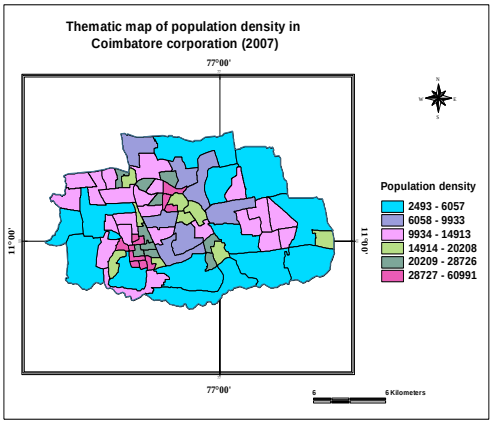
Based on population of each ward and the waste generation of each ward using this per capita waste generation map were prepared. Per capita waste generation is calculated using Per capita solid waste generation = (Total weight of solid waste generated per day) / (Population served)

For each ward area, this method was used to prepare a thematic map of per capita waste generation in Coimbatore urban. Natural breaks classification method was used to classify the area based on high per capita waste generation wards. From the result of thematic mapping, it is observed that out of 72 wards in Coimbatore urban only 4 wards namely 48,49,50,51 are highly waste generated areas in the range of 1.37 to 2.28 kg/person/day as shown in Map 3.

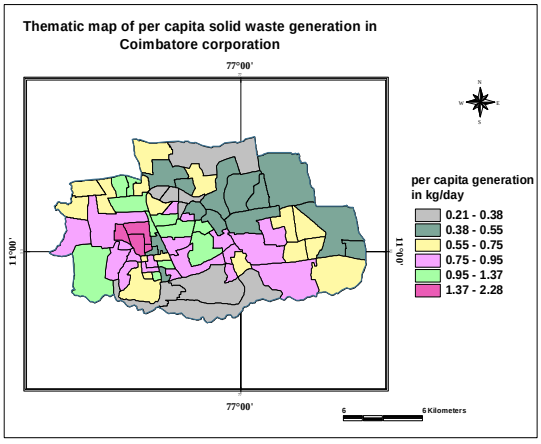
The details of the sanitary workers of the wards was obtained from the zonal offices and attributed into the existing ward map. Based on this, the distribution of the ward workers was prepared using natural break classification into six classes. A relationship was identified between the waste generation and workers. Workers distribution is high in the wards where the waste generation is more as shown in Map 4.



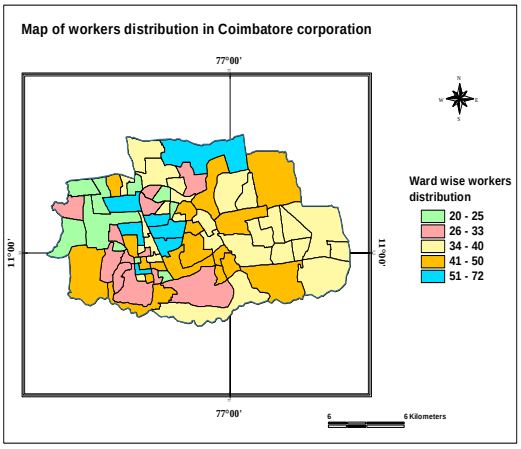
Map. 1



Map. 2



Map. 3



Map. 4

VI. CONCLUSION

The municipal officer involved in the solid waste management should be clear about the function and their role in terms of managing the cities effectively with the help of GIS system. These Thematic maps will help officers to identify and monitoring the more waste generated wards.

Promoting waste markets and recycling would also create awareness to reduce the total volume of waste at the landfill. There is a need to improve the data system of solid waste for the monitoring and management to support environmental reports has been improved

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