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Optimum Location of Dust Bins Using Geo-Spatial Technology: A Case Study of Kumbakonam Town, Tamil Nadu, India

J. Senthil[1]*, S. Vadivel[1] and J. Murugesan[2]

[1]*Department of Geography, Govt. Arts College (A), Kumbakonam, TamilNadu, India.*
[2]*Department of Geography, Periyar EVR College (A), Tiruchirappalli, TamilNadu, India*

ABSTRACT

Urbanization and changing consumption patterns are resulting in the generation of increasing amounts of solid waste and visible environmental problem in many urban areas. It creates more environmental problems, as many cities are not able to manage it due to institutional, regulatory, financial, technical, and public participation shortcomings. According to the Central Pollution Control Board (CPCB), the average Indian generates about 490 grams of waste per day. There is strong evidence which suggests that individual or group awareness and attitudes towards waste generation and management is critical in the effort to respond to the waste management challenge. The rapid growing of Kumbakonam Town faces problems in poor solid waste handling for a large part of its population. The present study was focused on household solid waste disposal and optimum location of dust bins to access and maximize its utilization. The field data collected with help of Global Positioning System survey was transformed into SPSS .v.16. For the empirical survey; existing location of dust bins, and household population with distance from home were collected. Finally, finding the alternate location of dust bins and mapping.

Key Words: Solid Waste, Land Pollution, Environmental Degradation

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INTRODUCTION

Waste management is the collection, transport, processing, recycling or disposal, and monitoring of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is also carried out to recover resources from it. Waste management can involve solid, liquid, gaseous or radioactive substances, with different methods and fields of expertise for each. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator. Municipal solid waste is defined to include refuse from households, non-hazardous solid waste from industrial, commercial and hospitals, market waste and street sweepings. Municipal Solid Waste Management (MSWM) encompasses the functions of collection, transfer, treatment, recycling, resource recovery and disposal of municipal solid waste. The first goal of MSWM is to protect the health of the population, particularly that of low-income groups. Other goals include promotion of environmental quality and sustainability, support of economic productivity and employment generation. Achievement of MSWM goals requires sustainable solid waste management systems, which are adapted to and carried by the municipality and its local communities.

Globally, Municipal solid waste management is one of the major problems, especially severe in developing-country cities where increased urbanization, poor planning, and lack of adequate resources contribute to the poor state of municipal solid waste management [1]. In Africa, rapid urban growth since the 1960s has put pressure on the land resources within the area surrounding the cities; it has led to increased generation of waste. The problem is aggravated by the open dumping nature of disposing waste especially in the slum areas of most African cities. An

example of this is found in the waste management practices in Tanzanian municipalities. Traditionally, their administrations permitted uncontrolled dumping in abandoned quarry sites with no provision for sanitary landfill, causing huge health problems [2]. A large part of the problem is inadequate financial and data resources for site selection and management; but the problem persists even in African countries like Kenya where the Nairobi City Council had provision for public collection, but found the system was available to only 10% of residents [3]. In Accra, Ghana, public administration of waste collection was also inadequate for a variety of reasons which led the administration to privatization, where private cost recovery seemed to indicate a better solution. These problems have resulted in serious environmental and social complications [4]. The use of GIS and aerial photography for landfill-site selection and management has been documented [5]. Combined aerial photographs and topographic data were used to select waste disposal sites and facilities for Palestine The major importance in Qumsieh studied [6] placed on building an initial geographic information database of Palestine and later linked this spatial information to selecting a landfill site. Siddiqui [7] applied multi objective planning techniques to find the suitable location for landfill sites in Cleveland County, Oklahoma taking into account physical and environmental characteristics using a geographic information system. In Kaohaiung city, Taiwan [8] combined GIS and mixed integer programming model to analyze several waste selection sites before selecting the final sites. Muttiah [9] indicated combined Markov-chain-based simulated annealing algorithm with GIS techniques to locate potential waste disposal sites in the Indian Pine watershed in Indiana. Results showed that simulated annealing achieved the best results in selecting waste disposal sites, at the same time taking social factors into account. Kao [10] developed a multimedia network information system with GIS to improve municipal solid-waste landfill site in Miaoli, Taiwan. The study showed good results when multimedia network (image, graphics, video etc.) are effectively combined. Identification of suitable site for Thermal Power Plant along the mining area in Rajpardi district of Gujarat, India is one of the evidence of Geospatial technology for mankind development. Multi-spectral satellite data and collateral data of geology, geomorphology, topography, settlement and transport, forest cover, hydrology and climate were used to generate the integrated thematic database in GIS platform for selecting the suitable site for Thermal Power Station (TPS) construction [11]. Selection of site for TPS was based on four primary criteria, such as land, water, coal mine and environment, and two secondary criteria, namely settlement and accessibility to the site.

The identified potential waste disposal sites using Remote Sensing and GIS techniques for Karaikudi Municipality. Selection of suitable sites for waste disposal is based on several factors.GIS technologies using weighted overlay analysis help to select the possible suitable solid waste disposal sites and are categorized in to three category. There are Good, Moderate and Poor. Among these categories, the sites which are in between the 4-5km buffer is selected for the disposal of solid wastes [12]. In the Golbasi region of Turkey, Basagaoglu [13] used GIS technology to identify sites for solid waste disposal. The authors used a set of conditions including environmental factors and overlays using ARC/INFO 7.1 to shortlist sites to meet desired criteria the literature suggests that countries around the world have successfully applied GIS and remote sensing to their urban waste management planning process. Effect of refuse dumps on ground water quality research was conducted evaluate the effect of solid waste dumps on ground water quality. In order to achieve this, water samples were obtained during dry and wet seasons from hand dug well. Hand dug wells were selected close to the dumps site. pH and conductivity were determined using pH/conductivity meter, TDS, Ca, Cl, P, Ni, total hardness, DO, BOD were determined using standard method. Most the values are within the permissible limit but the all samples are not in conformity with WHO limit for bacteriological values which make the water to be unsafe for drinking, further treatment is recommended for the water. The study concludes that the hand dug well water around the refuse dumps sites are not safe human consumption [14]. However, these effective planning tools GIS and remote sensing have not been effectively used in most Indian cities and certainly not in Thanjavur district of Tamil Nadu. There were no studies aimed at integrating these technologies into a planning process to improve the efficiency of municipal solid waste management in Kumbakonam.

Problem Statement

The latest technological advancements in digital revolution have demonstrated the conversion of land and population details are incorporated with GIS data files. This is very useful in locating a house and knowing the details of various household types of land features such as vacant land, plots, and settlement types. Further, this can be used for administrative purposes; for example by using such details in a particular spatial unit the eligible voters can be identified. Similarly, based on the number of settlements the suitable dust bins location can be predicted. It will be more useful for the disaster prone areas to plan the post disaster and mitigation processes. This GIS database will be immense help for the administrators for relief distribution. Thus the present study is a sample work for a ward (Number 45) in Kumbakonam town, Tamil Nadu.

Objectives

To fulfill the above problem the following objectives have been formulated:

a. To find out the spatial distribution of existing waste bins and mapping the incorporated data base using ArcGIS module.
b. To analyze and suggest the optimum locations of waste bins using Weighted mean centre.

MATERIALS AND METHODS

The present study is based on Global Positioning System (GPS) and Geographical Information System (GPS). These were used for accurate measurements and formulation of geographic data bases for the analysis purpose. GPS is used to create instant local area map and to enclose the desired data base on the point, line and area. This component has an antenna through which a cable was connected with a palm card computer and receives the satellite emitted radio signals through the software called ArcPAD. Before the measurement a data base for point, line and area were created by using ArcView GIS mapping software. The GPS, particularly the palm card computer is a handheld one and the antenna can be hanged on the surveyor's shoulders. This can be carried very easily to any accessible areas and instant map could be recorded in the palm carder. The finished map was downloaded to the mainframe computers for analysis. To study the location of solid waste bins of ward 45 in Kumbakonam town an area symbol has been created in the ArcGIS 9.0 and tracked (by walk and vehicle) along the border line of ward-45. Then the major roads were also tracked with a global accuracy of 4 meters. Using ArcView GIS different point symbols were created to locate the different features (Settlement, dust bin locations). All the features with the point symbol enlighten the house hold details. The GPS measured geographical co-ordinates are used as input data with the Number of settlements which were used as a weight of the respective street. Using the co-ordinates and the settlement data the Weighted Mean Centre (WMC) has been applied to extract the alternate locations of dust bins by using SPSS v16.software. Thereafter, GIS maps were created using the re-distributed co-ordinate system will provide us the suitable location of dust bins which will cover the entire population to maximize its utilization.

Study Area Description

Kumbakonam is a municipal and second largest town in Thanjavur District, Tamil Nadu. It has forty-five wards. It is well known by Temple city and also is called as "Kudanthai". Two rivers are namely "River Kaveri" on the north and river "Arasalar" on the south. There are two Govt. colleges in Kumbakonam town. One is Govt. Arts College and it is described as "Cambridge of South India" and another one is Govt. Women College. Mahamaham festival was celebrated once in every 12 years during the Tamil month of Masi (February-March). This town has extended between 10˚57" north latitudinal and 79˚28" East longitudinal Extension. The total area is 12.58 sq km and about 313km away from Chennai, 90 kms from Tiruchirapalli District and 40 kms from Thanjavur.

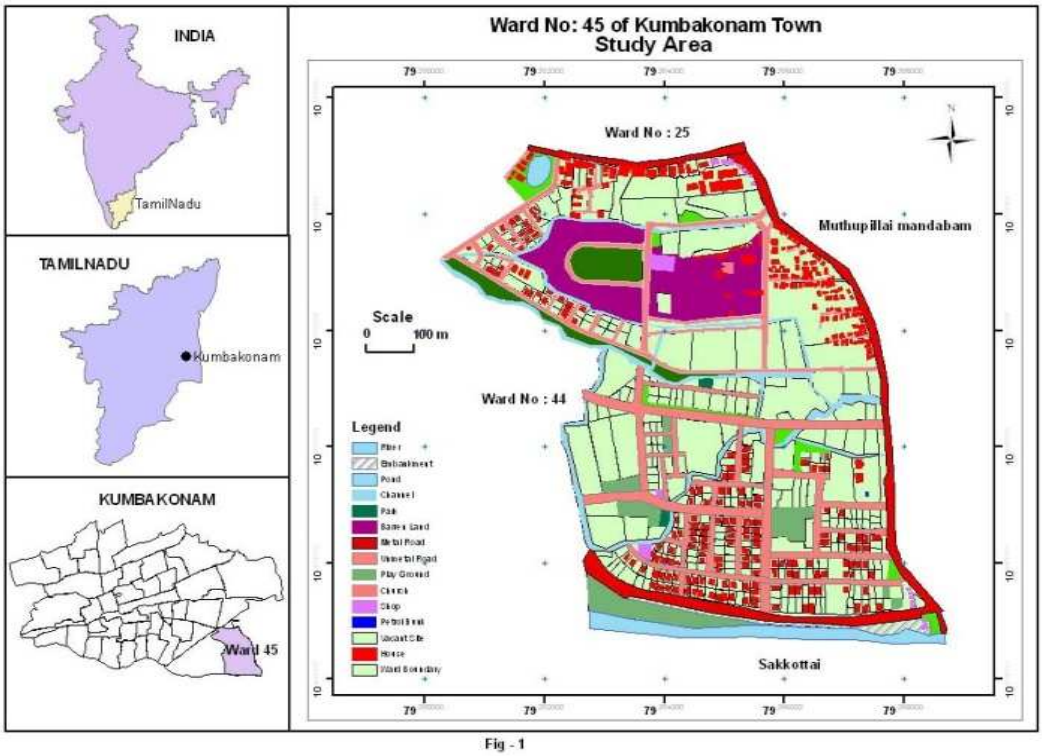

Fig - 1

Allocation of Solid Waste Bin Suitable Site Selection in Ward 45, Kumbakonam Town

The ward (45) map of Kumbakonam town is obtained from Taluk Administrative office, scanned and digitized with Arc GIS 9.2 then converted in the form of digital maps to show all the minute details to use for the present study.

The study area map (Figure-1) shows the details of ward - 45, (River, Embankment, Pond, Channel, and Park, Barren land, Roadways, Playground, Church, Shop, Petrol Bank, Vacant site and Houses) with attribute data. These features have been traced out by using Arc GIS 9.2 and Geo referenced by GPS.

The settlement map (Figure-2) is showing that the distribution of settlements namely linear, cluster and nucleus types were observed. Particularly linear types are found along the road side, cluster and nucleus types are found in somewhat farther away from the road or interior. However over all development and distribution of settlements are noticed except in the central part of the ward. The settlements are mostly houses and few were shops. Most of the buildings are two and three floor structure. Perhaps in this ward the concentration of settlements are in southern and northern part. In the centre of northeast direction substandard houses are found (tailed and thatched).

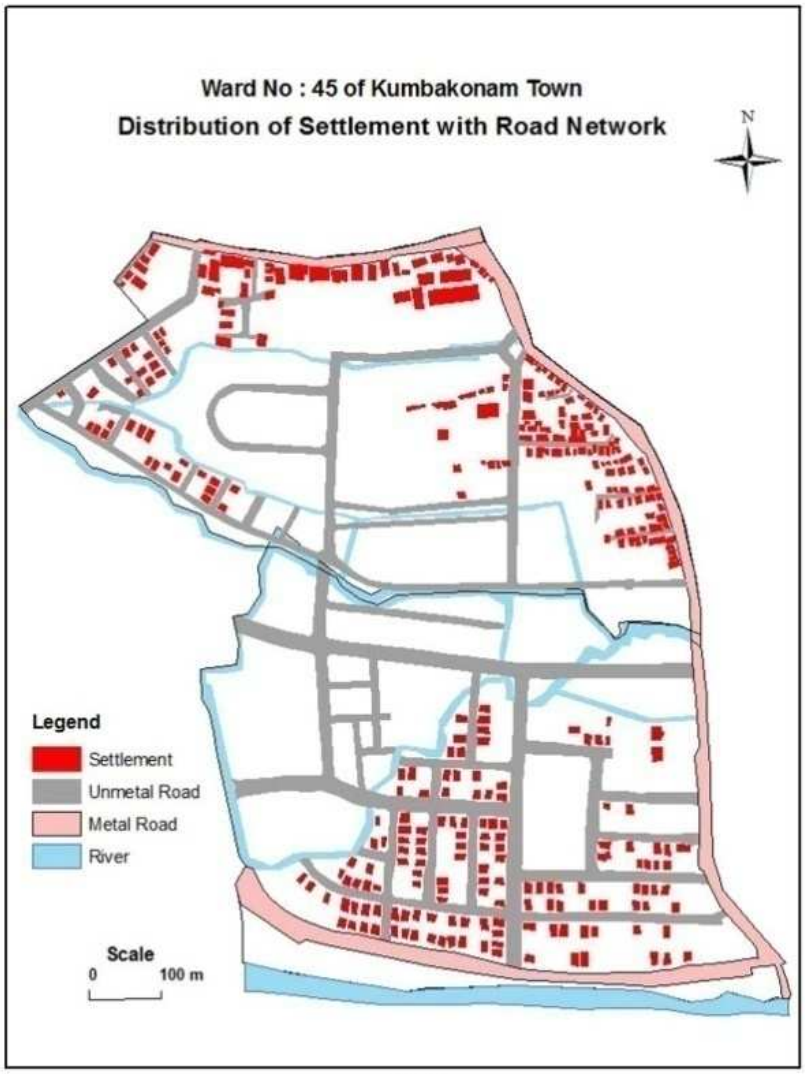

Fig - 2

The present study is based on the population of particular streets and collections of household waste from individual house, then the suitable location of waste bins were identified. Firstly, trace out the existing settlements (Figure-2), the centroid (Center point of Individual House) location are identified by using GPS survey and prepared a map (Centroid Analysis with the help of Arc GIS), which shows (Figure-3) that the Centroid Settlement Patterns of ward 45.

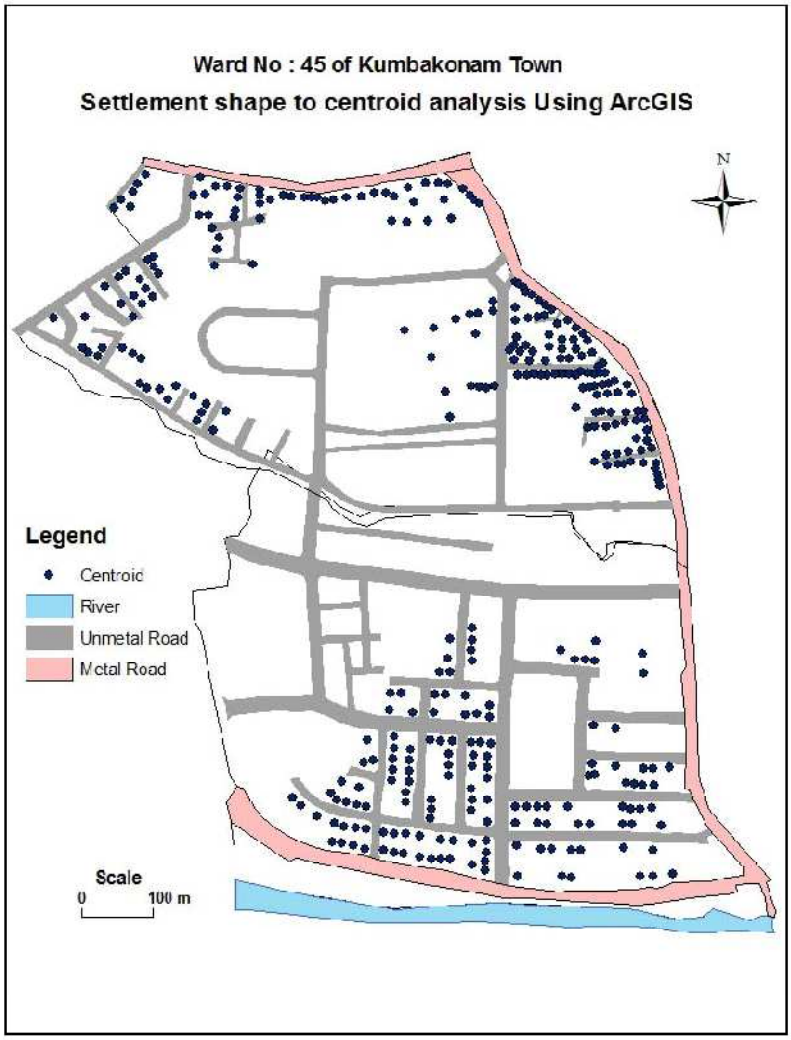

Fig - 3

Similarly the present locations of dust bins are surveyed and a separate map (Figure-4) was prepared as above mentioned procedure. The location of dust bins are not found in optimum location because they are not used by all households due to lack of accessibility, inconvenience and other problems. At present there are 23 waste bins and giving service to only for 155 houses and the remaining 187 were not. However these numbers are enough for public service but not situated in proper location. So, to avoid such inaccessibility based on the individual house (342), settlement pattern and numbers of people living in a house are statistically weighted and new predicted and allocated points are generated with the help of Arc GIS 9.2. This new location of dust bins can serve for the entire living community of ward 45, Kumbakonam Town.

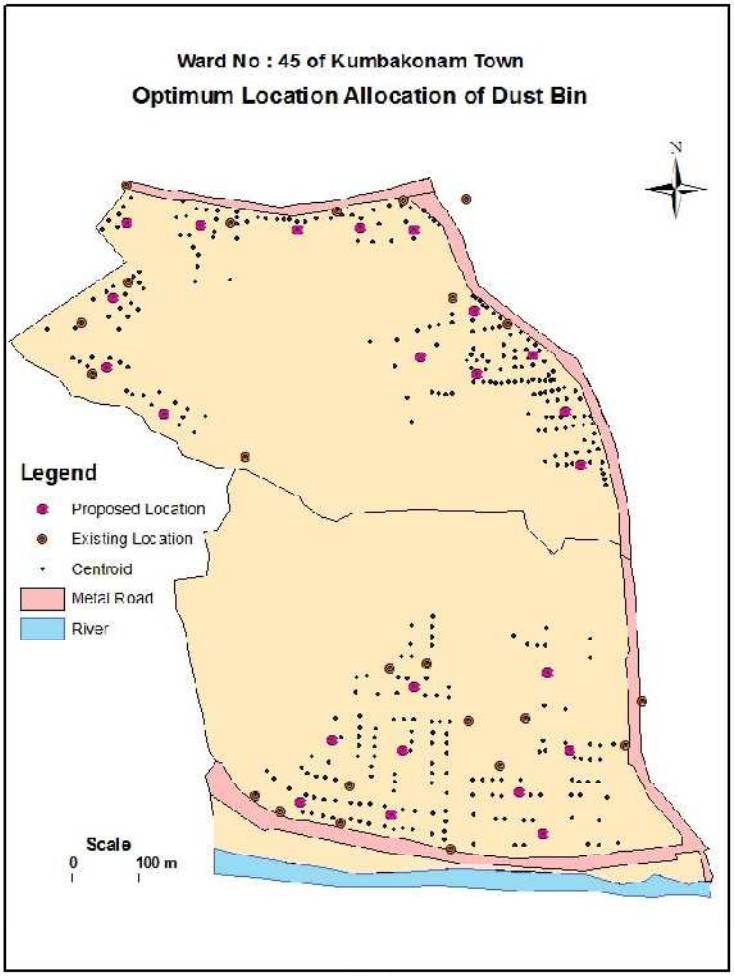

Fig - 4

CONCLUSION

Creation of Spatial Data base using mapping software ArcGIS along with the incorporated database can provide useful information for the users. In India this system is slowly developing and will get a shape in the near future. Geo-spatial data base can provide a full-proof system and easy to monitor and manage during public distribution to all aspect. From this study the individual household to streetwise details can be queried according to the user community. This database can be used for various municipal administrative purposes like collection of land revenue, house tax, public distribution system and hospital management.

This present study, reallocation of waste bins of ward 45 in Kumbakonam town findings and conclusions are follows.

❖The present locations of waste bins are not placed in convenient location.
❖Present waste bins are not properly used by the people.
❖Many of the waste bins are overflow and spreading on the floors. In contrast some are filled half or few. People were put their household wastes on either side of the road and cesspool.
❖Animals and birds are pulling out, spreads over the surface and creating untidy environment.
❖Creating awkwardness due to the presence of waste bins in residential front.
❖ Creating odor to the surroundings.
❖The overflowing wastes are blocking the sewage water and it is creating stagnation of cesspool and it leads a breeding place of (larva) mosquitoes.

After the findings of reallocation model the waste bins will serve in following ways:

❖The predicted or allocated waste bin locations are suitably located.
❖It will serve for all people.
❖There will not be natural or artificial barrier to use this waste bins.
❖This model predicting the future scenario of settlement development.

❖There will not be overflow or half filled because it is measured on the basis of number of people living in a house and waste generated by individuals in a day.

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