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Effective Management of Solid waste by using GIS and Artificial Intelligence Based Support System in Nagpur City

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ABSTRACT: Municipal solid waste (MSW) management has emerged as one of the major environmental challenges globally. The objectives were to increase the current recycling rates and the purity of the recovered materials; to collect additional materials from the current rejected flows; and to improve the working conditions of the workers, who could then concentrate on, among other things, the maintenance of the robots. Based on the empirical results of the project, this paper presents the main results of the training and operation of the robotic sorting system based on artificial intelligence, which, to our knowledge, is the first attempt at an application for the separation of bulky municipal solid waste (MSW) and an installation in a full-scale waste treatment plant. The key questions for the research project included (a) the design of test protocols to assess the quality of the sorting process and (b) the evaluation of the performance quality of the training of the underlying artificial intelligence and its database.

KEYWORDS:- Solid Waste Management, GIS, Environment, Nagpur City, Artificial Intelligence

I. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Now a day, many cities and towns are growing rapidly in India. Among the fast growing towns and cities, Nagpur is probably the prominent one. This is due to its strategic position located along the ancient long distance trade routes. The city is expanding rapidly with increasing number of industries and service sectors such as hotels, restaurants, small and micro enterprises. As town grows, so does the amount of waste production specially the solid hazard waste. It is inevitable that waste production and management problems increases with rapid urban growth resulting in pressure on sanitary related problems in the city. Because of Improper waste management practices and limited public and community trucks and containers, people are being forced to dispose their wastes in any open fields. Poor sanitary situation has become a common characteristics of many villages in the city. This necessitates the applications of Geo-information systems on landfill site suitability assessment as a solution to address the problem and effectively manage the wastes in the city. 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 of low or medium level wastes, they are causing environmental pollution and have become perennial problems for mankind." (Ramasamy SM, et. al., 2003). If this situation is not handled in a proper manner within time then it would lead to worse consequences on a global level. There has been awareness regarding waste management amongst many countries. There has been development of new technologies for improving the waste management systems. GIS is one of the new technologies which have contributed a lot in very less time span to the waste management society. "The Geographic Information System (GIS) helps to manipulate data in the computer to simulate alternatives and to take the most effective decisions."(L. Narayan., 1999).

1.2 SOLID WASTE MANAGEMENT

Solid waste is composed of garbage or refuse, a broad array of materials discarded by households, businesses, industries, and agriculture. Solid waste can be discarded as food waste, paper, plastic, glass, rubber, wood, textile, metals, stones, rocks, and ceramics. The major sources of the solid waste are residential, institutional and commercial waste and City Corporation or municipal services (street sweeping) wastes. Municipal Solid Waste (MSW) disposal has been enormous concern in developing countries due to poverty, population growth, urbanization and ineffectual fund (UNDP, 2004). MSW management is a big challenge due to number of problems including; inadequate management, lack of technology and human resources, shortage of collection and transport vehicles, and insufficient funding. Waste disposing is another important part of waste management system, which requires much attention to avoid environmental pollution. The most common problems associated with improper dumping includes; diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses. The effectiveness of solid waste disposal depends upon the selection of proper site and current global trend of waste management problems stems from unsustainable methods of waste disposal, which is ultimately a result of inadequate planning. Waste management processes comprise complex operations and non-linear parameters due to the multiple interconnected processes involved and the highly variable demographic and socioeconomic factors affecting the overall systems. Moreover, achieving satisfactory performance in SWM systems without compromising other health and environmental factors is a rather difficult task. The emerging artificial intelligence (AI) techniques are sought to be well-suited for application in the SWM field. The AI technology deals with the design of computer systems and programs that are capable of mimicking human traits such as problem solving, learning, perception, understanding, reasoning, and awareness of surroundings.

1.3 CONTRIBUTION OF GIS IN SWM

There are several phases in solid waste management, right from the stage where it is generated till it reaches its final destination or at a stage where it is no more a threat to the environment. It is observed that solid waste management can be bifurcated into mainly two phases. One is the waste management in the area where it is generated and second is the management of waste at dumping grounds. This paper will cover the first phase which deals with the municipal waste management within the city limits. This includes the issues related to the waste generation, their storage, collection and removal from the collection points. The waste is generated in all areas but there is large variation in its type and quantity. According to (R. K. Garg., 2002), the quantity and nature of the waste generated vary with the activities and with the level of technological development in a country. "The issue of waste is not only because of the increasing quantities but also largely because of an inadequate management system." (E. Tinmaz& I. Demir., 2005). The analysis of this variation would give the information which could make it easy to understand the area's waste generation nature and trend. This trend can help to propose a proper waste management system that could recognise this variation. The suggestions made after considering these variations would maintain a balance in this variation by considering the areas which generate more or a different category of waste. Also there is some general categorisation in the waste generation which also helps to analyse the waste generation ternds. These trends are useful while planning waste management. An analysis done in this systematic way can bring out the appropriate remedies for the solid waste management applications. GIS could help in dealing with several factors simultaneously which needs to be considered while planning waste management. "GIS is a system of computer hardware and software, designed to allow users to collect, manage, analyse and retrieve large volume of spatially referenced data and associated attribute data collected from a variety of sources."(S. Upasna& M. S. Natwat., 2003). There are also lot of planning aspects in waste management. A good planning would support proper management policies. There are several problems which need to be treated with decisions taken considering all the related factors. Often the order and the amount of preferences given to these factors, decides the decision's credibility. Manual methods adopted for analysis of many factors would be a lengthy and tedious work. Also there are possibilities of errors while merging the spatial and non spatial data. But in GIS, as the work is carried in layers, there are least chances of confusion or error and the system is capable enough to coordinate between spatial and non spatial data. "The spatial operation is normally performed in conjunction with GIS functionality found in most GIS software." (G. J. Lunkapis., 2004). GIS is a good decision support tool for planning waste management. There was a research conducted for Landfill site selection in Malaysia and it was mentioned in the report (G. J. Lunkapis., 2004) that, the purpose of the research was to use Geographic Information System (GIS) as a tool to aid the decision-making process and to test its effectiveness using some established government guidelines. Due to the multifunctional feature of the geographical information systems, the information can be related spatially with a very good flexibility to exchange, compare, evaluate, analyse and process it.

"By assessing the location of something and then combining it with what's around it, you're able to make a decision you were never able to make before," said Erich Seamon, GIS manager for San Francisco. (Wired News Publication website)

Solid waste management comprises several phases, starting from the stage where the waste is generated till it reaches its final destination or at a stage where it is no more a threat to the environment. It is observed that solid waste management can be bifurcated into mainly two phases. One is the waste management in the area where it is generated and second is the management of waste at dumping grounds.

The development of Geographic Information System (GIS) and its use throughout the world has contributed a lot in improving waste management systems. GIS helps to manipulate data in the computer to simulate alternatives and to take the most effective decisions. GIS can add value to waste management applications by providing outputs for decision support and analysis in a wide spectrum of projects such as route planning for waste collection, site selection exercises for transfer stations, landfills or waste collection points. GIS provides a flexible platform which integrates and analyses maps and waste management databases. GIS allows us to create and store as many layers of data or maps as we want and provides various possibilities to integrate tremendous amounts of data and map overlays into a single output to aid in decision making. GIS in solid waste management in coastal areas as a decision support system with a case study on landfill site selection. The results of the study are that GIS is becoming a powerful tool in SWM. However there are still some drawbacks and deficiencies in applying the method extensively. Since routing models make extensive use of spatial data, GIS can provide effective handling, displaying and manipulation of such geographical and spatial information. For example, proposed a model for the system of Municipal Solid Waste (MSW) collection that provides planning for distribution of collection bins, load balancing of vehicles and generation of optimal routing based on GIS.

Machine Learning Algorithms. IoT with machine learning algorithm can be used in waste management system to develop the smart city in effective manner. -e waste can be classified depending on its characteristics by using ML classifier algorithm. ML algorithm can be classified into three major types. -ese are supervised learning, unsupervised learning, and reinforcement algorithm. Mainly, supervised learning algorithm is used for waste collection and management to develop the efficient smart city. Because it provides better output and to solve classification and regression challenge. So, this work mainly focuses on supervised learning-based waste management system. Applications of Machine learning algorithms send the monitored data through an android application, and these kinds of android application are well suited for deep learning approach, and they collect the real time data with the help of Bluetooth technologies.

1.4 OBJECTIVE OF THE PROJECT

Any research is carried out for the attainment of certain intended objectives. Likewise, this master thesis has a general and well as specific objectives to be achieved at the end of the work. Therefore, the general objective of this thesis is to assess the solid waste problems and find software solution for optimal site selection for disposal in the study area.

- To study the current status of solid waste management in the case study area [Nagpur, Maharashtra].
- Identify the economic values of solid waste in the town.
- Pointing out the main contributing factors affecting the solid Waste Management process in the town.
- Identifying conflicting interests among actors in collection, processing and disposal of solid waste products.
- To increase efficiency of the waste collection system through GIS based waste collection routes which will also monitor performance of waste operators through tracking of waste collection and transportation vehicles planning.
- Classification of waste using Artificial Intelligence. Here Machine is trained through machine learning algorithm to detect glass, metal and plastic objects using different shapes, degradation levels, sizes, colors and different levels of contamination.
- To provide operational guidelines for efficient municipal solid waste management system.

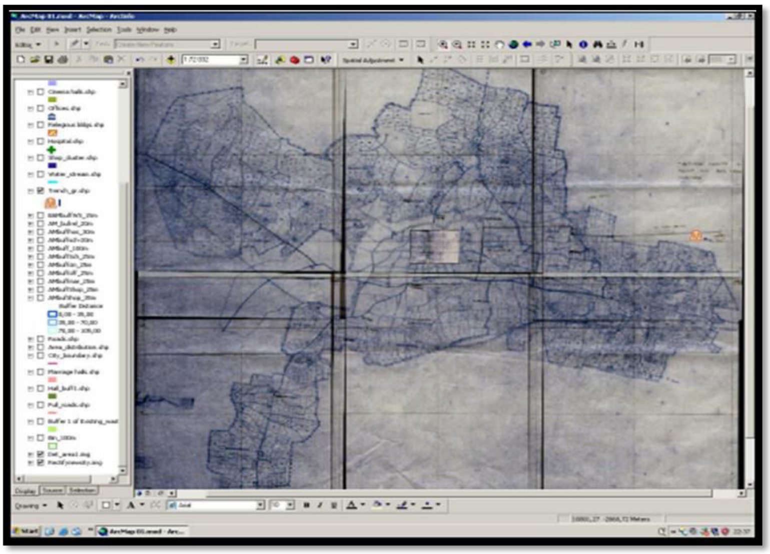
II. LITERATURE REVIEW

IoT with machine learning-based waste management system mainly focuses on dispersion of waste and enhances the environment to healthier. -e collection and decomposition of waste things in intelligent way are the major issue in smart city application. Because rapid development of smart city and population increases the wastages in every day, in a traditional way, the decomposition of waste requires more human resources and more time. And it spoils the environment, social life, and atmosphere. Abdullah et al. and Talari et al. discussed the review of waste management system based on Internet of things [1, 2]. Monika et al. proposed the smart dustbin system to collect the waste with Arduino UNO board with GSM module. But it has limitations like difficult to maintenance, and more time to collect [3]. Similarly, Kumar et al. proposed dustbin by using ultrasonic sensor to continuously monitor the garbage level. And it ensures immediate disposal of waste after reaching the certain level of waste in dustbin [4]. In India, Shyam et al. proposed the intelligent based dustbin in Pune by using IoT prototype [5]. It analyzes the IoT-based waste administration, for example, the closest neighbor search, province advancement, hereditary calculation, and molecule swarm enhancement strategies.Pardini et al. proposed the solid waste management system to collect the waste information from other data [6]. Similarly, Bueno-Delgado et al. proposed waste collection system using optimization in smart cities. It is mainly used to improve the rural areas. But it does not provide clarity results [7]. Lozano et al. discussed the linear regression and genetic algorithm-based waste management system to collect the waste and check the status of bins. But it has limitation to change the waste from bins to other devices. So, it is difficult to achieve waste transformation system [8]. Hannan et al. proposed garbage waste management system by using line following robot to collect the waste, but it is not developed for optimization of waste [9].Popa et al. discussed the method to collect the food waste by using RFID technology and transferred through wireless networks. But this method is not suitable for huge distance area to obtain smart city. And practically, it cannot be applied for real time applications [10]. Cerchecci et al. discussed the sensor-based waste management system. But this work can be tested only in board but not in real time applications for waste management system [11].

III. PROPOSED METHODOLOGY

3.1 City and case study area maps

Maps were collected from the Nagpur Municipal Corporation, Nagpur. The maps were available in the form of blue prints. Usually the corporation office has an original record copy from which the blue print copy was developed. The Nagpur, Nagpur map was available on the scale of 1:32000 and had the information of city boundary, different areas, important landmarks, major roads, railway line and airport. The second map was a detailed map of case study area which was on a larger scale. It was of scale 1:2000 and covered an area of 2 sq. km. The detailed map had the information about the detailed road network, major buildings, religious buildings, cinema halls, market, landmarks and water stream. Both the maps marked with a grid and were scanned in A4 size images. Later these grid map images were imported in the Arc View 3.3 and joined together by mosaicing technique. Then the base map raster image of Nagpur, Nagpur was geo-referenced. The detailed map raster image of the case study area was then located on its position on the city map which can be seen in figure 5.1. Then the raster images were digitized to enter the spatial information in vector form. Different information was spatially located on the maps in point, line and polygon features. The case study area detailed raster map with vector data information in different features is seen in figure 5.2. The information about the schools, hospitals, offices and marriage halls was collected by general survey and the information from the local source like the area residents.



[Fig.3.1: Geo-referenced raster image of Nagpur, Nagpur with case study area image]

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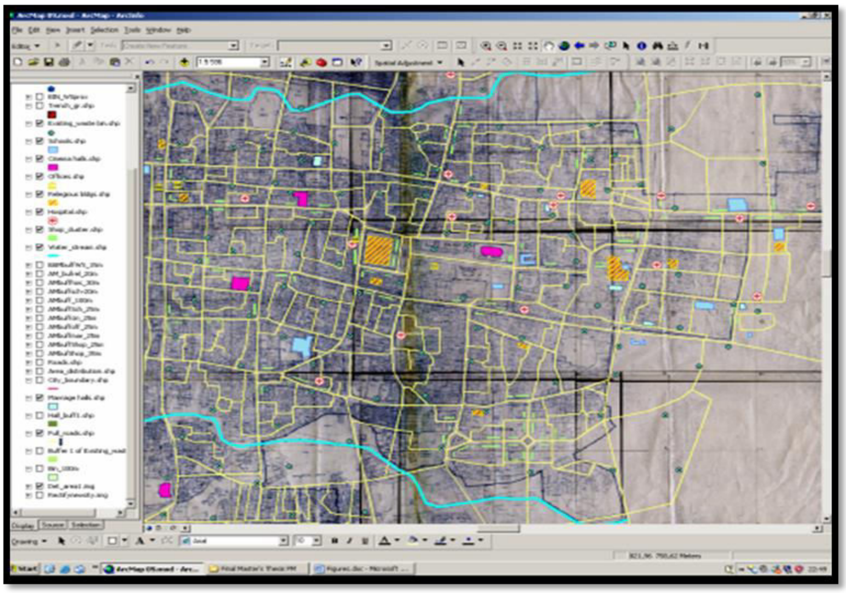
3.1.2 Land use data

The areas which are shown in the land use are the schools, hospitals and nursing homes, cinema halls, marriage halls and religious buildings. There was information of some of the land uses in the municipal map which is used as the base map. The land uses available on the map were the location of schools, cinema halls, vegetable market and major buildings. The other land uses which were required in the analysis and were not available in the map were collected from other sources. Those were the hospitals, nursing homes, clinics and office buildings. The maps being old, some latest land use information was also needed to be updated. There are two natural water streams passing through the case study area and those are demarcated in the municipal map.

3.1.3 Waste bin location data

This information was collected from the municipal office. The location of the waste bins was demarcated on the case study area map. These locations also include some open dumps which are presently in use for waste collection. But on a whole all were used for waste collection and are represented as existing bin location. The same information was used in the database.



[Fig.3.2: Raster image map of case study area with feature vector data in different layers]

3.1.4 Shop waste generation data

It was a complex job to collect the information regarding the shops and the type of waste generated by them. A simplified technique was adopted so that the waste generation trend of the shops can be assessed. For getting the data about the location of shops in the case study area, a map of the study area was used to mark the location of the shops. The shops in a row or a group were represented by a single line. This line represents group/number of shops (irrespective of the exact number of shops) at this location. The location of the group of shop was sufficient to spatially refer its position on the map. The second information was, the type of waste generated in the shops. For this the waste was divided into three categories i.e. composite (organic), recyclable (inorganic) and mixed (containing both type of wastes). Now as per these three categories the shops in the case study area were to be assigned the appropriate category as per the type of waste it generates. The list of total number of shops in the area was divided into three categories. The line representing the group of shops was assigned with the category of waste according to its waste generation type. If all the shops in the group generate recyclable or a composite type of waste, then it was assigned the category 'recyclable' or 'composite' on a whole. If there are shops which generate both type of waste in the group of shops, then that group was assigned 'mixed' category of waste generating group. This information was sufficient to have a basic idea about the type of waste generated in shops. The third is the attribute information which will form the attribute data giving the information about the spatial elements. For instance, for a group of shops in the map the attribute date of that group will posses the information about the category of waste generated in that group or any other land use.

3.1.5 Limitations of the data

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The data information was collected from different sources and tried to incorporate in the GIS data base. There were some limitations in the data; it was related to both data type and data availability. All these limitations are discussed below; The maps available form the municipal corporation were old enough and does not have the information about the later date and changes. There can be more precession in the waste generation in the shops by having the exact information. But this requires a detailed survey conducted with exact number of shops and each shop represented by a point feature and attribute information about the category and quantity of waste generated in that shop. Well this detailed information would make the analysis in a much refined way and could achieve precession in the analysis. But the data which was available was for a group of shops so the quantity of waste generated by the shops cannot be evaluated. But the type of waste generated by a group of shops can be used to determine the requirement of the waste bin type in that area where the group of shops is located. The land use data of the hospital, clinics and nursing homes is available in a point feature. The point feature only demonstrates the location by a point and does not give the exact area of the land use. It would have been more convenient to have the boundary and area of the hospitals to have a precise analysis for waste bin proximity. There can be an analysis of the quantity and the type of waste generated in an area on the basis of population density, land occupancy and type of settlement. This could help in analysing the waste generation situation in a precise manner. But as there is no availability of detailed information of the population distribution, the quantity of waste generation cannot be related to the area density.

3.1.6 Type of wastes

We got an idea about the type of waste generated in houses. The content of waste thrown into the municipal waste bin is food waste, vegetable waste, yard waste. All these are of wet or semi wet type and the swept garbage comprises of soil, dirt and dust which is of dry type. There is sometimes usage of paper or cardboard in the household which also goes in the garbage. As it is used along with the food materials it gets dirty and semi wet in contact with food and vegetable waste. It is not practically possible to separate it from the food waste and usually it is less in quantity and can decompose with the other organic waste so it can be left as a part of organic waste which can decompose. As far as plastic and polythene items are concerned, though they are also less in quantity but still it is advisable to separate it from the organic waste before the final dumping of the waste to the landfill.

3.1.7 Storage of garbage

Regarding the waste storage, it is seen that 90%of residents use their personal house waste bins to collect and store the house waste and throw the waste into the municipal waste bin by directly emptying the garbage from their personal bins into the MWB. Whereas 10% use polythene bags to collect and store the waste and throw it along with the garbage. It is seen that 65% of residents keep the garbage for 1 or 2 days at their places and 30% keep for 2 to 3 days and only 5% keep it for 3 to 4 days. It is clear that mostly people do not prefer to keep the waste for long. A strong reason for this is that the domestic waste being damp in nature gets spoiled very fast thus starts producing foul-smelling and invites flies and insects.

3.1.8 Recyclable waste

About the recycling waste, usually the type of materials people sell to the waste buyers are glass, old books, newspapers, plastic bottles, polythene bags, metals, clothes, footwear and other such kind of waste. There are different categories of recyclable waste buyers in the market as per different categories of recyclable waste materials. The most significant point about the reselling market it that almost every recyclable material which has even a least resale value is been utilised. This is a positive thing in the waste system that, somehow the system is successfully promoting the waste recycling. Mostly the citizens are adjusted to the recycling pattern and find it feasible to separate the waste at their places itself. There is one more general observation regarding the response of different income group people regarding the resalable waste. It is observed that there is a positive attitude towards selling the recyclable waste to the waste buyer's .The lower and middle income group people prefer to sell waste, as they get returns out of it. In higher income group, citizens might not be much interested in the returns but they usually have servants for the household work who often take initiatives to selling the recyclable waste as it could make some additional income for them. Regarding the storage of the recyclable waste, it is observed that, 45% of the people have been keeping the resalable waste for a week's time, 15% have been keeping it for 2 weeks and next 15% have been keeping it for 3 weeks. The left 25% keep it for more than 3 weeks. This type of waste is absolutely dry and can be kept for long without getting spoiled provided that there is no storage inconvenience to the user at its place. Usually people store this kind of waste materials in their storage and give it to the waste buyers whenever they come to buy the waste. There is no other inconvenience in keeping it for long.

3.1.9 Convenient distance

According to (CPHEEO 2000) the maximum distance between a household to a waste bin should be 250 meters. This limit is set to take care of the public convenience. So keeping this in mind the option in the questionnaire were given from a range of 50 meters and up to 250 meters with a regular difference of 50 meters. These choices were given with the intention to get the exact preferences of the citizens and it worked. The preference of majority of people was achieved. Almost 70% had given a preference to 100 meters as a convenient distance for them from their places to the municipal waste bins. Whereas 20% wants it to be within 50 meters and only 10% feel that it can be up to 150 meters. Majority of citizens prefer to be nearer so it is advisable to provide a bin within a reach of 100 meters for all the citizens. It might be less than this for many houses but it is more important that it should not be more than 100 meters for all the residents. Those who are having a bin more than 100 meters away should be considered for providing this facility within a convenient distance.

IV. GIS WORKFLOW MODEL

This model is designed for proposing a system which could reconsider the existing bin locations in the city and providing some better alternatives in allocating and relocating the existing and the new proposed waste bins. The proposed amendments in the system through this model would reduce the waste management workload to some extent and solve some of the present situation problems. Figure 7.1 demonstrates the work flow pattern of the proposed GIS model. This model is divided into four key components which are primary data, analysis, functions and results. These key components explain the further detailing of the contents in them.

4.1 Primary data

The primary data comprised of different map layers of the case study area. The layers are boundary (base map), bin locations, land use, road network, environmentally sensitive areas and shops. The primary data has both spatial and attribute information.

- The bin location includes the location of both existing bins and the open dumps. These are represented in point features.
- The land use includes the locations of different buildings in different layers. They are schools, hospitals, religious buildings, theatres, marriage halls and offices. The land uses are represented in polygon and point features.
- This layer shows the road network of the case study area which is represented in line feature.
- The environmentally sensitive areas are two natural water streams which are represented by line feature.
- The shops are represented by a polygon. Each polygon represents a group of shops and there is a classification of all the shops in three categories which is based on their category of waste generation.

4.2 Analysis

The model covers five analyses which are to be made on the available primary data. These analyses are proposed for suggesting some improvement in the existing waste management system. The results of the analysis made on the available data will help as a decision support in planning the allocation of new recyclable waste bins and relocation of the existing bins whose presence at that location is causing inconvenience to the citizens and also risk to the environment. These analyses are discussed below under separate headings.

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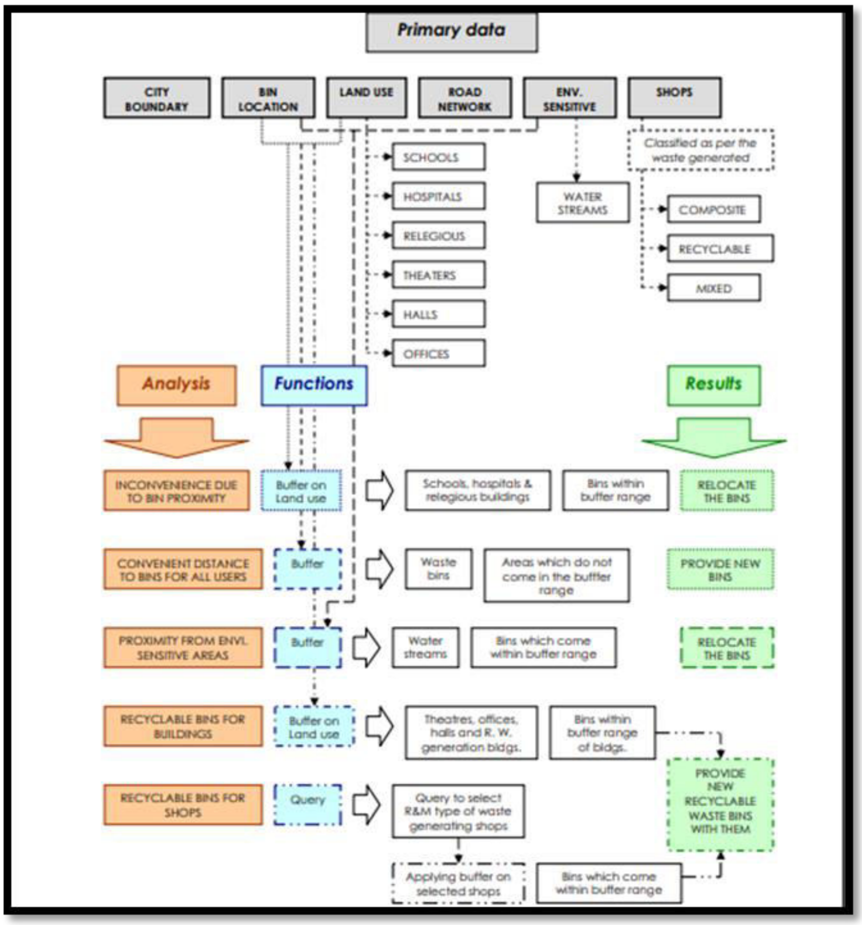


[Fig.4.1: GIS workflow model]

1. Inconvenience due to waste bin proximity

There are certain areas which need to be kept away the areas from the dust bin. So this factor will be analysed for existing bins and it would be also a guideline for proposing new waste bin in future. This analysis will cover the factor of inconvenience to a particular category of land use due to the proximity of municipal waste bin. The land use like schools, hospitals and religious buildings are preferred to have a considerable distance from the waste bins. For this, a buffer analysis of 20 meters will be carried around the three land uses i.e. schools, hospitals and religious buildings. In case of hospital buildings the data available was only the point theme representing the locations of hospitals and clinics where as in other land use we had a polygon feature to represent the whole building area. So for this analysis, the buffer will be created in three layers of 10 meters each which will make a total buffer of 30 meters. This would provide a margin of considering the first band of 10 meters buffer as the hospital building area and left two bands of 20 meters can be used for analysing the proximity.

2. Convenient distance to bins for all users

It is seen that seen the preference of majority of people for a maximum convenient distance for a waste bin from their places is 100 meters. For this analysis a buffer will be created around all the waste bins of the study area. The areas which come in the buffer zone will are within the convenient distance to use the bin, so these areas need not have to be considered for any changes in the bin location or allocation of new bins. The areas which are not in the buffer zone have to be considered to be having an inconvenience in using the waste bins due to long distance from their places. So these areas need to be considered for providing with new waste bins which will be at a convenient distance to those areas.

3. Proximity from environmentally sensitive areas

To avoid this situation the waste bins which lie in the close proximity of the stream should be detected. For this a buffer analysis will be carried around the water stream. A buffer of 15 meters will be applied on both the sides of the stream. This analysis will highlight the bins which are in proximity of 15 meters. These bins need to be relocated from their locations and it should be considered that no waste bin or open dump is placed in the water stream's buffer range in future.

4. Recyclable bins for buildings

For selecting the nearest located waste bin to a building from the selected bins, the buffer can be applied in bands of different distances. This will make it convenient to make a comparison between more than one bin in a close proximity of a building. The closest placed municipal bins to those buildings can be suitable for providing new bins along with the existing municipal waste bins.

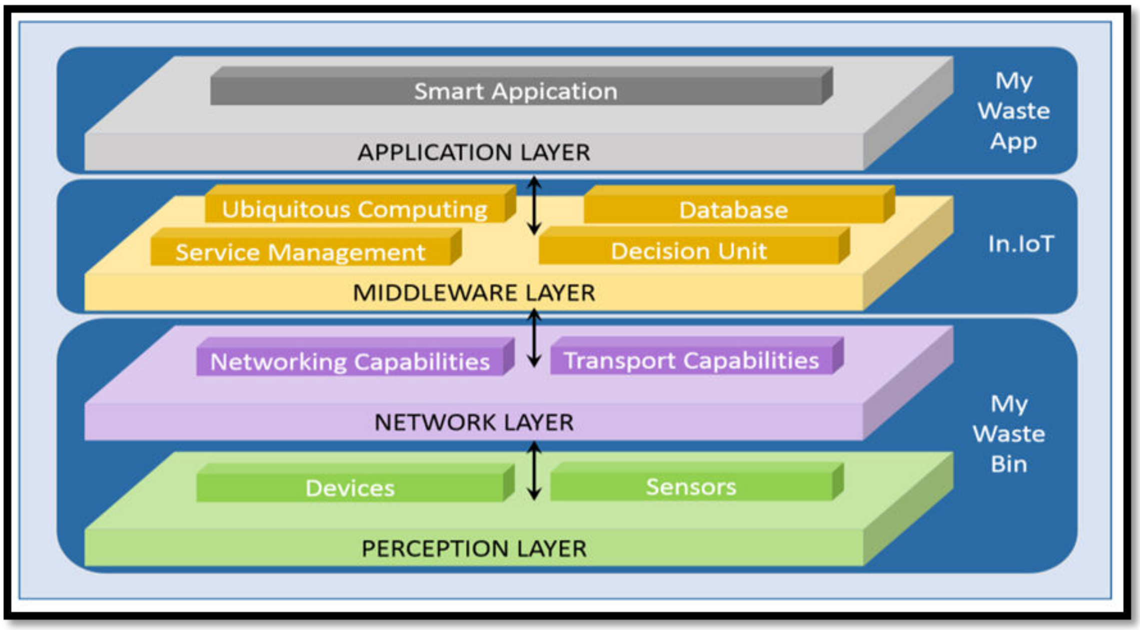
5. Recyclable bins for shops

This was intended to achieve two aims; to have an idea about the requirement of recyclable waste bins in the areas and to minimise the amount of waste going to the dumping ground. From the groups of shops those groups have to be identified which generate recyclable and mixed type of waste. So these can be identified by placing a query to select 'Recyclable' and 'Mixed' type of waste generating shops from the shops category. This will highlight the required groups of shops. These shops require recyclable waste bins to dump their recyclable waste. For locating recyclable waste bins for these shops the nearest municipal bins to every group of shops should be selected. This can be obtained by applying a buffer around the shops which are selected from the query results of recyclable waste generating group of shops. Similar to the recyclable waste for buildings, for selecting the nearest located waste bin to a group of shops, amongst the selected bins, the buffer can be applied in bands of different distances. This will make it convenient to make a comparison between more than one bin selected in a close proximity of shops. The closest placed municipal bins to shops can be suitable for providing new bins along with the existing municipal waste bins.

V. ARTIFICIAL INTELLIGENCE SYSTEMWORKFLOW MODEL

The waste management processes typically involve numerous technical, climatic, environmental, demographic, socio-economic, and legislative parameters. Such complex nonlinear processes are challenging to model, predict and optimize using conventional methods. Recently, artificial intelligence (AI) techniques have gained momentum in offering alternative computational approaches to solve solid waste management (SWM) problems. AI has been efficient at tackling ill-defined problems, learning from experience, and handling uncertainty and incomplete data. Although significant research was carried out in this domain, very few review studies have assessed the potential of AI in solving the diverse SWM problems. This systematic literature review compiled 85 research studies, published between 2004 and 2019, analyzing the application of AI in various SWM fields, including forecasting of waste characteristics, waste bin level detection, process parameters prediction, vehicle routing, and SWM planning. This review provides comprehensive analysis of the different AI models and techniques applied in SWM, application domains and reported performance parameters, as well as the software platforms used to implement such models.This project would deal with, how Geographical Information System along with Artificial Intelligence system can be used as a decision support tool for planning waste management scientifically and efficiently.

Global industry is undergoing major transformations with the genesis of a new paradigm known as the Internet of Things (IoT) with its underlying technologies. Many company leaders are investing more effort and money in transforming their services to capitalize on the benefits provided by the IoT. Thereby, the decision makers in public waste management do not want to be outdone, and it is challenging to provide an efficient and real-time waste management system. This paper proposes a solution (hardware, software, and communications) that aims to optimize waste management and include a citizen in the process. The system follows an IoT-based approach where the discarded waste from the smart bin is continuously monitored by sensors that inform the filling level of each compartment, in real-time. These data are stored and processed in an IoT middleware providing information for collection with optimized routes and generating important statistical data for monitoring the waste collection accurately in terms of resource management and the provided services for the community. Citizens can easily access information about the public waste bins through the Web or a mobile application. The creation of the real prototype of the smart container, the development of the waste management application and a real-scale experiment use case for evaluation, demonstration, and validation show that the proposed system can efficiently change the way people deal with their garbage and optimize economic and material resources.



[Fig.5.1: Artificial intelligence (AI) techniques]

These layers alternate according to the proposed model.

- Perception Layer: The IoT architecture perception layer is similar to the physical layer of the open systems interconnection (OSI) model, because it is based on the hardware level and has the responsibility of collecting physical information, processing and transferring it to the upper layers through secure channels. It applies technologies for the detection of parameters of physical characteristics through specific sensors, such as weight, temperature, humidity, etc. In addition, it performs the collection of object identification data, such as quick response codes (QR codes) and RFID.
- Network Layer: The network layer is responsible for transferring the measured information in the perception layer to the upper layers, where the processing systems are located, and uses ZigBee, Z-wire, GSM, UMTS, Wi-Fi, Infrared, 6LoWPAN. In addition to the basic assignments, the network layer also performs the cloud computing process and the data management process.
- Middleware Layer: The middleware layer is a layer of software or even a set of sublayers that work to interconnect components of the IoT that would not be possible to communicate otherwise, that is, as an interpreter. In addition to providing concurrency so that the application layer can interact with the layer of perception and ensure effective communication, it plays an important role in the development of new technologies.
- Application Layer: The application layer does not directly contribute to the construction of an IoT architecture, but it is in this layer where the various services are built that interface with users, that is, where the interpretation and availability of the information occurs.

5.1 Primary data

The primary data comprised of different map layers of the case study area. The layers are boundary (base map), bin locations, land use, road network, environmentally sensitive areas and shops. The primary data has both spatial and attribute information.

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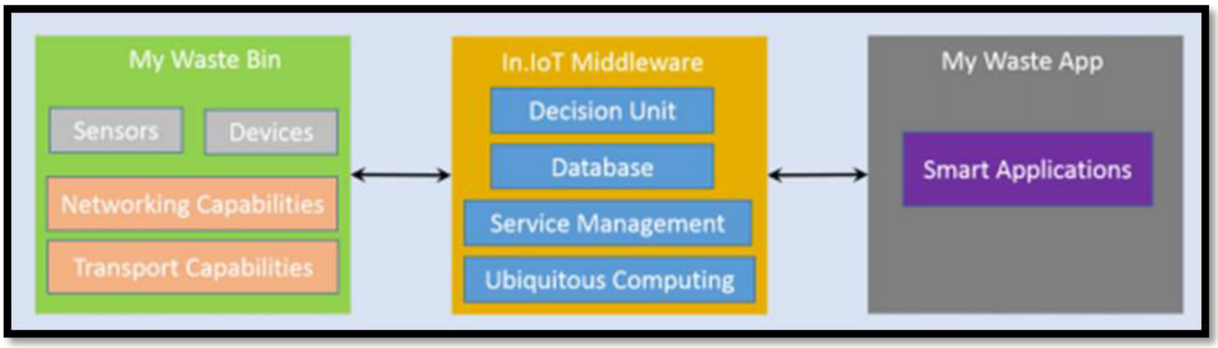
- The bin location includes the location of both existing bins and the open dumps. These are represented in point features.
- The land use includes the locations of different buildings in different layers. They are schools, hospitals, religious buildings, theatres, marriage halls and offices. The land uses are represented in polygon and point features.
- This layer shows the road network of the case study area which is represented in line feature.
- The environmentally sensitive areas are two natural water streams which are represented by line feature.
- The shops are represented by a polygon. Each polygon represents a group of shops and there is a classification of all the shops in three categories which is based on their category of waste generation.

5.2 Analysis

Architecture of My Waste Management System:

The system includes an applied solution where the compartments are monitored continuously by sensors, which inform, in real-time, the filling level of each one. These data are transferred to a storage and processing unit to serve as information, so that competent authorities can stipulate priority collection areas and collection paths with optimized routes and generate statistical data so the resources are employed adequately in regions with the highest demand for service. However, the main focus of the solution is to provide citizenship for residential users. Citizens can identify the compartments close to their home and know their level of usage in advance, via the Web or a mobile app. If the system recognizes unavailability at the nearest collection point, the user will be directed to discard his/her garbage at another available point and will receive the collection forecast from the previous bin, which allows the user to choose between a possible disposal at another location not so close, or even preserve the garbage at home so the disposal takes place at another time, after the municipal collection. The My Waste Management system considers three main blocks, as shown in Figure 5.2. The first describes the smart bin, the second considers the IoT middleware integration, and the last block presents the user's application.



[Fig.5.2: Illustration of the system architecture]

VI. MODEL IMPLEMENTATION ON STUDY AREA DATA & RESULTS

6.1 RESULTS AND DISCUSSION

CASE STUDY AREA- Nagpur

This chapter is a discussion of the implementation of GIS workflow model on the case study area data and the results of the analysis. This model is implemented on the data using GIS software Arc View 3.3 and Arc Map. We have data of Nagpur, Nagpur and we will be implementing the proposed model on the case study area of 2 sq. km. The first analysis is for studying the inconvenience to schools, hospitals and religious buildings due to close proximity of the waste bins. For this, a buffer analysis of 20 meters is carried around these three land use buildings. Separate buffers are applied on each of the land uses i.e. schools, hospitals and religious buildings. The buffer of 30 meters around the hospital buildings point features is created in three bands of 10 meter each.

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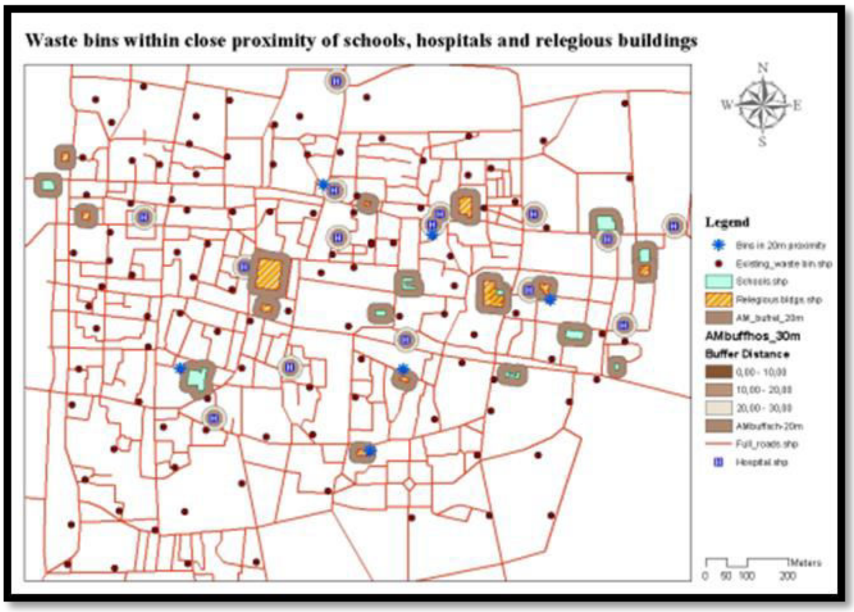
After application of the buffer the following results were obtained which can be seen in figure 6.1;

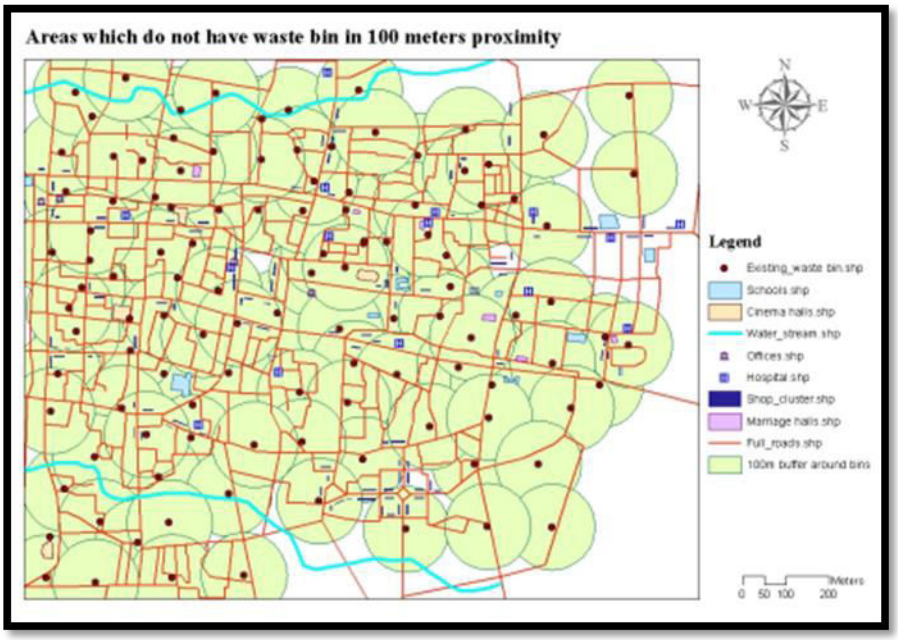
- There is only one municipal waste bins in a proximity of 20 meters of a school buildings.
- There are two municipal waste bins in proximity of 20 meters of hospital buildings.
- There are three municipal waste bins in proximity of 20 meters of religious buildings.



[Fig.6.1: Waste bins within close proximity of sensitive buildings]

In all there are six waste bins in the case study area which are in close proximity of schools, hospitals and religious buildings. These are required to be moved out of the buffer range of the respective buildings.

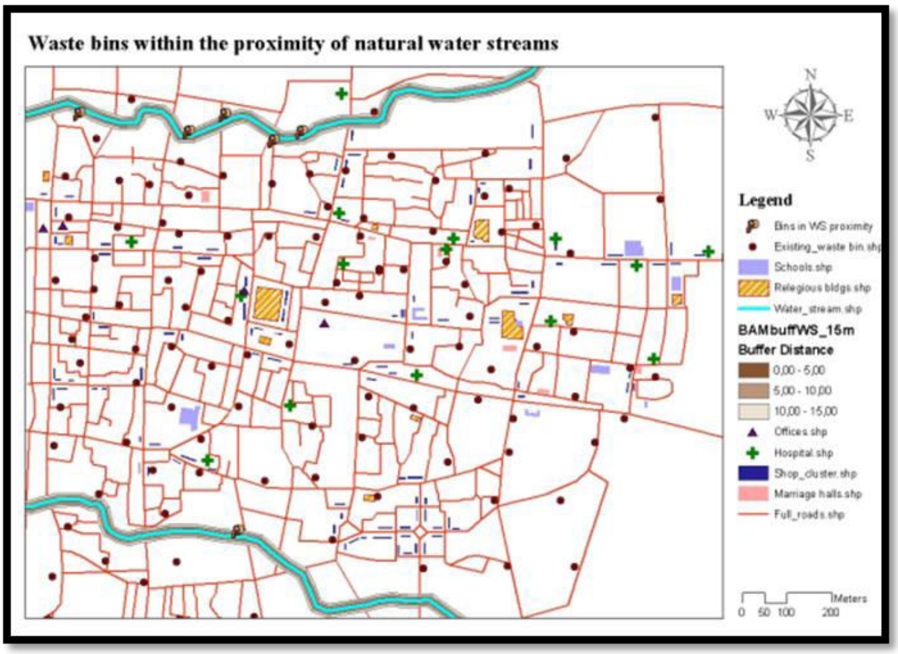
The second analysis is to check the waste bins proximity from the users to provide the bins at a convenient distance from all the users. For this a buffer of 100 meters is created around all the waste bins.



[Fig.6.2: Areas which do not have waste bin within a distance of 100 meters]

In the result of the analysis in figure 6.2 it is seen that most of the case study area is covered under the buffer except some areas. So the areas which do not come in the buffer range indicate that these areas do not have waste bins within a distance of 100 meters. So these areas require new waste bins within a distance of 100 meters. The allocation of bin can be done by finding a suitable location in the areas which needs waste bins. This will provide bins within a convenient distance range to all the residents. The proximity range can be again checked by applying buffer on the new bin locations.

Third analysis is for checking the proximity of waste bins from environmentally sensitive areas. For this a buffer of 15 meters is created on both sides of the two water streams. This will identify the bins which come in proximity of 15 meters of the streams.

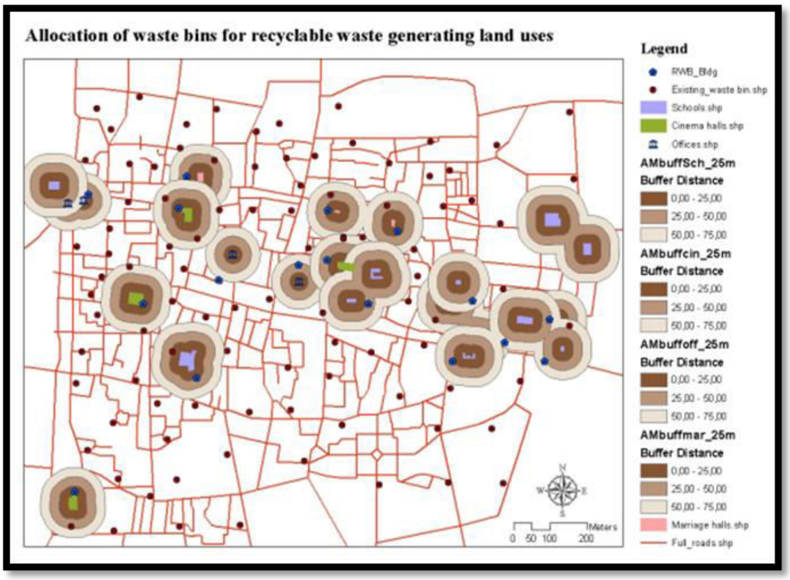


[Fig.6.3: Waste bins within close proximity of environmentally sensitive areas]

In the results of this analysis in figure 6.3 there are 6 waste bins which come in the proximity of water stream. So these bins are required to be moved out of the water stream proximity. The allocation of bin can be done by finding a suitable location where they do not come in the water stream proximity. This buffer can be used as a guide line while allocating bins near the water stream in the future.

Fourth analysis is for selecting the location for recyclable waste collection bins for recyclable waste generating land uses. It is a required to make analysis for the availability of a proximity organic waste bin to provide recyclable waste bins along with them for buildings which generate the recyclable waste. A buffer of 75 meters is applied around the school buildings, cinema theatres and marriage halls. The buffer is applied in three bands of 25 meters each. This would help to select the nearest located municipal waste bin for placing the new recyclable waste bin.

In the results in figure 6.4 there are in all 14 waste bins selected for providing the recyclable waste bins. It is seen that the school buildings, cinema theatres, marriage halls and the offices have municipal bins in the buffer range. The closely placed waste bins are selected for the location of recyclable waste collection bin. The recyclable waste bins will be provided along with the existing municipal waste bins. Out of 10 school buildings, 2 do not have a waste bin within 75 meters distance. The 2 school buildings without waste bin in their buffer range should be provided with recyclable waste bins and the new location is required to be found within the buffer range around the building.

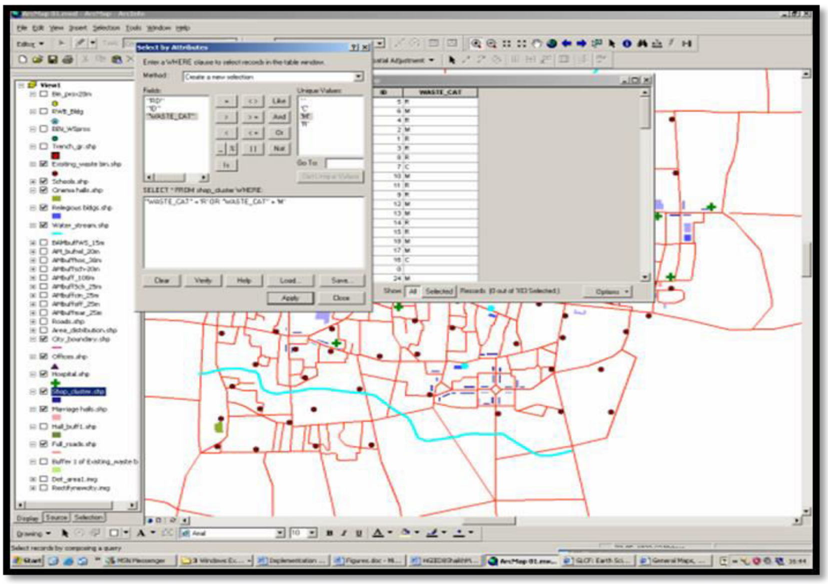


[Fig.6.4: Allocation of waste bins for recyclable waste generating land uses]

In cinema halls, marriage halls and office buildings all have waste bins in a range of 75 meters so recyclable waste collection bins can be placed with the nearest bin. The results displays the nearest located waste bins which are selected for placing the recyclable waste collection bins.

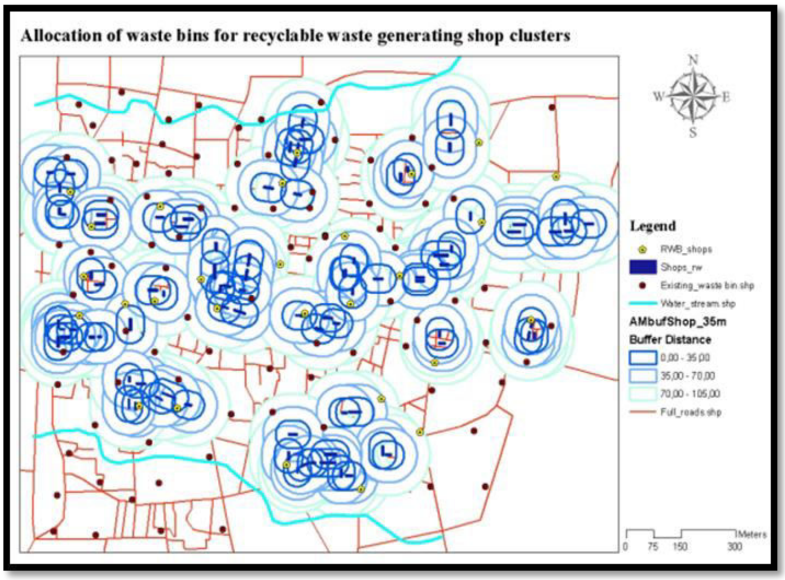
There was one waste bin which was ideal location for placing a recyclable waste bin for school as it was in its close proximity, but the same bin was also selected in the first analysis in the category of bins which were required to be moved away as they were too close to the school buildings. So that bin was ignored and the next nearest bin which do not come in the close proximity criteria constrain and also fulfil the buffer condition was considered suitable for allocating the recyclable waste collection bin for the school building.

The fifth analysis is to select locations for recyclable waste generating shops. First the information about the recyclable waste generation group of shops needs to be identified from the total groups of shops available in the data. For this a query is applied to select the ‘recyclable’ and ‘mixed’ waste generating group of shops as seen in figure 6.5. The query applied was, SELECT From shop_cluster WHERE; “WASTE_CAT” = ‘R’ OR “WASTE_CAT” = ‘M’



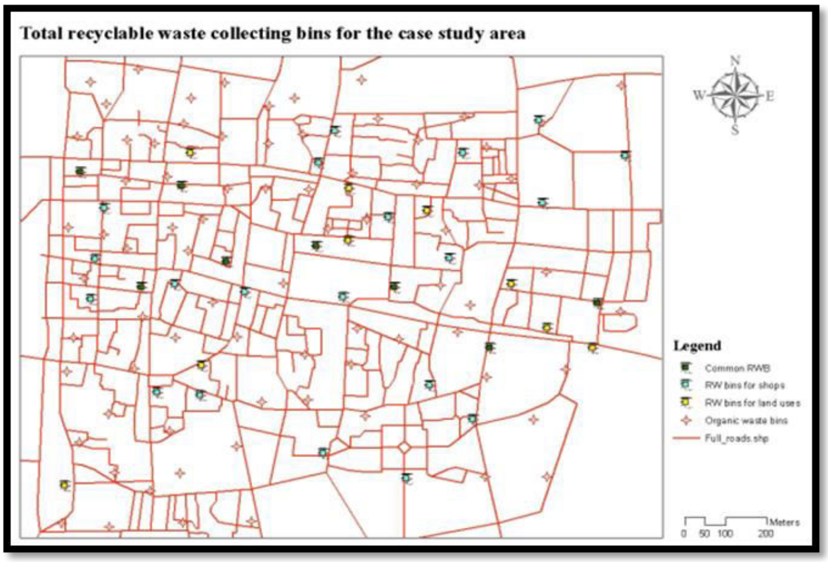
[Fig.6.5: Query application for selection of recyclable waste generating group of shops]

In the query results the group of shops generating recyclable and mixed type of waste are selected. Now to find suitable location for placing the waste bins is carried by applying buffer on the shop clusters. Buffers are applied in three bands of 35 meters each. The bands will help to select the nearest located waste bin and also to select a bin which would be nearer for maximum possible group of shops. The results of this analysis can be seen in figure 6.6.



[Fig.6.6: Allocation of waste bins for recyclable waste generating shops]

There are total 24 waste bins selected for placing the recyclable waste bins. Out of those 24 bins 8 bins are those which have been already selected for providing recyclable bins for the other land use buildings. So as they have been already selected, they can be ignored in any one category. Now in all we have to provide 20 recyclable waste bins for shops. In the final results for allocation of recyclable waste collection bins there are 35 bins to be provided beside the municipal waste bins for collection of recyclable waste.



[Fig.6.7: Total recyclable waste collecting bins for the case study area]

There are in al97 municipal waste bins in the city out of which 35 needs to be provided with recyclable waste collection bins along with them. These bins would collect recyclable waste from schools, office buildings, cinema theatres, marriage halls and recyclable waste generating shops. All the bins are provided at nearest locations but even the furthest one is within a distance of 100 meters from the waste generating area.

VII.CONCLUSION

The model proposed in this paper was designed for planning the allocation of waste bins in the case study area. There were several aspects taken into consideration in planning the waste management by evaluating the bin allocation. First was to analyse the location of the existing waste bins in the area. The planning concern was to verify the convenience and inconvenience of the users from the existing bin location. This was done by checking the location of bins for a convenient proximity distance for all the users and also for the inconvenience to the users due to close proximity of the bins to sensitive land uses. The planning of waste bin allocation also included the segregation of waste in two categories and for this, the provision of recyclable bins was proposed. The proposal was intended to provide the recyclable waste collection bins to those areas which generate recyclable waste. The identification of those land uses was carried which generate recyclable waste and then find the suitable location for placing those bins so it would be convenient of the users. The analysis sowed the required results which are useful for relocating the existing bins and for locating the new ones for a refined waste management system. The proposal is cost effective with the consideration of the budget constrains of the system while planning the waste management proposals. That is why an emphasis is given on revenue generation from both the categories of wastes. Situation based planning is carried to make the consideration of the existing situation and guidelines based on the consideration of the data availability and situational constrains. Managing the study with the available set of information and also not ignoring the important aspect of public participation by means of analysing the public behaviour in waste dealing. It is a generalised proposal with a margin of flexibility for changes and up gradation as per the situational changes or preferences.

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