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Smart Waste Information Management Model

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Abstract

Environmental waste is the end product of human existence within his environment. The purpose of the study was to design a Smart waste information management Model (SWIMM). It explored web-based technology, and garbage truck weighing mechanisms. They help waste management agents in monitoring location of waste in the environment. The method explored in the study was the rapid application development Model because it is reliable and reusable software art. The study developed mechanism that reports waste disposal within homes; integrated waste disposal mechanism into the database for effective information processing; implemented the integrated waste disposal mechanism using Hyper pre-processor (PHP) programming language linking it up with Microsoft Structured Query Language (MySQL) in Xamp and Javascript.; tested the integrated waste disposal Model by testing the phase integrated with the software application with the external computer peripherals devices in order to check how components interact with one another and with the Model as a whole; End to End scenario testing. When deployed, the Model enables the reporting of waste information through connected sensors embedded camera display system with which waste handlers can assess the level of waste at dump sites. The web-based Model stores the history of the driver and various records related to waste. It uses the image processing system to measure the waste index of a particular dumping site. The waste index is calibrated as low, medium, or high. A dumper truck database is generated in the system so that data and details of dumper truck ID, meeting date, meeting time of garbage collection, and so on are collected.

1. Introduction

Waste Information management is the collection, transport, processing of waste treatment and the recycling or disposal of waste materials, produced by human activity, in an effort to reduce their effect on human health or amenity. Many methods of waste reduction had evolved over the years and the way they are done varies from one country to another and also with respect to the type of waste generated as well as the countries productivity strength. In Nigeria the only Model that is being used is an automated web-based Early Warning Model (EWM), which could be used in dealing with the destructive effects of persistent flooding in the country and this was launched in Lagos in the year 2011. This is an effort to combat the adverse effect of climate change for sustainable development, food security, and the wellbeing of the people. The major weakness of

this Model is its inability to show a spatial view of the waste collection sites and the appropriate collection time, to prevent overflow and blocking of drainages which results in flooding.
Pollution has been a major problem in Nigeria, which has contributed to environment degradation. As a result of increased urbanization and infrequent environment sanitation exercises, urban resident dump solid wastes carelessly or haphazardly; anywhere they deem fit. Such disturbing tendencies and attributes many seem incomprehensible; if we desire to live in healthily environment. Some of the drainage system in the county has been turned into a dump site for human and all sorts of solid waste, with the constant pollution of the environment it is evident that human beings are being affected health wise thus calling for help and solution mechanisms. The current garbage collection management involves individuals who walk from, and to every household giving receipt of payments for garbage collection service. To get the service of the individuals or company, a resident or flat caretaker has to look for them and request for their service. For disposal, the collectors mainly consisting of youths, pick the waste and disposal it in landfills, some of whom are not even legal hence leading to pollution and environment degradation [1]. The study aims to design Smart waste information management Model.

A huge number of wastes are created by technological and technical activities, but several types are re-used; metal, plastic, paper, and glass. A number of issues from Smart protection consider the re-use of materials: to reduce the need for raw materials, reduce the pollution of water and soil. Industrial waste is divided into;
i. Scrap,
ii. Waste wood,
iii. Waste plastics and other materials,
iv. Industrial waste. Ecologically beneficial and comprehensive technologies that reduce the amount of the primary production are developing [2].
Since solid waste consist of several types of waste, it is important to briefly examine the various forms and types of solid waste. Municipal Solid Waste (MSW) Municipal Waste as waste from households, as well as any other waste which, because of it nature or composition is similar to waste from households. This broader definition therefore considers waste from commercial premises to be municipal, where it is similar in composition to household waste.
MSWs are difficult to manage. MSWs consist of materials such as metal, paper, glass, food waste, wood, ashes, plastics, textiles, rubber and other organics mixed together [3]. Similarly, a study [4] revealed that the characteristics of MSW depend largely on the sources, however, in some countries, nearly more than half of all MSW are recyclable materials while the recyclable constituents such as cardboard, paper, glass and plastics make up a significant percentage of the total MSW [5, 6]. [6] Opines that, due to the composition of MSW, the waste could easily be used for energy recovery or the production of fuel.
In developed climes, the volume of construction waste is on the increase and the wastes produced are significantly high when compared to the total waste generated. For instance, figures from Eurostat, revealed that in 2008 Construction waste in the UK account for about 100,999,493 tons while in 2010, the sector contributed about 105,560, 291 tons of waste. [7-9]. Similarly, France produced 252,979,840 tons and 260,225,886 in 2008 and 2010 respectively while construction waste in Germany was 197,206,500 and 190, 990,217 tons in 2008 and 2010. Cumulatively the 27 member countries of the EU produce about 871,370,000 and 859,870,000 in 2008 and 2010 respectively [10]. European Environment Agency [11] reported that in all about 31% of all waste produced in the EU annually are construction waste. A report [12] revealed that construction and industrial waste amounted to about 50% of all waste produced in the EU in 2006. A study [13] found that on the average about 15% of solid wastes in Australia are generated from construction activities annually
Industrial wastes as waste produced as a result of processing of raw materials for the production of new products. This could be from factories, mines or even mills. In Malaysia, Indonesia and

Thailand a large percentage of the total solid waste is from palm oil processing [11, 41]. The report found that, annually about 3.2 million metric tons of solid waste is produced in Thailand from the palm oil industry. The corresponding value for Malaysia and Indonesia are 47 and 40 million tons respectively.

Commercial waste is another source of waste stream. In eastern Nigeria about 1.5 million tons of solid waste was generated by commercial and industrial activities in 2005 [15]. Similarly, in the South-South, retailing, wholesales, hotels and restaurants produced the largest volume of commercial waste in 2006 [16]. The survey revealed that some areas of the country with a large concentration of businesses produced more business waste than other areas with fewer businesses. Lagos particularly produced higher percentage of waste than other states. On the overall [5, 6] revealed that in 2009, the commercial sector contributed about 29% of the total waste volume of in country. Commercial solid wastes are solid or semi-solid wastes.

It is obvious that there are certain factors that affect the environment. In Nigeria, Smart waste management is still only imagined. There is no Smart mechanism provision or awareness of it to enable the citizens take active part in preserving the environment.

There is no doubt that illiteracy forms part of the wastes management problems. When the citizens are environment-based literates, they will are better positioned to save the environment with effective waste management. When the citizens are not literate, they will not be able to comply with existing rules and regulations governing the effective disposal of wastes; they will also have very wrong attitudes to waste disposal initiatives. They will not be able to read some sign posts, such as “Do not dump wastes here”. The issue of rapid population growth is yet one of the problems affecting effective wastes management in Nigeria. This is because, as the population increases, more wastes are generated and the environment ultimately becomes polluted, especially when there are no effective wastes disposal Models in place to cope with the quantity or volume of wastes generated daily.

There are different forms of approaches to waste management. Wastes streams with different characteristics may require different management approach. For instance, industrial waste might contain more hazardous materials than municipal waste streams. Hence, the management of these two waste streams might differ [13, 14]. Although waste management might differ between countries, there are some basic processes or paths that waste management needs to follows. These paths are illustrated in Figures 1 and 2. Wastes generated must be gathered and stored by the generator in a place. The municipal authorities or their agents collect the waste from the point of storage, for transportation to processing or disposal sites. The study added that, in some instances, the waste generators separate the waste into various materials from where they are collected for recycling by the recycling industries.

Waste as an essential product of human activities, but also the result of inefficient production processes whose continuous generation is a loss of vital resources. In conclusion, wastes are materials whose owners no longer have a need for. Waste Management: Researches have shown that waste production is as a result of human interactions and/or activities with the environment [6, 7]. As [9] reported in his research that waste production and management was not a major issue until people began living together in communities. Subsequently also, as population and purchasing power of citizens increased worldwide, more goods were produced to meet the increasing demands, thereby leading to the production of more wastes. These continuous productions of waste resulting from human activities, have overburdened the environment. It has been affirmed that the production of waste materials have remained a major source of worry as it has always been since primitive period. In modern times, most developing or underdeveloped countries in various communities face lots of health and pollution challenges in relation to daily wastes generation [17]

There are variants of Sustainable Waste Management (SWM) through Systems Engineering Models and Remote Sensing Approaches (SEMRSA). The past literature analysis revealed that the cost-benefit analysis Models were used to appraise a waste management system’s positive and negative economic effects. In contrast, optimization Models were used to reach the best solution among

several options, considering a set of objectives. The analysis also revealed that the GPS applications were primarily done for tracking waste bins and collection vehicles for monitoring collection time and location. Moreover, the investigation revealed that the combined applications of GPS and GIS techniques performed better than their specific applications. The analysis of numerous global case studies disclosed that political, socioeconomic, hydrological, geological, and environmental factors should be taken into account for a proper landfill siting.

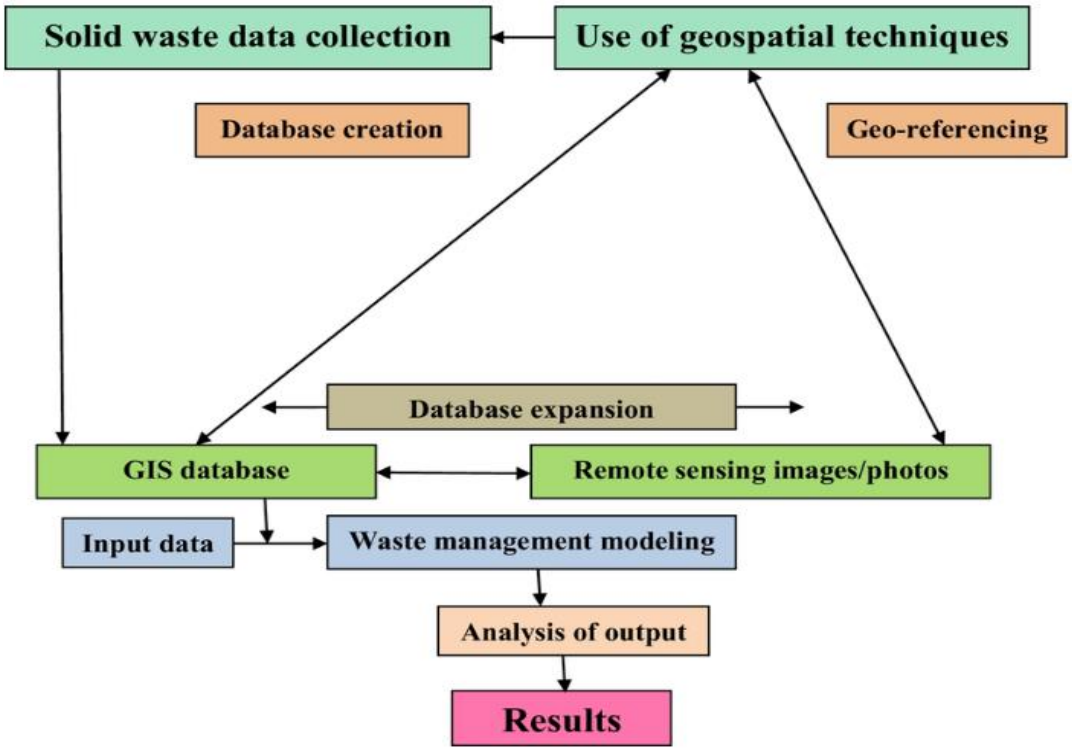


Figure 1. Common methodology used in the employment of RS and GIS in waste management Modeling Source [17]

There has not been a recent investigation concerning the use of systems engineering approaches, remote sensing, GIS, and GPS for municipal waste management. This paper provides an overview of the applications of systems engineering approaches, remote sensing, GIS, and GPS in solving the environmental problems of solid waste disposal. The applications of these approaches in numerous case studies worldwide are detailed in this paper and some conclusions of the analysis are summarized. Several recent examinations have proposed an appropriate reduction, reuse, and recycling of materials for managing the disposal problems of the tremendous waste amount in municipal environments as depicted in Fig.1 because appropriate disposal and organization of MSW are prerequisites to reduce harmful ecological effects and degradation of surface and groundwater reserves [18].

Systems Engineering Approach Various systems engineering Models have been extensively utilized for managing environmental problems recently. For example, cost-benefit investigation Models have been used to appraise the positive and negative economic effects. A distinct cost-benefit analysis Model may transform environmental facets into financial terms [19]. Optimization Models were used to arrive at the best solution among several options, considering a set of objectives [20]. Shmelev and Powell presented an analysis of a multi-criteria optimization Model to realize the goal of sustainable MSW management at regional scales. The approach considered the spatial and temporal distribution of MSW production and processing. Also, it considered the financial and environmental impacts on biodiversity and well-being. The fundamental detailing and activity of an optimization Model appear in figure 3.

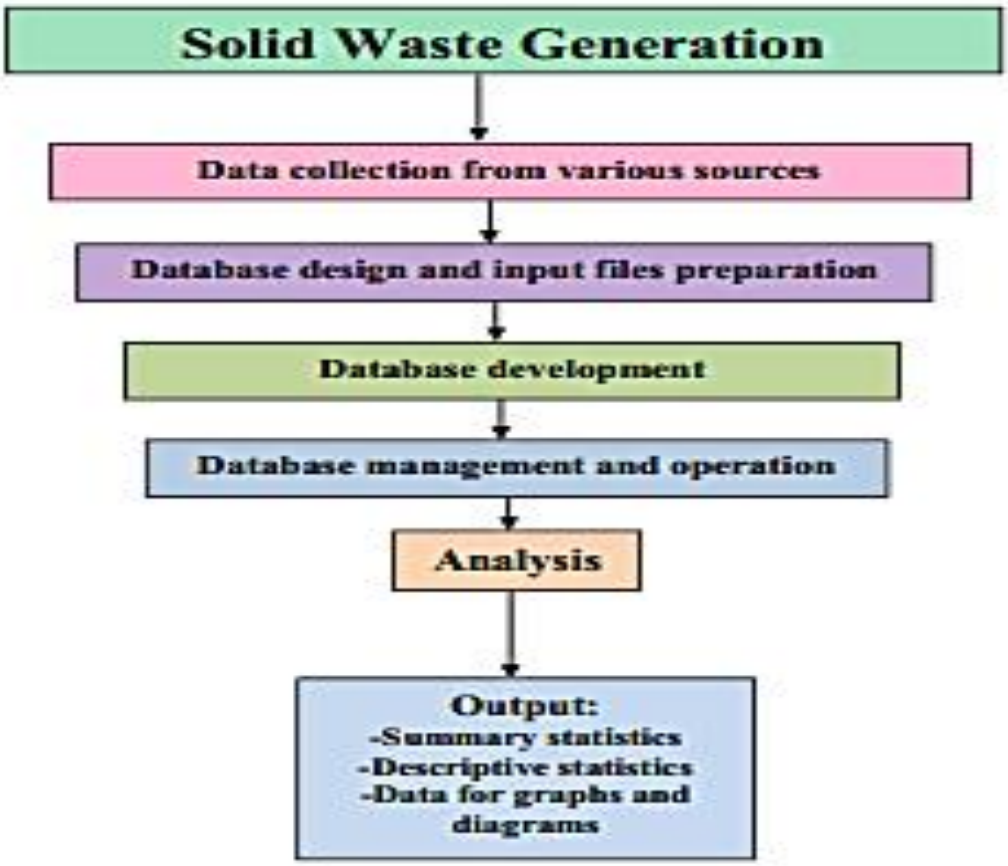


Figure. 2 Flowchart of database analytical structures source: [18]

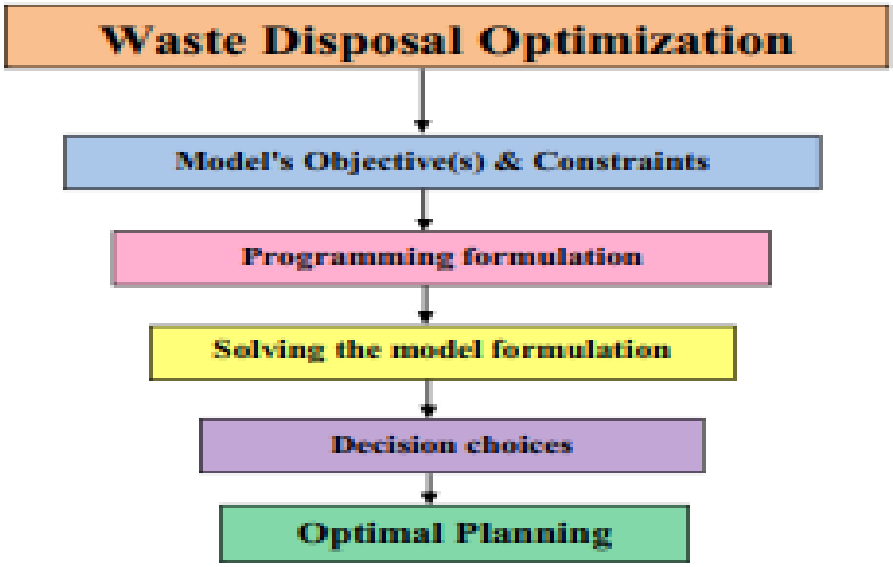


Figure 3 Waste optimization Model Source [20]

A waste organization scheme's efficiency can be amplified by the best possible utilization of IACTs [21]. There are various systems available to use IACTs in waste management, for example, data possession technologies based systems in which distance and image sensors are fitted in the waste bins, classification technologies based systems in which barcode tags are fitted in the waste bins for

and geospatial technologies based systems in which RS, GPS, and GIS are used to track the location of waste bins [22-25]. These technologies also have been used for site selection waste planning. Data transmission technologies are generally used in all the systems above for assisting the communication of processed data. [26] Reported that progress in IACTs and sensing technologies had made the instantaneous monitoring of waste bins handier and more feasible. Remote sensing (RS) usually refers to the efficient utilization of airborne detecting advances for sensing objects on the ground from a distant location through signal transmission from satellites [25, 27].

The use of RS in SWM has been done for siting landfills for waste disposal evaluation of the ecological impact of covered waste, and monitoring for waste landfall. [27] Built up a framework for siting landfills by examining the emissions from domestic waste disposal landfills. The researchers used a GIS database in conjunction with RS for five waste sites in the urban regions of Suzhou city and Wuxi in China. Earlier, [28] used satellite data and aerial images to explore apt waste disposal locations in underground corridors. Later, [29] used data acquired from field sensors and NASA's Aqua and Terra satellites for the ecological study. They examined pollution and recovery status for environmental appraisal of waste dumping. A spatial analysis was performed by Jensen and Christensen using industrial location constraint criteria and remote sensing data for locating suitable disposal sites for hazardous waste and MSW. Later, Irvine and his team performed an analysis of RS thermal image in conjunction with a past aerial image for location remediation planning by spotting the buried waste [29, 30].

More recently, [20] used satellite collected high-resolution images for locating the waste transportation route and waste disposal sites in the city of Abeokuta. Previously, [23] used an imaging method for the remote monitoring and categorization of synthetic waste from total waste materials. In this study, near-infrared imaging was used to acquire the images and it was followed by linear discriminate analysis. Geographic Information System The geographic data framework is a standout among the most broadly utilized devices for overseeing geographic information [19, 26, and 28]. GIS has been widely utilized for dealing with the diverse issues of MSW. It is most commonly employed for landfall siting and transfer stations. [29, 30] reported using GIS for the predicted data-based scheduling and routing optimization. The researchers also have used the GIS-related methodology to assess MSW production, considering the local demographic and socioeconomic data. Karadimas and his team used feet depot tracking via spatiotemporal analysis in a GIS environment for SWM framework design to compute total expenditure and viable options. The geospatial techniques have been program.

The problems above of MSW management have been solved by using a range of techniques and tools such as systems engineering Models and information and communication technologies (IACTs) in the recent past [22]. Nuortio and Johansson used systems engineering Models for addressing the solid waste disposal problems of urban areas. They underlined that waste management's diverse vehicle routing problems had been analyzed for minimizing emission, reducing cost, serving customers, and following the optimized route for waste collection [24, 27].

Global Positioning System Researchers worldwide have extensively used geospatial techniques for waste management and allocation of sites for the aptness of wastewater treatment plants. The global positioning system (GPS) applications have been broadly made for dealing with SWM issues such as tracking waste bins and collection vehicles for monitoring collection time and location. The GPS-based waste management scheme is mainly employed in collection monitoring path optimization, efficient billing, and vehicle tracking. Arebey used a GPS receiver set in trucks and a remote server tracked it to monitor waste bin and collection trucks [15]. Similarly, Alam Flora used a truck-installed GPS receiver for tracking collection trucks. Earlier, Wilson with some research friends used GPS fitted in 5 solid waste-collection trucks to gather diverse information required for SWM planning. Monitoring of solid waste and collection trucks was done by Lee and Thomas by using GPS and individual communications services [25, 29]. Figure 4 shows the Sustainable solid waste management template.

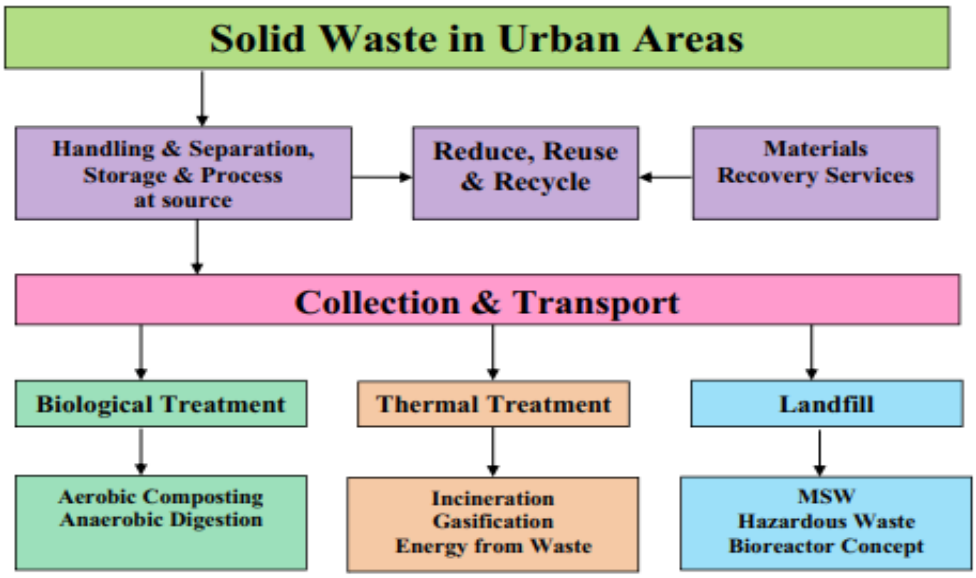


Figure 4. Sustainable solid waste management in circular economy Source [22]

2.0 Methodology

A web-based mechanism is developed to store the history of the driver and various records related to waste. In this application, we also used image processing to measure the waste index of a particular dumping site. The waste index can be low, medium, or high. A dumper truck database is generated in the Model so that data and details of dumper truck ID, meeting date, meeting time of garbage collection, and so on are collected. This technique keeps track of all the truck drivers' activities and the waste gathering Model of waste management. This Model allows on-time waste gathering and also allows automobile trace through database along with of Global Positioning Model (GPS) automation. The GPS employs satellites to determine a vehicle, person, or other assets' precise position and records the asset's position at regular intervals. The trucks' details are then forwarded to the data centers with are mote correspondence interface. With the help of the tracking Model, the authorities of a waste management organization can keep track of their vehicles. Our Model provides an optimized path for collecting waste, which saves much time and increases the efficiency of the work done. In this Model, we have used the Arduino UNO micro-controller. Sensors are connected with the microcontroller for processing. Ultrasonic sensor ranges from 2cm to 400cm measurement function of noncontact. Moisture sensors are also used to detect whether the waste is wet or dry.

The following are the merits of the proposed Model, it provides for;

i. automated updating of waste position in the database
ii. fast information retrieval from the database
iii. accuracy in information recording
iv. effective waste location monitory

2.2 Method adapted in the study

This research work adopted Object-Oriented Model Development Methodology (OOSDM). This method views, Models and implements the proposed Model as a collection of interacting classes and objects. OOSDM is adopted because it is an effective, efficient, reliable, reusable and a faster way of developing Models.

3.0 Results and discussion

3.1 Architecture of the proposal model

The Model consists of Smart trash bins with a real-time monitoring Model which integrates multi-choices, such as ultrasound distance, along with a transmission module. Low energy use was considered throughout the design process. Each node is consequently supposed to be powered by multiple sources; solar energy or batteries. Selection of the best electronic components for their interconnection and for energy efficiency strategies during the employment of the methods was considered. Furthermore, technical solutions will enable turning off nodes (or parts of them) when they do not work. Once principal components of the node has been chosen, the overall design was targeted at their integration. The data are used to track and predict the status of the trash over each period. Furthermore, they will be used to calculate the optimal path, accordingly. The predicted state of each trash bin can be examined, based on assigned training data. It is, then, reviewed to refresh the appropriate waste fill level, which is an essential input parameter of the optimal path algorithm. The architecture of the Model is shown in Fig. 5.

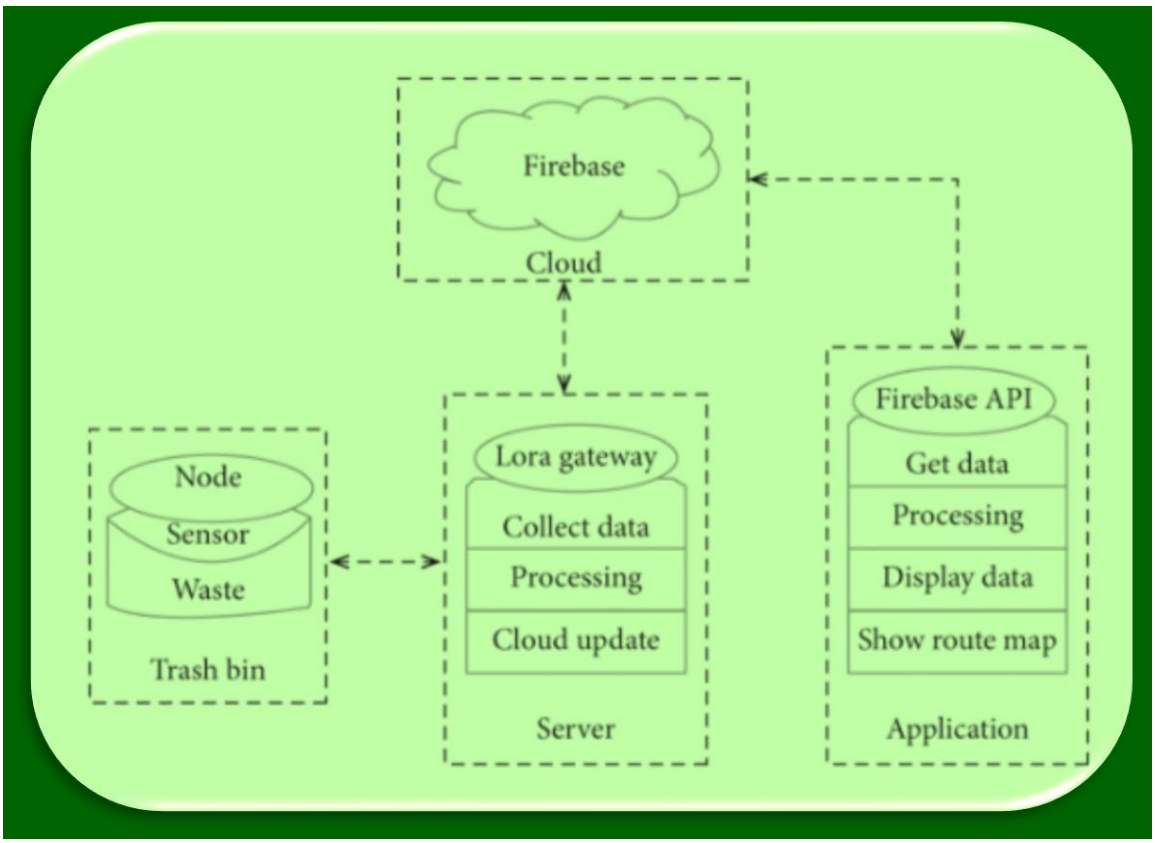


Figure 5: Architecture of Design Proposed Model

3.2 Input design of the proposed model

The input of the Model includes fields like: house address, GPS location, phone and size of the waste. The input is entered through any keyboard. The input design is shown in Fig. 6.

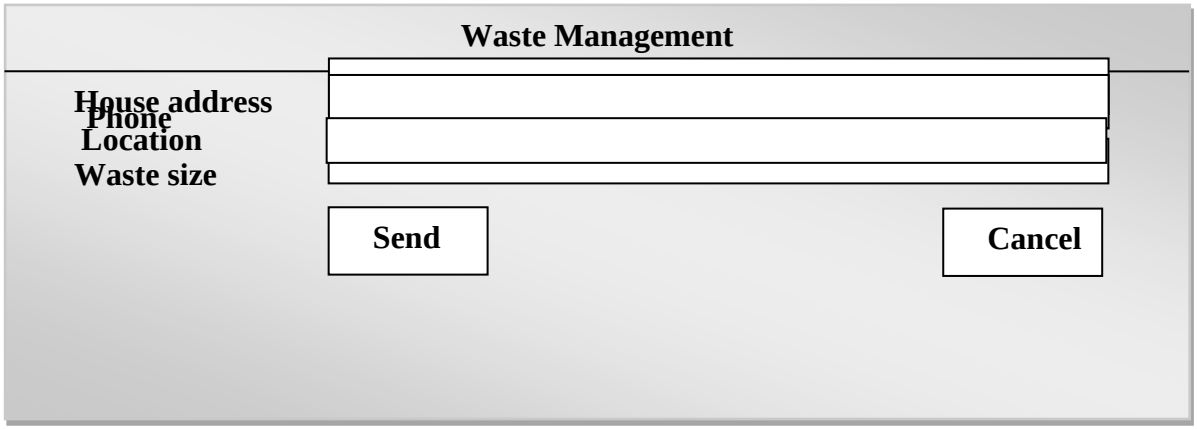


Figure 6: Input Model of the Smart waste management system

3.3. Process model design

The design Model showed all the graphical design of the proposed Model for the developer to use in the data flow process in the proposed MODEL. The design tools used were USE-CASE diagram, sequence diagram, class diagram and program flowchart.

3.3.1.The sequence diagram of the model

In the waste management Model, the sequence diagram is used to Model and visualize the logic behind the sophisticated function, operation and procedures. Where the user send the data needed to company database, the waste management company retrieve the data and also makes confirmation on the database, check the available service and send a reply to the user.
Figures 7, 8, and 9 show the sequence, Class, and USE-CASE designs of the Proposed Model.

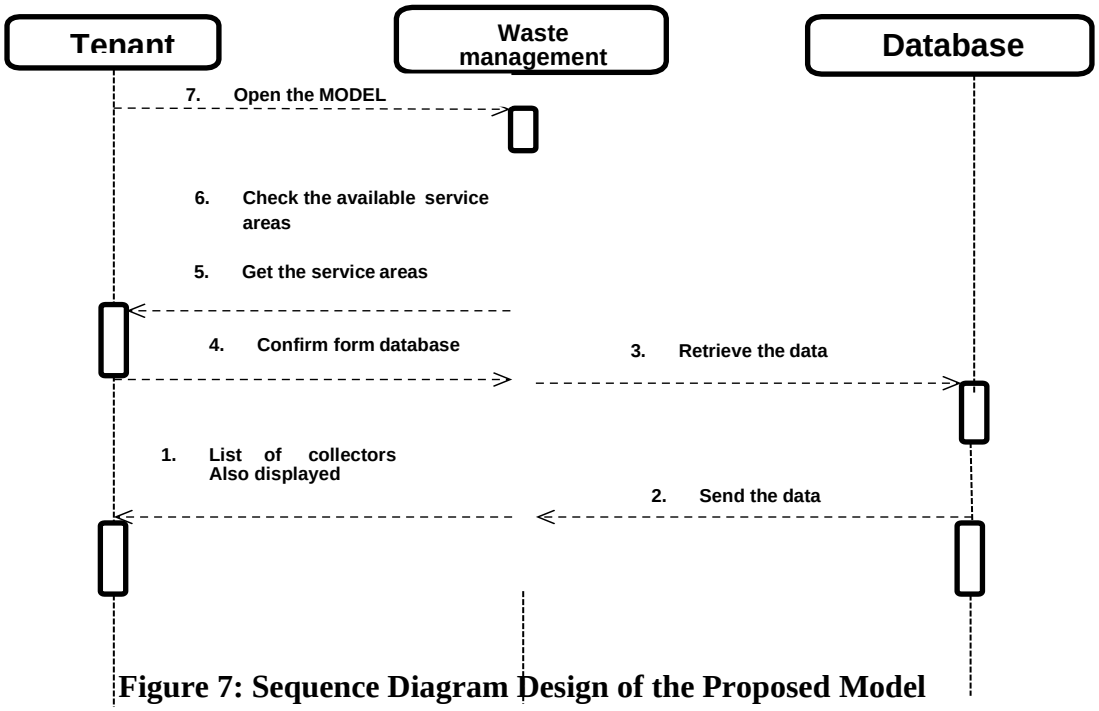
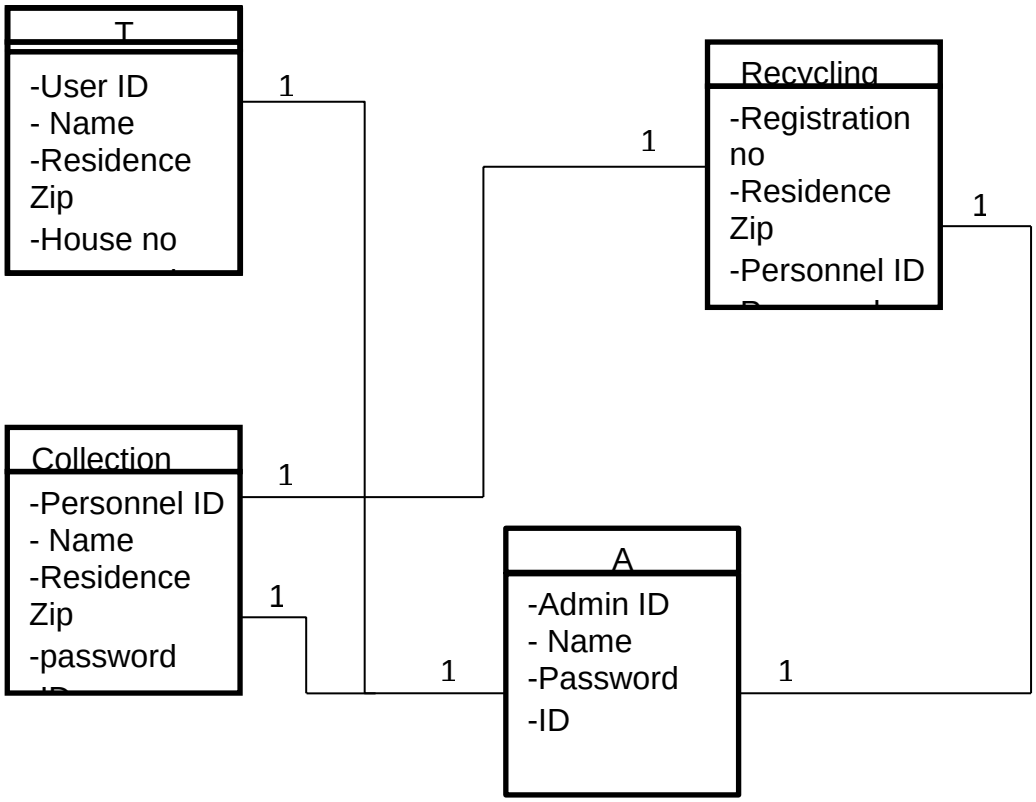


Figure 7: Sequence Diagram Design of the Proposed Model

3.3.2.Class Diagrams

Figure 8: Class Diagram of the Proposed Model



3.3.3.USE-CASE Diagram

The **USE-CASE** depict an admin in the waste management Model. The other users will be indirect users.

3.3.4. Algorithm of the proposed model

The state of algorithm is recursive, it can search and fill value simultaneously,
Hence, the steps involved in this program include:

1. Start
2. Login
3. If login= valid then
4. Search for waste
5. Display location
6. Update MODEL
7. else
8. Stop

3.4. Output design of the proposed model

The output of the Model is based on the required input sent by the user to the Model admin who in turn sends work to be done. Fig. 10 shows the output design of the Model.

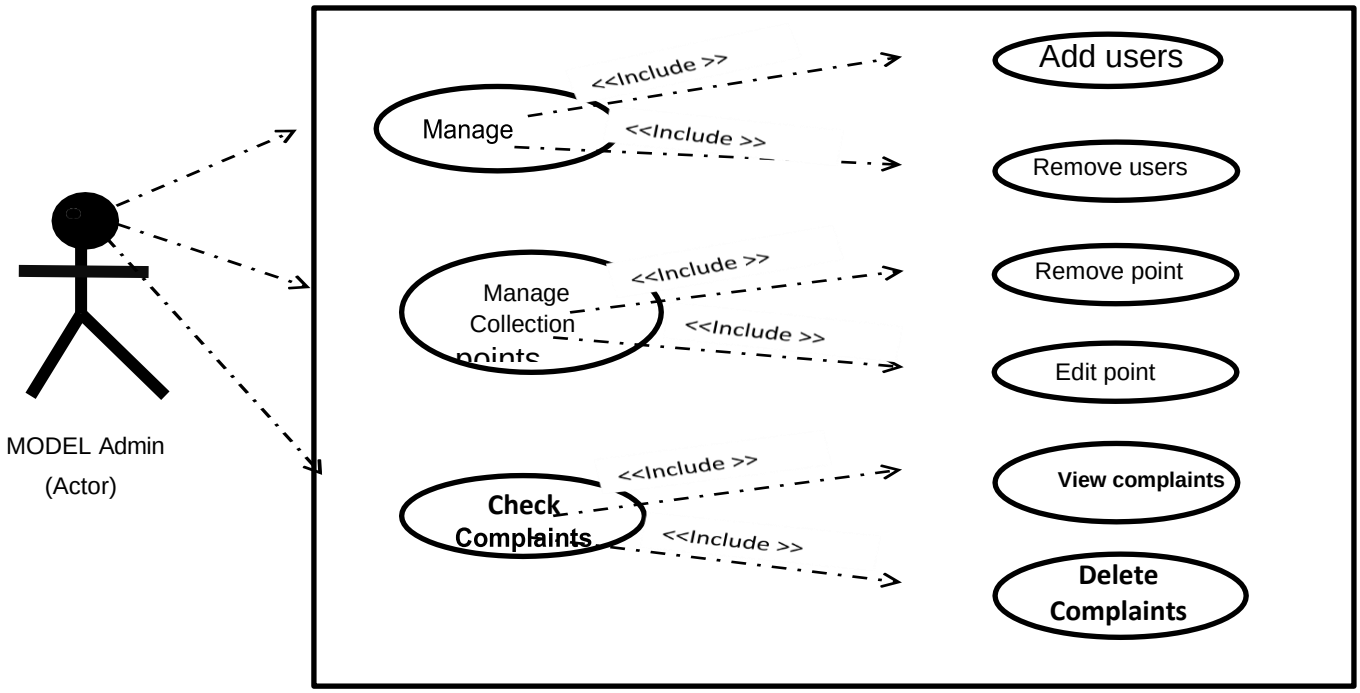


Figure 9: USE-CASE Diagram of the Proposed Model

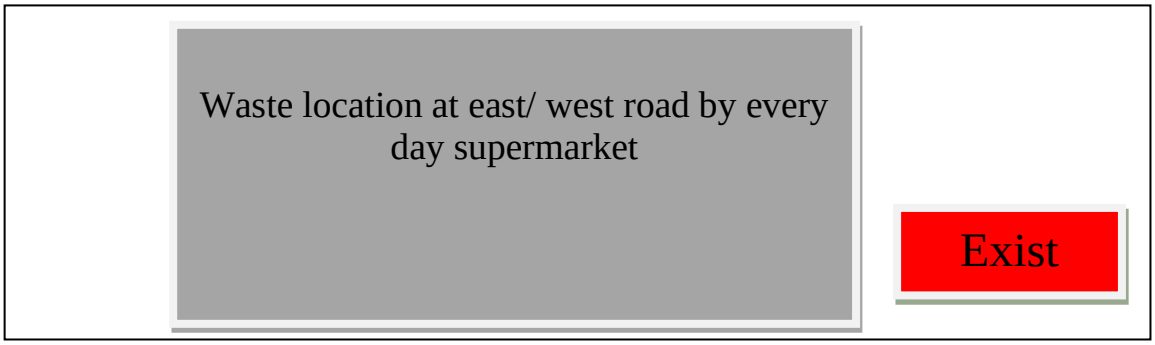


Figure 10: Output design of the proposed Model

3.5. Database design of the proposed model

The propose Model was design to implement environment information management model for easy disposal of waste in our environment. The database server provides controlled access and rapid transaction processing to meet the requirements of the client. The user of the new Model have to create an account with the model before user can login. User login information is secured on a cloud server which helps in avoiding unauthorized access from the outside world. User can make request of waste disposal from the waste management company and also cancel or decline request. The waste management company will also have to accept the request as the admin of the Model.
This record will be used to grant or deny user access to the smart cities environment. Fig. 11 show the logical data model of the database while Fig.12 shows the Logical Database Description.

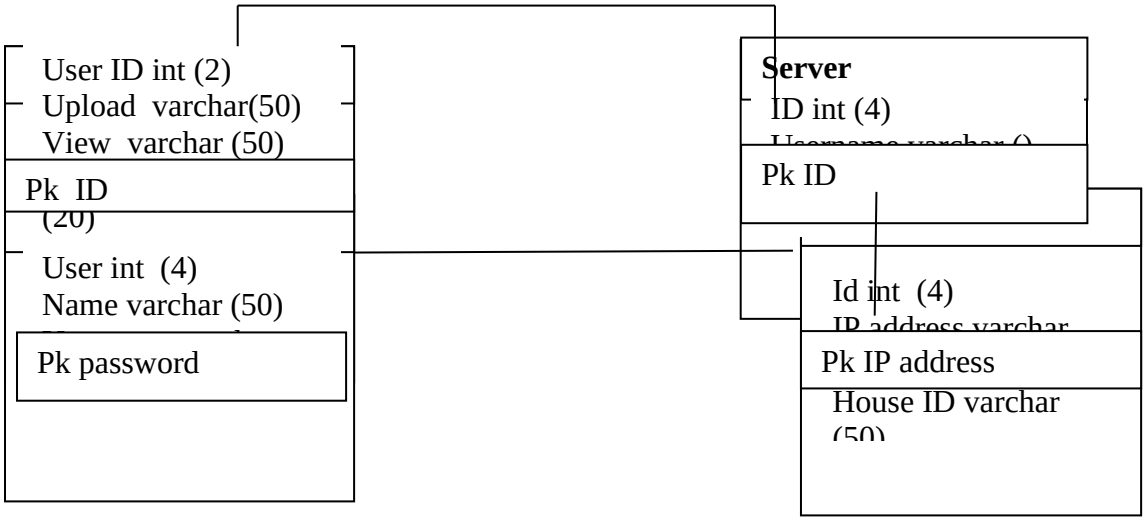


Figure 11: Logical Data Model

Table 1: Registration table of model products

SIN	**Fields**	Datatype	**Constraint**
1	Address	Varchar (30)	
2	Waste size		
2	Phone Number:	Varchar(15)	Primary Key

Table 2: Logical database description of the proposed model

S/N	**Fields**	**Datatype**	**Constraint**
1	Id	Integer	
2	Username	Varchar(50)	
3	Password	Varchar(50)	Primary Key

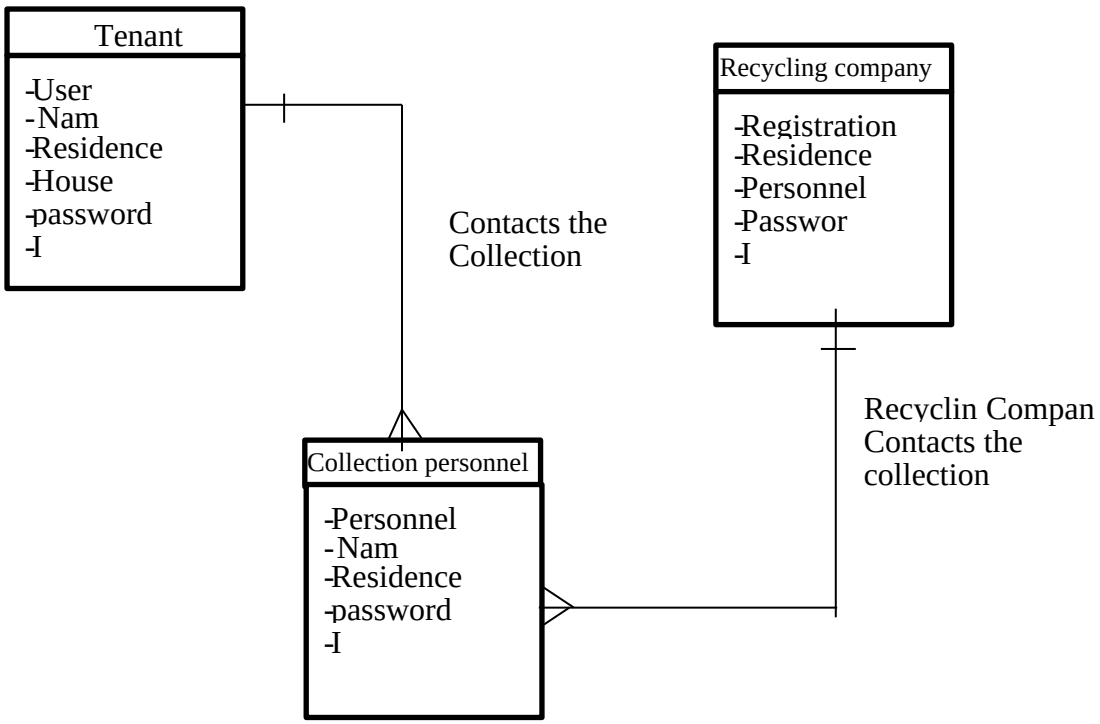


Figure 12: Collection

The study;

i. developed a SMART waste information management Model using the object-oriented development tools,
ii. implemented the SMART Model using the php programming language, and
iii. evaluated the Model with time and space complexities as metrics.

The admin and new user's login page is one of the input stages where the admin and new users input their login details which are their email and passwords. The user's information is later processed and outputted through a computer output interface.

The functionality of the Model was implemented and evaluated. The Model interfaces justify the efficiency required in reporting waste information through connected sensors embedded camera display system with which waste handlers can assess the level of waste at dump sites. The system stores the history of the driver and various records related to waste. It uses the image processing system to measure the waste index of a particular dumping site. The waste index is calibrated as low, medium, or high.

4.0 Conclusion

The work modeled a waste management in a developing environment, using web-based technology brining support to waste management agent. The basic design tools used were the USE-CASE diagram, sequence diagram, class diagram and program flowchart.

This Model will help improve the management of waste in an effective and efficient manner where Users have to create an account with the Model platform before user can login. User login information is secured on a cloud server which helps in avoiding unauthorized access from the outside world. This allows the user access services which is the primary reason for using the Model which allows them to request and decline service from the waste management company. The system cater for real-time reporting of waste activities occasioned by the users on one hand and the agents

or operators on the other hand. Users are assisted with information on how to dispose their waste while the operators are provided with the on-the spot data on how to efficiently carry out their environmental tasks thereby securing the environment as required.

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