Best Out of Waste: A Prototype Software Solution for Fund Management using MATLAB –GUI

Ms. Renuka	**Dr. Radha Kumari Challa**
MBA II Student	*Professor at Management and Commerce*
Sri Sathya Sai Institute of Higher Learning	*Sri Sathya Sai Institute of Higher Learning*
Puttaparthy, Anantapur, Andhra Pradesh, India.	*Puttaparthy, Anantapur, Andhra Pradesh, India.*
	chradhakumari@sssihl.edu.in.

Abstract:-In the context of "SwachhSarvekshan", the concept of waste management plays a very significant role in achieving the vision and mission of "Swachh Bharat Abhiyan", the clean mission of India. Waste, on one hand can become a factor undesirable, on the other and the most important angle, can contribute significantly to the national income as it has the potential to become a great source of income if put to use through recycling and reusing. The present research paper focusing on domestic waste highlights the software solution that was designed using MATLAB-GUI for using in accounting for revenues or losses generated during the administration of waste management, particularly at municipality level. Considering nine modules with nine parameters as one for each module, the software formulated assists in calculation of revenues generated out of recycled and reused waste, in a flash of a moment. The software will also provide a solution for re-planning the process of re-usage of waste, if any discrepancy is found between the budget amount and the actual costs incurred. The cumbersome managerial issues hitherto involved in various administrative processes for waste management find easy electronic solution in the software designed in the current research paper.

Key words: Waste Management, Matlab-GUI, SwachhSarvekshan, Software, Electronic solution

I.   Introduction

A Cost-Effective Prototype Software Solution with Test Sample for Fund Utilization in Waste Management Administration using MATLAB-GUI

The Government of India, with effect from 1 April 1999, has restructured the earlier Comprehensive Rural Sanitation Programme and launched the Total Sanitation Campaign (TSC) which was renamed as Nirmal Bharat Abhiyan (NBA) programme on 1 April 2012. As a part of reorganization of the entire NBA and to clearly identify the vision and the goals of the scheme, on 2 October 2014, the Prime Minister of India, Sri Narendra Modi launched the Swachh Bharat Mission (SBM) which is also called as the Swachh Bharat Abhiyan (SBA)**.** The SBM is a national campaign, covering 4,041 statutory cities and towns. Swachh Bharat Abhiyan which is called as the *"Clean India Mission"* in English is a national programme covering 4,041 statutory cities and towns, focusing on cleaning the streets, roads and infrastructure of the country. It is the India's first and the biggest ever cleanliness drive in which 3 million government employees; and also the school and college students of India participated during the launch of the programme.

The Union Ministry of Urban Development commissioned an extensive survey to study the progress of the SBM between 5th and 20th January 2016. The survey, the first ever performance measure for SBM, was conducted by the Quality Council of India (QCI) and was named as *Swachh Sarvekshan*. It covered all state capitals and another 53 cities with a population of above one million. The survey involved three streams of data collection covering interaction with municipal body, direct observation and citizen feedback. Swachh Sarvekshan evaluated the work done in the following six measurable aspects of sanitation and hygiene:

- Strategy for Open Defecation Free town (ODF) and Integrated Solid Waste Management (SWM)
- Information, Education and Behavior Change Communication (IEBC) activity
- Sweeping, door to door collection and transportation of solid waste

- • Processing and disposal of solid waste
- • Provision of public & community toilet seats
- • Construction of household individual toilets

Solid waste can broadly be classified into two categories. According to Indian Municipal Solid Waste Rules 2000 "Municipal Solid Waste" includes commercial and domestic wastes generated in a municipal or notified area in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes. Solid waste also includes hazardous waste generated by various industries.

Municipal Solid Waste (MSW) can further be classified into biodegradable waste such as food and kitchen waste; recyclable materials such as paper, glass, bottles, and metals and certain plastics and domestic hazardous waste such as medication, chemicals, light bulbs and batteries.

Solid waste management is one of the major challenges faced by many countries around the globe. Inadequate collection, recycling or treatment and uncontrolled disposal of waste in dumps can lead to severe hazards, such as health risks and environmental pollution. The management of solid waste typically involves its collection, transport, processing and recycling or disposal. In the context of *Swachh Sarvekshan*, the concept of waste management plays a very significant role in achieving the vision and mission of the *Swachh Bharat Abhiyan*.

Waste, on one hand can become a factor undesirable, on the other and the most important angle, can contribute significantly to the national income as it has the potential to become a great source of income if put to use through recycling and reusing. It can also become a great source of energy where energy can be extracted from dumping sites of waste.

The present research paper focusing on the domestic waste, aims at developing a software solution using MATLAB-GUI that will aid in accounting for revenues or losses generated during the administration of waste management, particularly at municipality level.

II.   Review of Literature

The available literature in the area has been reviewed in the following section to identify the gap that motivated the current research:

ET Bureau, (2016) article identifies the immediate need for new rules regarding waste management. This study also takes into account all the varied types of wastes (which includes solid, e, and bio-medical, plastic). ET bureau, (2016) In the light of achieving smart cities, government emphasizes on the waste management. It laid down the importance of proper planning of urban areas, which are the major sources of waste in the country. In the name of development, cities have been rehabilitated to slums. Green Biz, (2015) this article focuses on waste prevention than waste management. Managing 12 million tons of waste every day is a tedious job. It also states that waste prevention increases revenue and cuts the cost at bottom line. The article of Kumar & Pandit (2013) studied the problems of waste in Indian cities and proposes the necessary solutions for the problems. It identified the different types of waste s generated and various stages in which it can be managed. It also states that the major portion of the non-biodegradable waste is generated by high income group of urban areas whereas the small income group contributes a significant portion of the degradable waste. It also describes the problems of storage of waste at the generation itself. It states the importance of segregating the waste at the source level. It avoids the hazardous effects on the environment.

This study by simon, lan, & David, (2001) shows the shortage of land for land filling which is the usual destination of many places. Land filling is facing the problem of increasing cost, restraining force from community etc. Since the relationship between the availability and need of land is not found this study forecasts the land need for disposal measuring .It predicts that the demand of land for waste disposal overcomes the supply before 2050. The research paper of Hishashi,(2011) provides an analysis of different types of solid waste. It studied the failure of management techniques of waste and probes into the factors causing it. This study brings into light the need of scrutinizing solid waste disposal. It gives different approaches for developed and developing countries uncovering the gaps in techniques. Nannyonga, (2007) studied the question whether this reduce, reuse and recycle is economically viable or not. It also environmental point of view and the potential use of the waste and the study revealed the limitations of violating the regulations that were laid down by the government. ET bureau,(2015) notifies the amount of waste generated in cities from Bangalore to Delhi. 18 meter pile waste is accumulated in Mumbai. India drowning in detritus will face threat of garbage. It states that 377 million people in urban area are producing 72 million tons of waste daily out of which 45 MT is left untreated. ET Bureau, (2016) offers a new mobile app for the convenience of the citizens to complain. This is done in collaboration with NGO for the effective enactment of swacch bharath soon. This app helps in resolving the complaints enabling 4041 ULB's and strives to achieve swacch bharath by 2019. Francesca, Luca, & Cossu, (2015) studied the problems caused due to food waste and recognized a series of solutions to be executed. It states that the problem of food trash is on rise and gives sustainable solutions that can be extended to all sectors. It came up with an awakening idea of using the food waste in producing biofuels, biopolymers. Land filling and incineration became less desirable choices. Morrissey & Browne,(2004) deal with all the models undertaken by municipality and their limitations. It focuses on all those problems of cost benefit analysis, life cycle, and decision making. christian, ephraim, & zurbrugg,(2014) emphasizes the need of financial sustainability for effective waste management. The Hindu bureau, (2015) advocates replicating the waste management system of Techno parks. The minister was

overwhelmed by the waste treatment plant and recommended that every house should have a waste treatment plant to treat the trash at source level. A set up of facility is laid in 50 cents to treat 3 tons of waste per day.

ET bureau,(2016) felt that due to rapid urbanization in India, and the need to achieve smart cities gave birth to the sustainable and immediate need of waste management in India. This idea of forming smart cities gave rise to four point strategy of waste to energy, solid waste management, green urban transport and meeting housing needs for all. It emphasizes that producing biogas through this solid waste meets the electricity needs of the inhabitants.

Bridging the literature GAP

A software solution for the problem of accounting for revenues and expenses in the waste management process at municipality level is seen missing. The current study provides this solution using MATLAB-GU.

III. Statement of the Problem

The expansive study in finding the solution to the most lingering problem of the society i.e., waste management is one of the most significant and prevailing problems across the world. The Ascending standard of living and high consumption rates have had an involuntary and undesirable impact on the environment .Countries are now facing very serious threat of trash, and the costs involved in its administration, the discarding techniques and practices.
There are five sources of wastes as depicted below:

The waste generated through these sources is getting mixed up with non-degradable wastes as the segregation is not being done at the source of waste generation. This is due to the poor maintenance of the mega bins on road sides as well as the bins in houses. There is a very serious problem concerning even the collection and disposal methods.

These unorganized methods of collection and disposal are the main causes for most of the problems. The inappropriate supervision and management of domestic waste from various sources are causing adverse effect on the environment and the health of people at large. Inefficient management of waste is causing a very serious problem to the citizens.

In the context of enormous problems poor and inefficient waste management are causing to the environment in general and the society at large, the current study plays a significant role as it provides a software solution to the administrators of waste management in the direction of fund management.

IV. Need and Significance of the Study

Management of solid waste which is already a mammoth task in India is going to be more complicated with increase in urbanization, changing lifestyles and growth in consumerism. Financial constraints, improper choice of technology, and institutional weaknesses, and public unconcern towards Municipal Solid Waste (MSW) have made this condition worse. Besides, the existing practices of uncontrolled dumping of waste on the towns/city's outskirts are causing serious concerns on environmental safety in addition to impacting the public health.

In this context the present paper plays a significant role. It provides a software solution to fund management at the administration level dealing with waste management.

V. Objectives of the Study

The current research is conducted to achieve the following twin objectives:

I. To formulate a cost-effective prototype solution for finance accountability using MATLAB-GUI for enabling effective fund administration relating to waste management at municipality level.

II. To sample administer the devised software tool using the data collected from a municipality for facilitating easy replication of the same.

III.   To offer few workable suggestions for sustenance of the initial enthusiasm among the Citizens in following the techniques devised for managing the waste.

VI. Methodology

The methodology describes the procedure followed for achieving the above two objectives in two different sections. The first section describes the features and uses of MATLAB - GUI software. This section is followed by the description in several steps of different modules developed as part of the current software.

1.6.1 MATLAB-GUI- Features and Uses

The MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses of MATLAB-GUI include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics

As an application development including Graphical User Interface building, MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows solving many computing problems, especially those with matrix and vector formulations, in a fraction of the time, once the program is written in a scalar non interactive language such as C or FORTRAN.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects, which together represent the state-of-the-art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of application-specific solutions called toolboxes. Being very important to most users of MATLAB, these toolboxes allow anyone to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

1.6.1. i The MATLAB System and its Five Main Elements

a) The MATLAB language: This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both programming in the small" to rapidly created quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

b) The MATLAB working environment.
This is the set of tools and facilities that we work with as the MATLAB user or programmer. It includes facilities for managing the variables in our workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications.

c) Handle Graphics.
   This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow us to fully customize the appearance of graphics as well as to build complete Graphical User Interfaces on our MATLAB applications.

d) The MATLAB mathematical function library.
   This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigen values, Bessel functions, and fast Fourier transforms.

e) The MATLAB Application Program Interface (API).
This is a library that allows writing C and FORTRAN programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

MATLAB is a very large (and growing) database of built-in algorithms for image processing and computer vision applications. MATLAB allows testing algorithms immediately without recompilation. Anything can be typed at the command line or execute a section in the editor which will produce the results immediately facilitating algorithm

development. The MATLAB Desktop environment, which allows working interactively with the data, helps to keep track of files and variables, and simplifies common programming/debugging tasks.

1.6.2 Development of Cost-Effective Prototype Software Tool for Finance Accountability at Municipality Level in Relation to Waste Management as Part of the First Objective:
Four widely used parameters relating to finance management in municipalities such as Salaries for employees at different levels, Purchases, transportation, sale of potential waste are chosen and applied in nine different modules for developing the current cost-effective prototype software tool for finance accountability.

MATLAB- Modules
Devaluing the waste generated and often the usage of waste is not organized and planned leaving the citizen dissatisfied. On the other hand, maintaining huge amounts of waste for a long time leads to great losses. In any case, this inefficient inventory management cost is both extreme and unnecessary. If the management controls the maintenance of waste generated and its utilization and disposal the fund can be saved and can be properly allocated. The fund saved can be diverted to improve other necessities.

As data flows among modules easing the calculation of fund allocated and costs incurred for the maintenance of waste produced it faces some complexities and problems. An integrated system that is standardized can be fed into to lower the burden. So the main aim of this prototype is to check the current practices and system, examine it and find the solution if necessary. The diagram below depicts the process to be done in the chronological order. It represents the typical management of waste process to be followed:
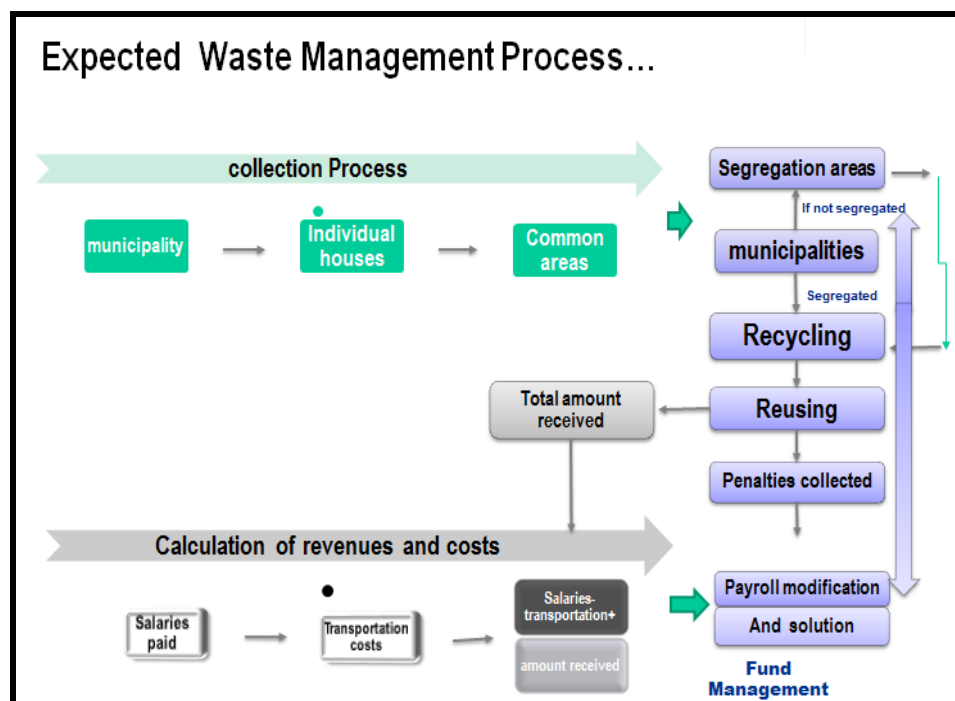
Figure: 1.1 Expected Waste Management Process

The current software tool, which is of prototype, is developed using the MATLAB (Matrix Laboratory) - GUI software. Taking the municipal office functioning at, chirala, India, as the model office, the software was developed based on the activities associated with different functions in the chosen office. Nine modules are prepared for nine different yet interrelated functions. These nine functions include security issue, general information, employees' salaries, logistic costs, sales details, data analysis, comparison function, and report generation. The description about how each module is developed and how it functions along with the screenshot of the same is given below:

Module -I: Security Issue
A program has been coded for the module covering the security issue using MATLAB-GUI, which limits the access to the soft files of the office administrator or the program developer. This is done by the current module, which requires the user to authenticate his identity by affixing his user name and password. Only on identification of correct identity, the user gets the access for navigation into the further modules. The following picture gives the snapshot of the module that allows the authorization for further navigation.
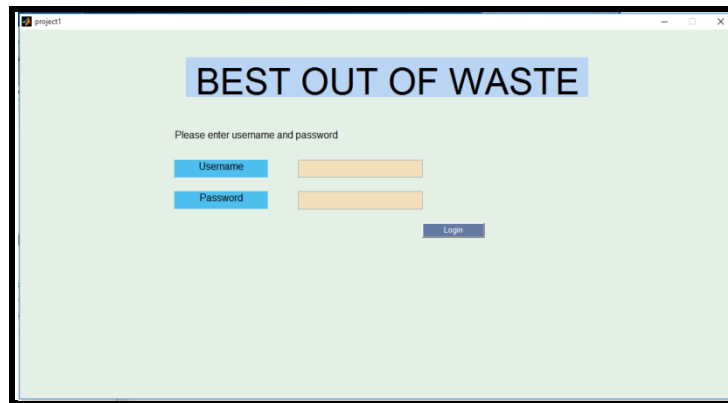
Figure: 1.1Security Issue

MODULE II: Requirement of user's acceptance to the conditions:

Conditions to be incorporated while navigating into the subsequent modules are portrayed in this module. Only on acceptance of these conditions takes the user to further set of modules that are apt for that type of management. This acceptance ensures that the administrators are following the strategy adopted for efficient management of waste.
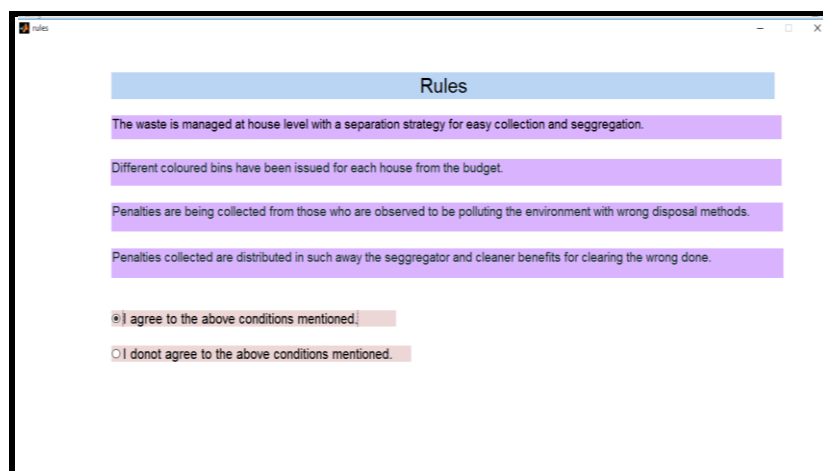

Figure: 1.3Requirement of user's acceptance to the conditions

Module III: Tracking Module

On receiving the agreement to the conditions mentioned in the second module from the user, the third module directs the user into subsequent action based on the type of management of waste that is being carried out at the office. This module gives two options to the user based on the type of waste the user is dealing with. Each option individually leads the user into the respective function. Selection of the option "segregated" enables the user to navigate to that panel where appropriate details are given. On the other hand if the user selects "non-segregated" it takes him/her to the other relevant modules.
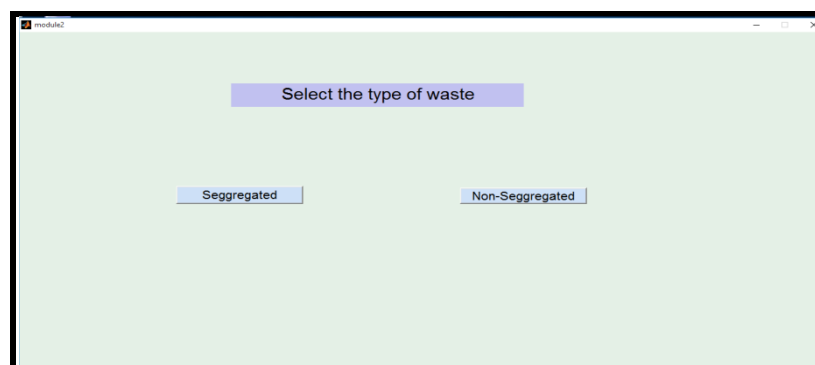
Figure: 1.4Tracking Module

This is done in order to give benefits to the segregated waste that is generated in order to motivate the people for attaining Swachh Bharath.

MODULE-IV: General Details of the Area:
This module specifies the details of the area for which the software is being executed. It includes the name of the place, state, area name, circle number and its ward. Only on filling all the details of the area it takes the user in to the next module. Else it will display the error message 'This field is mandatory.'

The information from this module is useful for generation of final report. The final report gives detailed account of various issues relating to fund management or finance management pertaining to management of waste aspect in that area.

Figure: 1.5General Details of the Area

MODULE V: Salary Details of Employees Working in the Office
This module comprises of the salary details of the different employees with different designations, which includes sweepers, collectors, supervisors, office staff, administrators etc. This will calculate the total salary paid during that month. This also consists of the main details of the project that is the maximum cost of transportation and maximum total cost it can incur during that month. This remains as a benchmark for further analysis required for arriving at a viable solution.

Figure: 1.6 Salary Details of Employees Working in the Office

To facilitate the smooth functioning and the ease of work the above two modules which comprises of general particulars and th are integrated into one single module as given below.

The above figure calculates only the salary details. It considers salary details of different caders along with their working days per month.The modules are been integrated and the results are checked with proper valid resources to find out the accuracy and the precision of the prototype. The administered module looks as below.

Figure: 1.7 Optimization Tool for Potential Use of Domestic Waste

MODULE VI: Transportation Details

The sixth module goes in continuation of fifth module. Additionally it calculates the transportation costs incurred for the transportation of garbage from its generation point (house to house) to its final disposal centers. The figure below is the screen shot of the module that calculates the transportation and overall costs. This is how a typical prototype looks like.

Figure: 1.8 Transportation Details

Since this step constitutes the most important task in the entire management of waste process the costs incurred must be precisely calculated. Hence this module has been designed with great care by considering all the risk factors involved in the process. This module also considers non-transportation costs incurred in the process. The output of this module finally represents the total costs and its segregation into transportation and non-transportation, costs of salary and other administrative expenses.

As mentioned above it calculated all the factors involved with values that have been fed into the system. After calculating the prototype looks as follows.

MODULE VII: Year-wise Retrieval of Data

This module can be used for retrieving the data of any of the previous years. This facilitates comparison of data for decision making. The comparison in turn will help in identifying etter methods for making the existing system more effective.

Figure: 1.9 Year-Wise Retrieval of Data

MODULE VIII: Sales Details

This module is the heart of the present prototype software. This constitutes the basis for revenue generation since it contains the sales particulars of waste collected. This includes the income created through re-cycling and re-using of the waste collected. Below is the figure how a prototype that is prepared looks like
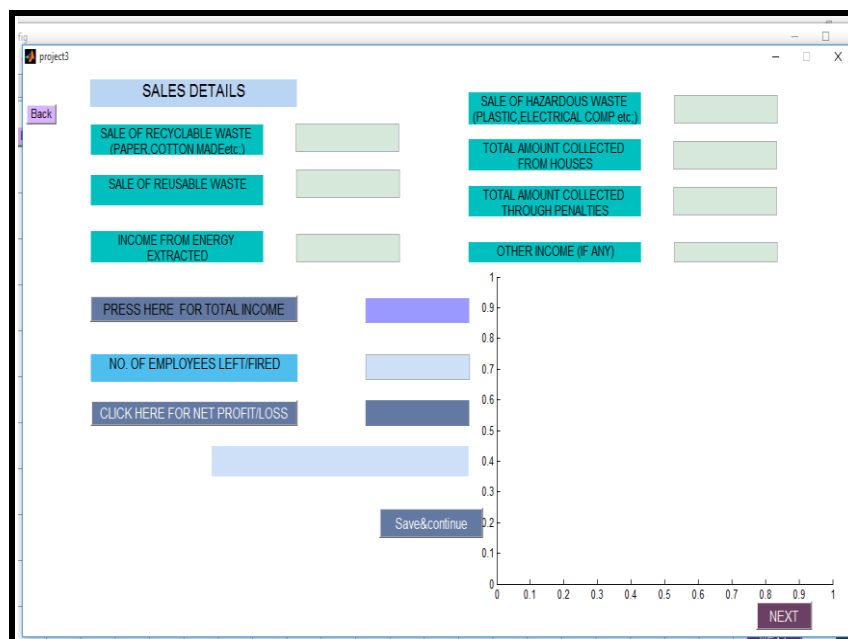

Figure: 1.10 Sales Details

All the users of the software, who have not signed up in the first module for segregated option, will be excluded from accessing this module. After giving these inputs the costs will be computed and the trend in the calculated costs will be automatically depicted in the form of a 3-d bar graph as is shown in the figure below.

As seen from the above executed module that is comparing the previous year's results with the current year results and represents in a pictorial format for greater comprehension and visibility.

MODULE IX: Report Generation

This generates the final report, which comprise of all the necessary details and integrates the results that are obtained during this implementation of the earlier modules.

Figure: 1.11 Report Generation

The final module for the current prototype software deals with report generation. The report generated will contain the data, which represents the final output. The report also produces analytical reasons attributable to the data in the report. The report depicts in summary the output from each of the previous modules representing the particulars of the geographical data, computed total costs and the result. This serves as a guide to the administrators in their fund management besides facilitating in checking the on-going processes.

1.7 Sample Administration of the Software Tool Developed – Second Objective

The formulated modules are integrated and the results are checked with valid resources to find out the accuracy and the precision of the prototype. Using above pre-tested modules and with the help of notional figures, an attempt is made to show case the sample administration of the prototype software developed.

MATLAB-GUI as a software has as added feature of graphical user interface, which facilitates easy interaction with the user. The features and tabs provided by the MATLAB software have their own property inspectors, which assist the programmers to define the necessary properties that each tab has to perform. A step-wise procedure followed for sample administration of the same is described below:

- **Step one:**
  The two tabs namely "edit text and static text" are used for developing this module. The username and password tabs are considered as static text which denies access to the users. Edit text represents the empty space given to the user to fill in the required details. The login tab is a click button that helps the user to navigate to the next module after checking the authenticity of the details. If the details supplied in to the fill in tabs are wrong, the module will display the error message as "wrong user name:' or "wrong password". Therefore as the first step the user has to login by providing correct details to gain entry in to the subsequent modules, as depicted below:

Figure: 1.12 Administered Security Module

Figure: 1.13 Administered Security Module with Error Message

- **Step two**:

    The second module is prepared using two tabs viz., static text and radio button. The static text cannot be changed by the user and hence ensures that the rules described in the module are agreed either to be followed or disagreed to be followed.

    The radio buttons helps the user in selecting the "agree or disagree" button, which finally directs him to the subsequent module based on his / her choice. In this module, the user has only one choice of selection meaning either to agree or disagree but not both which can be seen in the figure below:
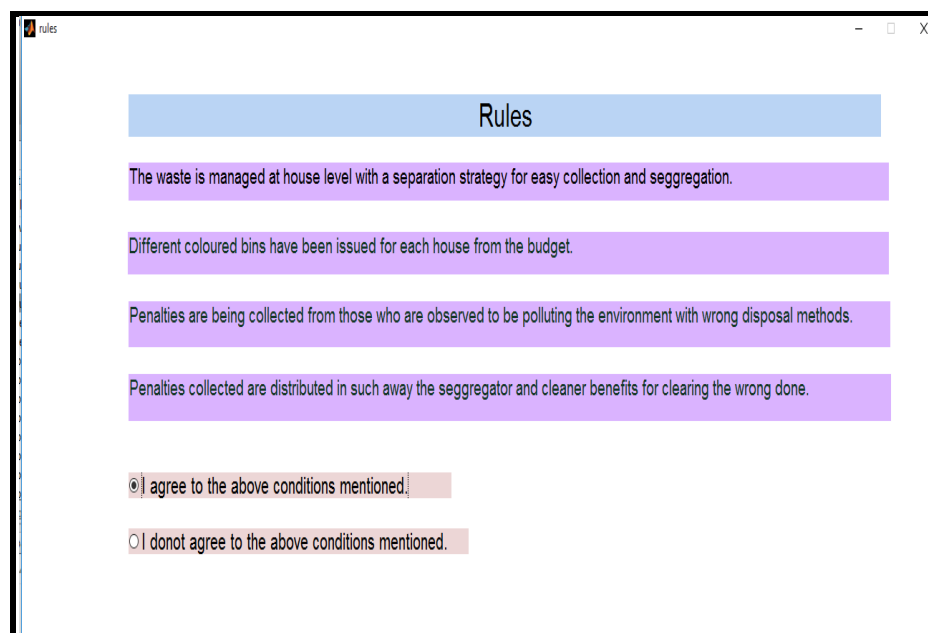
Figure: 4.14 Administered Module for the Rules to be followed

- **Step three**:

    This module too is based on above three properties of MATLAB-GUI i.e., edit text, static text and click button. This module requires the user to fill in the respective details in the empty cells provided. If any cell remains unfilled, the access for further navigation will be rejected. This unfilled error will generate a report with error message that "This field is mandatory". This module contains global variables. The specific feature of these global variables is that they can be accessed in any of the modules that need them for their use. This module calculates the total salaries paid by retrieving the data from the filled cells. We can navigate to the next module only if the total cost is calculated else it will give error message as is shown below:

Figure: 1.15 Administered Module for Financial Details

Figure: 1.16 Administered Modules for Financial Details with Error Message.

- **Step four**:
  This module uses the same properties of MATLAB as in the previous modules. But also uses also uses the click button for a special cause of navigating backwards. This helps in rectifying the discrepancies if any, found in the previous modules. It calculates the total transportation and miscellaneous costs taking the data filled in the same module. Using the property of global variables this module finally calculates the overall total cost incurred for the entire unit, as is shown in the figure below

Figure: 1.17 Administered Module for Calculating Total Cost

- **Step five**:

This module makes use of global variables which will help in functioning of the next module where a comparative analysis is made. At front end this module facilitates recovery of the financial details pertaining to previous years and helps in producing a comparative picture in the form of graph as depicted below.

Figure: 4.18 Administered module for retrieving past data

- **Step six**:

This sales module constitutes the core module for the entire prototype. Incorporating the sales particulars generated from various sources it will calculate the total income generated during the period under consideration when the click button named "press here for total income" is clicked. The total cost from the fourth module will be carried to this module and used for arriving at the total profit / loo figure. By clicking the "save and continue" button user will be able to see a visual representation of the profit / loss calculated for all the years considered.
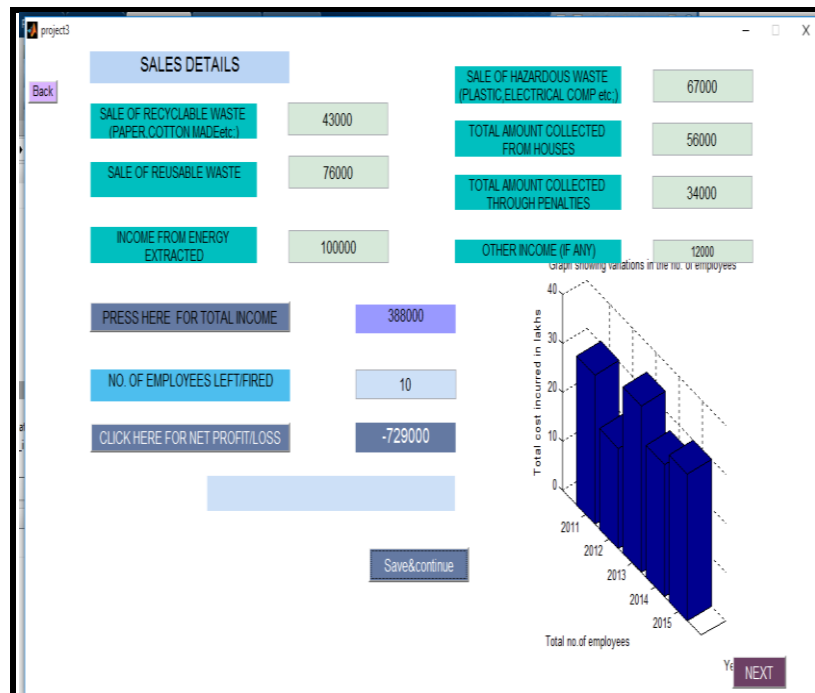
Figure: 1.19 Administered module for calculating total income

- **Step seven**:
  Based on the analysis done in the sixth module the seventh module generates a final report consolidating the information provided in all the previous modules. The specialty of this module is that besides generating the report, it also gives a solution in the form of modification required if necessary.
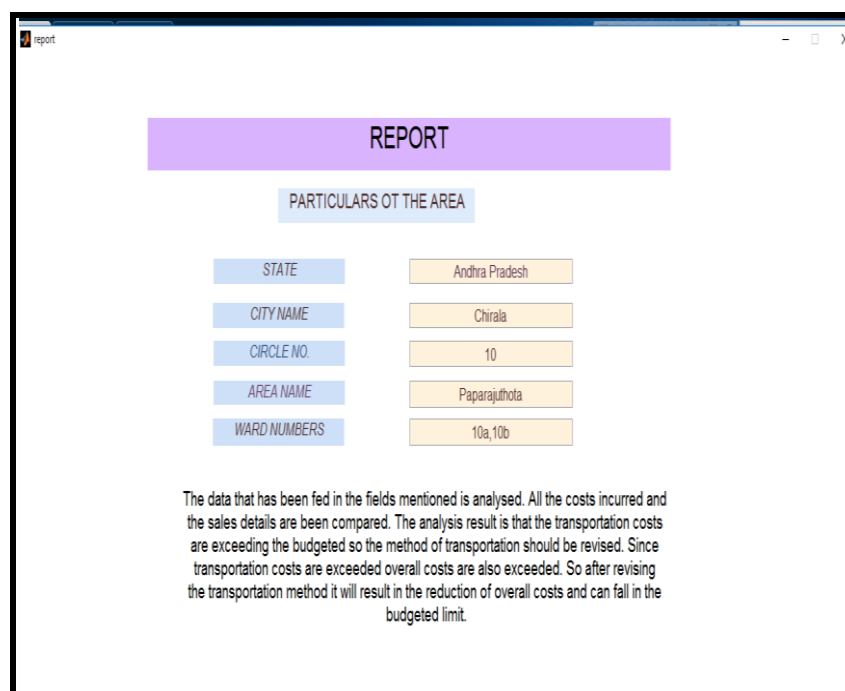

Figure: 1.20 Administered modules that gives solution.

1.8 Workable suggestions for sustenance of the initial enthusiasm among the citizens in following the techniques devised for managing the waste: Third objective:

Effective management of waste requires measures for sustaining the initial enthusiasm of the citizens in following the procedures laid down by the administrators. Unless such measures are simultaneously developed, the expected outcome of waste management cannot be realized. Therefore based on the insights gained on the need for encouraging the citizens to follow the procedures formulated on a sustainable basis the following suggestions are offered:

- **Free distribution of trash bins:**
  Initially people have resistance to invest their money in buying bins. Distribution of different colored bins for segregating different types of wastes might encourage them to follow the procedures. Once people get used to following a procedure they will make efforts to continue even if it means making attempt to buy the same at their cost.

- **Charging Penalty:**
  Various researches have proved that the general tendency among people is expressing high reluctance in following the rules that are laid down. So for those households who violate the general rules or fail to follow the norms laid down for waste segregation should be charged penalty as per the theory of "Carrot and Stick" approach.

- **Devise a toll-free number:**
  There are studies that have suggested an app for this trash management but due to lack of skill and access to such apps for majority of the people it's not been a success. Devising a toll-free number and providing the same to all the citizens for complaining in case of evidencing any waste thrown on the sides of the roads will also contribute to sustaining the enthusiasm of the citizens in contributing to effective waste management.

- **Supervisor's incentives:**
  Introducing monetary and non-monetary measures to motivate the supervisors and other employees involved in implementation of waste management initiatives will bear fruits both in the short run and long run periods of time. For example the supervisors whose areas are inspected regularly for ensuring regular collection of waste and encouraging citizens in segregating the waste collected may be given an incentive of 10% on their salary either quarterly or semi-annually. Conversely the supervisors whose areas are contributing to mounting non-segregated waste will have to face a disincentive of a pay cut of 5% on their regular drawings of the month.

- **Constituting local level committees:**
  Constituting local level committees involving one member representative from each family will motivate families in responding to the effective waste management initiatives.

- **Installation of CC TVs:**
  These TVs will identify the people who transgress the rules and procedures laid for managing waste and accordingly facilitate administrators in taking punitive measures.

- **Maintenance of a trash bin in each public transport service**:
  Installation trash collection bins in the public transport services will prevent the commuters from throwing the trash on the roads while travelling.

- **Strengthening the current "Whole School Approach":**
  One way to gain sustainability is through a whole school approach, which works to make the school "a microcosm of sustainable society". A whole school approach, as the name implies, focuses on the school as a whole - it applies to the curriculum as well as to operations and other facets of school life, and involves all members of the school. This brings about a holistic outcome for the sustainability efforts.

- **Conducting periodical local workshops / seminars:**
  Local workshops are conducted involving area wise representatives from each home preferable the women to create awareness and understanding about the benefits of following the rules laid down for dealing with waste and the need for sustaining the initial enthusiasm in keeping up to the same.

1.9 Superiority of the current software solution: The current prototype software is considered to be superior for the following reasons:

- Reduces the time of calculation:
  The above software reduces the enormous time otherwise required for maintenance of records and fund management related issues.

●   Increases its efficiency of calculation by reducing the complexity:
The software reduces the complexity involved in calculations and thus facilitates quick processing of data for instant decision making.

●   Reduces the costs incurred:
The development and installation costs for the software are minimum.

●   Easy fund management:
The output of the software represents the final requirement which constitutes the basis for decision making. Hence quick and efficient decisions can be taken for managing the funds pertaining to waste management.

●   Revision flexibility:
The software facilitates easy revision whenever necessary.

●   Cost comparison:
Facilitates cost comparison for the difference in costs before and after following the set strategies.

1.10 Competitive advantage of the current prototype software:

There are many applications of Matlab like optimization, GUI, Image processing etc. This study used the Graphical user interface (GUI) of Matlab which allows the users to analyze the data and arrive at a solution.

Several critical success factors have been identified by many researchers in implementation of MATLAB. This includes Math and computation Algorithm development, Modeling, simulation, prototyping, Data analysis, exploration, visualization, scientific and engineering graphics etc.

The current research however emphasizes on the expandability, installation simplicity, operational simplicity, cost effectiveness based on the prototyping and data analysis advantage of the software.

The critical success factors for the current prototype are discussed below.

- Rapid Deployment: MATLAB is advanced and skill based programming and needs high technically skilled persons. It has high degree of threat from other programming languages like c, c++ etc. Thus the implementation of this software in municipalities depends on how effectively the municipalities and the people track the strategies mentioned in the second module i.e. how quickly they respond to the changes and advancements. Hence rapid deployment is a critical success factor.

- Cost effectiveness: Municipalities acquire their funds through taxes collected in that area. Since its limited and in fact very less for all the functions of the municipality to rely on it, they need cost effective tool to maintain a clear and fair record of all the expenses and the incomes they get through the waste generated and collected. Any premium software that can be implemented faces a serious threat of failure because of lack of technically skilled staff. In such scenario we need to have a solution which can replicate the commercial software and yet stay within the budget of the municipalities.

- Installation simplicity: Some of the bodies of the government like municipalities which consists of people who lack in technical skills have a necessity of this type simple installation yet effective software for systematic functioning. A simplified version of MATLAB with the most critical processes would be a better option than investing in a full-fledged expensive software package of some other types.

- Operational simplicity: The cost does not end with the implementation of enterprise system. Cost also includes the cost of training the employees in using the software especially for the municipalities. Software of this kind which is easily comprehendible can be taught to the employees which will simplify the complicated managerial issues involved.

- Expandability: Any number of modules can be developed and added to the current MATLAB-GUI prototype depending upon the requirement of the functioning of the system. Such expandability can be expensive and time taking for any other commercial software.

1.11 Social Relevance of the Current Matlab-Prototype:
With increasing generation of waste at domestic level there is a need for efficient management of procedures, finances and resources in the municipalities. Hence it has become imperative to have a tool which can help coordinate various activities involved in managing these issues. One of the Information Technology tools that best serves the above purpose is Matlab. Matlab gives the opportunity of integrating every procedure of business while improving the quality of fund management simultaneously. Besides serving the above great purpose, the current Matlab application helps in enhancing the accountability for income

generated through potential use of waste and to control costs more efficiently, leading to effectiveness in the overall waste management function.

In the light of the significant role Matlab is playing in different sectors of the economy the current prototype Matlab application proves to be great relevance to the management in general and municipality in particular. While the software can be directly deployable by municipalities for effective fund management dealing with nine modules, the other highly complex waste management structures of the municipalities can also replicate the current model which has the flexibility needed for further addition of modules. The current Matlab supersedes software of similar kind with its competitive advantage in the cost-effectiveness and fund management.

Conclusion

In the light of the requirement for implementing an effective information technology tool at the municipality level for efficient management of waste, the paper demonstrated a cost-effective prototype Matlab solution. This solution offers a great degree of flexibility and installation simplicity.

The research effort highlights that the implementation of cost effective Matlab with low risk and high reliability becomes a substituting tool for any other expensive software. However the implementation of this kind of software demands a proper management and implementation of certain strategies and rules in the specified area for efficient and effective functioning.

By developing a cost-effective Matlab solution for municipalities the authors advise that the organizations planning to implement Matlab must learn how to identify the critical issues that affect the implementation process and know when in the process to address them effectively to ensure that the promised benefits are realized by avoiding the potential failures.

References

1. Afullo, A., & Odghiambo, F. (2009). *the primary solid waste gaps experienced by Nairobi households* .

2. christian, r., ephraim, j. c., & zurbrugg, c. (2014). waste management. *financial sustainability in municipal solid waste management costs and revenues in bahir dar,ethopia* , 542-552.

3. ET bureau. (2015, november 29). *Hoe start ips like attero recycling,karma recycling are making money out of waste* .

4. ET bureau. (2016, february 10). *Government stresses on waste management to achieve smart cities* , p. 1.

5. ET bureau. (2016, february 26). *cities in transition* , p. 21.

6. ET Bureau. (2016, february 04). *swacch city solutions app for garbage free india by april* .

7. ET Bureau. (2016, january 01). p. 1.

8. Francesca, G., Luca, A., & Cossu, R. (2015). waste management. *Food waste generation and industrial uses:A review* , 32-41.

9. Green Biz. (2015, april 01).

10. Hishashi, O. (2011). international perspective. *Sustainable solid waste management in developing countries* .

11. kumar, v., & pandit, d. k. (2013). *problems of solid waste management* .

12. Morrissey, A. J., & Browne, J. (2004). Waste management . *Waste management models and their application to sustainable waste management* , 297-308.

13. Nannyonga, B. (2007, march). A Mathematical model for solid waste recycling. *A mathematical model fior the doctor of philosophy in Mathematica of makerere university* . kampala.

14. simon, lan, & David. (2001).

15. Simone, l. &. (2001).

16. Simone, L., lan, B., & David, E. (2001). *assesing the demand of solid waste disposal in urban region by urban dynamics modelling in a gis environment* , 289-313.

17. The Hindu bureau. (2015, october 01). *Replicate waste management system:Minister* .

18. Vijay, k., & Pandit, D. (2013). international journal of scientific and research publications. *problems of solid wastre management in indian cities* , 1-9.