SUITABILITY ANALYSIS FOR SMART WASTE MANAGEMENT IN PAKISTAN

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Approval

It is certified that the contents and form of thesis suitability analysis for smart waste management (SWM) in Pakistan by "Mazhar Iqbal" have been found satisfactory for the requirement of the degree.

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Dedication

I dedicate this thesis to almighty ALLAH and my supervisor Dr. Asad Ali Shah. Without help of Dr. Asad and Dr Rafia Mumtaz I would not been able to complete this thesis.

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List of Abbreviation

GIS	Geographic Information System
GPRS	General Packet radio System
GSM	Global system of mobile communities
IERC	International Electronics Recycling Congress
IOT	Internet of thing
IR	Infrared
ITU	International Telecommunication Union
MSWM	Municipal Solid Waste Management
RF	Radio Frequency
RFID	Radio Frequency Identification
SWA	Solid waste Administration
SWM	Solid Waste Management
SWM	Smart Waste management
TWM	Traditional waste management
WEEE	Waste Electrical and Electronics Equipment
WSN	Wireless Sensor Network

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Abstract

Waste management is the most important challenge present in urban areas and within few years it will turn into a crucial issue because of a rapidly growing population. Accurate systems for solid waste management is required are important for improper envoirment and the well-being of peoples. The production of waste is domestically high but the struggle of managing it comparatively very low. In the Islamic Republic of Pakistan like (Rawalpindi) solid waste management sector is perhaps the worst off. There are no proper collection and lack of innovation and lack of new application of different ways. There are no reuse and recycling process in Pakistan.

In existing system, the entire work is based on manually or physically playing role, its time consuming and pure Labouré work. In each morning the sweeper visits to the areas and clean them. Than the trucks come and collect the waste. Truck use manual routes and round all areas where the waste bin is full and where its empty. That is total waste of fuel, time and man power in this method. This creates lack of management, control and coordination among different departments working on waste management and workers. Huge amount of resources is being waste for garbage collection using traditional approaches.

As proof of concept we applied our proposed system to a specific city. Our target city was Islamabad & Rawalpindi while our target service is waste management service. First, we had presented a comprehensive survey. This survey has been completed for collecting different details of TWM system, e.g. their problems, type of waste generation in different areas, type of waste disposal among different areas, waste collection techniques, satisfaction, dissatisfaction scenario of customers, their health issues and many more.

We tend to purpose smart waste management (SWM) system that permits cities to lower cost accounting by putting in sensors within the bins. It helps to monitor the trash level in every bin. Bins are often empty, and it is expensive to ga9ther the waste from those bins, once the bins square measure full, and the respective department can get notifications through the sensors only when the collection truck requires to empty the bin.

This project will deduct the amount of waste collecting vehicles on the road. It clearly saves the fuel price and lowers the traffic on roads. The waste management and collection system aim to produce high quality of service to the citizens of the Islamic Republic of Pakistan.

Chapter 1

1.0 Introduction

This chapter provides the opening and general information of smart waste management and problems of waste management in Pakistan and provide the complete idea of this thesis. It is also explaining the problem statement that is under discussion with its proper solution statement.

1.1 Opening Perspective

Solid waste management is a present challenge in urban and rural areas and it's changing into an essential problem because of a fast growing in population. The quantity of waste is directly proportional to the increased population of cities. The rise in human actions and using patterns produce numerous kinds of waste that must be suitably achieved to make sure property advancement and a good level of living for all urban populations. Everyone could be a probable generator of waste and so a sponsor to the present problem (RCRI, 2009).

One of the major sources of environmental pollution is waste, it can be solid, liquid, semi-solid and contains gaseous from industrial processing or agricultural operations (Bashir & Banday, 2013). In our daily routine, we do such activities that generate waste and for better health, that waste needs to be properly managed and because of increases in population the quantity of waste is also increasing (National Environment Management Authority, 2014).

As countries around the world are developing, their issues and responsibility are also increasing for a healthy and sustainable environment. The annual solid waste is 1.3 billion tons and it seems that this capability can rise to 4.3 billion tons by the year of 2025, which will cover the 500th of the general population worldwide (Hoornweg and Bhada-Tata, 2012).

Thus, inserting large pressure on town infrastructures (housing, water, transportation, power, and town services, waste collection) (Mishra, 2013). To develop an efficient management system for waste is one of the main problem for our modern cities. Thus our utmost need is to look into this problem (Bashir & Banday, 2013) (Dugdhe et al., 2016). The accurate waste management system is a must for clean, healthy society and to make our future world better. In order to secure humans as well as animals health and our ecosystem from the potential risks of deferred waste disposal a supervised and precise system is essence for these wastes (Bashir & Banday, 2013). The waste management is our duty, we face it variety of fields and context. In any environment moderate quantity of waste can be seen inhabited by human beings (Prassler, Stroulia, & Strobe, 1997).

Waste management is an essential need for ecologically maintainable growth in every country. Efficient management/ disposal of waste is a foremost problem for today's society (Glouche & Couderc, 2013). The results of inaccurate waste management within big municipalities and urban settlements like cities can be a disaster. (National Environment Management Authority, 2014).

Common methods of solid waste disposal is the use of waste bins (Lazaro, Alexis, & Rubio, 2014). The procedure of collecting waste material from societies and organizations are fixing a common place for waste bin and when the waste bin fills, a collection truck from management organization empty the bin by carrying the waste. This collection procedure involves the major task of checking either the waste bin is empty or full (Bashir & Banday, 2013). The common waste collection process demands that waste management personnel has to pass by and collect waste from all the different waste bins. The waste management personnel has to present himself in person at all the waste collection points without the knowledge of the bin status. In this case, two possibilities present; either there is no waste for collection, or the bin has overflown.

This is a complex and time-consuming process that needs to be settled. This is rising waste disposal costs and the visibility of frequent operations for waste disposal makes the living society anxious. So, the residents are forcing and demanding an efficient collection and waste disposal system (Dugdhe, Shelar, Jire, & Apte, 2016). In-time collection and cleaning of garbage bin ensures proper cleanliness of the surrounding (Thakker, 2015).

This study has explored that in Pakistan there is no proper management for waste. All over the country, it has been seen that there is no engineered way of waste disposal, rather the low lying areas are used to dumped the waste directly or burned in an open air that created another types of pollution (Korai, Mahar et al. 2017).

Through case study we find that in Pakistan different cities produce different Tons of waste in daily bases.

Table 1: 1: Solid Waste Generation / Population

City	Population in million	Solid waste generation/day in tons
Karachi	20,500,000	10000 above
Lahore	10,000,000	6,510
Faisalabad	7,500,000	4,883
Rawalpindi	5,900,000	3,841
Hyderabad	5,500,000	3,581
Multan	5,200,000	3,385

Gujranwala	4,800,000	3,125
Sargodha	4,500,000	2,930
Peshawar	2,900,000	1,888
Quetta	600,000	326

Source: Mr. Saadat Ali, USCS Pakistan contact from Project Procurement International, Pakistan, (website; http://projectpi.pk/)

In Pakistan, there are lot of problems that needs to be tackled to overcome this issue, some of are lack of funds, irresponsible behavior of residents & employees, poor practices of solid waste are reflecting the worst scenario in the country (Ejaz and Janjua 2012). Inappropriate disposal has created many environmental hazards by municipal solid waste in Pakistan (Korai, Mahar et al. 2016).

Current approach undergoes from lack of collection throughput because of poor information about collection time and site, this is all because of lack of effective observation systems of waste bins. Managing Urban solid waste is complicated especially to most of the resourced constrained regions. In Islamic Republic of Pakistan, we would like to implement a smart Waste Management (SWM) solution in Pakistan.

This will facilitate to reduce the overflow of the rubbish bin and therefore keeping the atmosphere clean. SWM approach explains, the System which is smart dustbins, connected to the network to get the time period data of the smart dustbins placed throughout the town or the field, that are given low price embedded device having a unique ID so it's simple to identify that garbage bin is full i.e. it becomes simple to trace the level of the rubbish bins that are set within the town(IJAERS, 2017).

Smart dustbins are synchronized with microcontroller based mostly system with RF modules and IR Sensors. Once the level reaches to its maximum, the controller will interrupt and transmit the status of that bin along with the unique ID provided. Then these details processed by the systems and send notifications to collection department for garbage collection, these systems assist and do all the processing required and help us in doing an immediate action to clean the dustbins (Hannan, M. A, 21015).

We have used this system for effective management and monitoring of dustbins or waste collection. Before some years when the technology was not so efficient this method was thought to be inefficient and waste of resources but now with optimized technology that is highly accurate with minimal energy consumption researchers are moving back for this technology (Sharmin, Sadia, 2016).

For example, for a busy street where different shops and outlets are working, the dustbins there

might be filled more quickly than a free area where the bins might not fill in two or more days. So we can save lot of gasoline by not visiting those areas that are not required to empty their bins.

1.2 Motivation

In these days most of us are working on smart cities and presenting new ideas about smart cities, smart waste management is also based on IoT's and for smart city that is resource efficient in term of waste collection, this project is the core. Still there are countless projects working in developed countries, but this is huge problem for developing countries which have poor or manual collecting system because waste is scattered everywhere and polluting the atmosphere. Because of a lot of factors as well as socio-economic and cultural drawbacks existing smart solutions don't seem to be compatible in developing countries like Pakistan, as there exists basic issues relating to the first task of waste management like correct disposal, collection, sorting, recycling etc.

In most of the populated cities, the major hurdle is its solid waste management and its effective management or recycling.

Why can we wish to move to smart waste management? (Keerthana B, 2017 B)

- ✓ Traditional waste management (TWM) has a high price of fuel
- ✓ It isn't possible to cover all areas with TWM and so will cause Health hazards.
- ✓ Increased level of pollution
- ✓ Takes a lot of time for collection waste using TWM
- ✓ Waste produced is not being monitored
- ✓ Difficult to collection data on waste management using TWM
- ✓ No Recycling of waste.

Citizens are not well aware of how they can get rid of the solid waste, so the disposal or recycling of waste by using different ways that are not efficient can cause public health issues

1.3 Problem Statement

The greatest drawback relating to waste management in developing countries is the lack of proper collection method. Due to lack of proper systems for disposal and collections, wastes and garbage's find yourself within the roads and surrounding. according to a report (Hoornweg and Bhada-Tata, 2012) the annual solid waste is regarding 1.3 billion tones and it looks that this capability can rise to 4.3 billion tons by the year of 2025, which can cover 500th of the overall population worldwide.

With the present ways of collecting and disposal, it's close to impossible to manage such quantity of waste within the future as around 30% of waste end up on the roads and public

places because of ineffective disposing and collecting strategies (Zurburg, 2002). Not only that, there's even no systematic methodology for the collected garbage for treating and usage therefore most of them end up in landfilling and stream water, making the surroundings unhealthier and no recycling. The prime impediment of implementing smart waste management system supported IoT in a very developing country is that the social and economic infrastructure of the country itself.

The initial stage of this method contains of correct disposal and collection that is the biggest challenge. Additionally, to inspire and influence individuals to follow correct waste disposal ways is additionally necessary.

There is no correct waste management in Pakistan. Thus, this research aims to purpose smart waste management (SWM) solution enabling cities by putting in sensors within the bins.

They have several advantages which are as following.

- ✓ It helps in observation the level of trash in every bin.
- ✓ Reduces the quantity of waste aggregation vehicles
- ✓ Reduces the traffic and fuel value
- ✓ The high quality of service to gather waste on time
- ✓ Reduce health problems
- ✓ Reducing air pollution
- ✓ Reducing traffic flow
- ✓ Reducing work force, time and cash
- ✓ Supports recycling

1.4 Research Questions

There are lot of related research questions but these four questions are core for this research, so these are four questions that we are employing in this study;

RQ1. How waste can be measured in Pakistan?

RQ2. Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?

RQ3. Which SWM methodologies exist and which are ideal to be implemented in Pakistan?

RQ4. How SWM can resolve Pakistan's existing waste management issues?

1.5 Objectives of the Research

RQ1. Review existing Literature on the subject and conduct survey to collect

remaining data

RQ2. Conduct survey to learn difficulty in the adoption of SWM, people's perception and awareness regarding it and identify hurdles being faced for its implementation.

RQ3. Review existing Literature and suggest models that meet us criteria for selection.

RQ4. Identify problems that can be solved by SWM, that are currently being faced by people and city administrative authorities

1.6 Justification

We clean our homes and through garbage outside, it's our duty as nation to clean our community and surroundings, it will not just affect our county neatness but also our living standards and health, it will take us a step closer for better living. This study helps to identify the gaps in observation of in-house waste bins. The study aims at developing a model to learn the domestic household and corporate user to be able to monitor the gas emission levels, and therefore the fill levels from the waste bins.

For this we conduct a survey in which we have covered 10 different areas of Islamabad, Rawalpindi areas for finding our research objective and conducted interview from municipal authority of area to know about waste generation, collection and their issues and find which method is most important for launch which ease our life.

The results of the study would possibly propel the usage of the planned model for detective work fill-level and gas emission level from waste bins and informing the waste observation personnel therefore making certain a safer, cleaner surroundings for all.

The research would even be important to scholars, as an addition to the present body of information additionally complementing the previous research administrated on a similar. It'll offer a good platform for more research to be administrated on the adoption of waste bin observation systems.

1.7 Scope

The study is aimed at formulating a prototype for the adoption of waste bin monitoring systems. This is because such a solution may go a long way in enhancing accountability, proactive responsiveness and better management of waste, thus ensuring a safer, cleaner environment for everyone. This study held in 2017.

This study bis for domestic household and corporate user. The prototype developed from this study will empower the domestic and corporate user to be able to monitor the household bin status (gas emission levels, and the fill levels) over a period of time, being able to send notifications when bins require to be attended and reports on average household waste.

Our target is to purpose an efficient model which is suitable for our community and easy to install and fulfill our requirements which is cost effective, real time monitoring, have a recycling, IOT base and easy understandable for un educated peoples of our areas. For this we conduct a survey and find their measurement of waste, issues, SWM hurdles, and many more which is suitable for our case study and for implementation of purpose solution.

1.8 Structure of the Thesis

This thesis is portioned into the following main parts to provide complete understanding and establish the proper structure of the thesis.

1.8.1 Introduction

The Chapter 1 of this thesis provides the opening perspective, general and clear understanding about the research of this thesis as well as which parameters will motivate to accomplish the research. It also addresses the problem statement along with solution statement.

1.8.2 Background and Literature Review

The chapter 2 & 3, after the introduction then comes discuss of the background and some work that is related tour study. It is also containing state of the art, characteristics of ABM and significance of using Agent based modeling and simulation approach.

1.8.3 Methodology

Chapter 4 focuses on the proposed framework for performing simulation to evaluate collaboration among Internet of Things using Agent based modeling. It is also discussing the case study of solid waste management system and contain the diagram of proposed simulation results and discuss the simulation results in detail.

1.8.4 Evaluating settings

Chapter 5 discusses the data collection and Metrics for evaluation

1.8.5 Simulation and Result

Chapter 5 discusses the simulation of the designed framework and its results.

1.8.6 Conclusion and Future Work

Chapter 6 conclude the whole discussion and show per future perspective that can be carried out in future to support this work.

Chapter 2

2.0 Background and Related Work

This chapter provides the reader a clear understanding of general information about the research of this thesis. It also described the background, history and the basic definition of the problem under discussion. This chapter provides an overview of the subject under consideration. It will help in explaining how the work is similar and varies with previous researches.

2.1 Background

The smart town service includes sensors distance measure for perceiving environmentally and concerned sensors for city conditions to support community, community resources furthermore as borough processes inside an educational methodology. The thesis structures combine completely different technologies like mobile, prevailing computing and ultrasonic sensor Networks (USN). Radio frequency (RF) transmitter/receiver GSM/GPRS and Arduino all over computing and communication technology. With computers that may method information and data, product can adopt good features and skills. This might additionally include electronic characteristics that may allow the product to be controlling from a particular distance and contain sensors so as to notice the alterations within the surroundings. With the commencement of internet of Things (IoT), daily used objects and devices can simply connect with different networks, IoT structure can contribute to the development of the network when the mobile and internet networks (Evans, 2011).

Majority of individuals lives in smart cities and this amount looks to increase a lot of. Excessive range of population cities raise, the issue in terms of city transportation, power, drinkable water, waste collection structures and community places. Therefore, these issues can need to be solved in a very smart effective and property, however at constant time it ought to contribute to the state wealth and community happiness. It may be achieved through mobilisation of the resources during a town and organization of town in terms of using modern technologies and new policies (Manville et al., 2014).

Furthermore, the world's cities population is expecting to extend therefore by 2050 the number of city inhabitants can increase by around sixty million annually. Because of the very fact that the world turns out to be municipal, a necessity of turning cities into good cities arises to tackle the environmental issues (Mishra, 2013). Moreover, information and communications technology (ICT) plays a very important role in empowering influence among urban areas to handle this type of difficulties in a very smart method. During this thesis, a smart city may be

outlined as a city that is a smaller amount inventive. At constant, time it provides the cities with smart organization and management tools (Manville et al., 2014). Thus, the most cause for growth of good Cities is that the demand to develop the excellence of services from town or stat activities to town populations. Currently, several projects for the creation of sensible cities

Pakistan is becoming a major country in waste generation but as we are increase in waste generation in response we are not working for its management, currently in Pakistan the traditional and legacy waste management system is working, which is not up to the mark and causes several issues related to environment & health. Govt is not investing or taking serious this project. We need special amendments and budget for waste management to overcome this problem.

2.2 Strategic Planning for Smart City

Smart and Intelligent city strategy and designing ways are offered in varied ways in which similarly as growth efforts, enforced on numerous balances alongside realms, together with half created methods, district methods, agglomeration of many canters and elements, and holistic/unity plans. Plans include improvement of cities at totally different steps of improvement, i.e., in remodeling and in improved cities. Numerous municipalities aim for smart Cities, which is able to utilize international communication networks, wide wireless sensors and smart systems for organizations so as to search out solutions for the present and future issues likewise as providing totally different services.

Smart city officers can want visionary leadership who drive smart town improvement and need partner businesses to fund totally different comes for the creation of smart cities and to make a lot of employment and active national economies by delivery in innovation to the town.

They establish official approaches and programs funded by government activities or developing creativities created by people, community teams, and citizens (Komninos et al., 2014). Developing a holistic methodology could also be achieved by classifying and implementing powerful methods and therefore the necessities for smart cities. In short, no short designing of politics method is offered however solutions are often found supported the govt and community requirements and budgets. even so, the preparation processes should be reconsider because the collective efforts finding the issues of the town and policies promoting the use of OCTs and intelligent technologies could also be a lot of complicated, resulting in different issues (Hodgkinson, 2011).

2.3 Waste Generation and Management in a Technological Society

Factually, waste managing functions within the engineering field. It developed with the event of technology get LED to the challenge of obtaining obviate the waste materials. The flow of materials in a technological society and also the ensuing waste generation are

Illustrates schematically. Wastes are produces through the mining and manufacture of raw

materials, like the tailings from a mine or the discarded husks from a grain field. Once the stage of eliminating raw materials, additional wastes are obtained because of the production and consumption applied by the community by mistreatment the mentioned raw materials. That the best methodology to form a much better resolution for this challenge is to decrease the waste created. Yet, people do a lot of consumption in line with the life standards that they might wish to increase. Consequently, new higher ways in which for disposal of wastes are researched. Moreover, the wastes are usually connected to the utilization of land and space area (Tchobanoglous and Kreith, 2012).

2.4 Waste Collection Problems

The old-style assortment ways of waste won't to be sufficient in cities however as there was a major increase within the quantity of created waste because of the increasing population in cities, these ways turned out to be insufficient. The issues enclosed the filling of reports, timetable, request that LED to the unstable waste collection activities (probably because of the incomplete waste once it had been imagined to be collected or most likely because of the irregularities in collection the waste). These encountered problems LED to the development of different strategies of collection, like good waste management collection to resolve the issues and cut back times and price of collection (Hoornweg and Bhada-Tata, 2012).

Although, as good waste management collection is totally good, doesn't want manual power, and permits a lot of an improved operating surroundings and it's additionally much faster. However, it wants a bigger budget which is why it's going to be a problem for various countries with smaller budgets.

2.4.1 Health Impacts

By keeping in mind about all the possible hazards originating due to solid waste, the hazards might be long term or short term depending upon the type of solid waste and the main threat is about human health. The waste collected by agriculture cause spontaneous flames of fire during hot weather. In addition, during rainy weathers like monsoon, rapid rottenness of things may produce gases and creates breeding ground for insects of various types. Further, the municipal and domestic solid waste should be properly taken care to avoid possible hazards.

Waste management companies separates non-degradable and degradable stuff while collecting or dumping the waste, it can further lower the risk of dangerous reactions and increase the benefits of recycling process. Water is crucial requirement for every living thing, solid waste and industrial waste pollute the water resources because of rain washing and leakage, that mixes up with the water reserves and water beneath the ground. This water also effects the cultivation and due to this the quality and quantity of organic and non-organic material varies.

The material that is organic is more towards degradable and cause in spreading hazardous material that might be there in lower quantity. We are not discussing any detail of which material or gases are more dangerous or not, because that detail is out of scope from this study.

However, some materials are very much common in combination with solid waste. The importance of such materials are different according to location. Erasable components e.g. hydrogen, lower molecular weight acid, ammonia, sulphide and other identifiable components including sulphur and nitrogen.

The local businesses e.g. agro farming and cattle farming wastes contributes towards of biogas, while slaughterhouse, tannery and dairy produces liquids and foul gases of different varieties and concentration. In addition, the process of decomposition related to animal tissues creates nitrogen and sulphur. The pesticides are also contributor of pollution in ecosystem, their residues contribute as solid waste as they contaminate and pollute ecosystem. These things contributes a little but saturate the atmosphere thoroughly. The polluted air react with human body and irritate in different ways, like skin and eyes infection and damage in respiratory system. The living things absorb these chemicals through different paths and create swear problems to ganglion nodes, nervous systems, cause nausea, headache, vomiting and intestinal problems. Longer connection with these NH3, H2S etc. foul gases can cause similar and adverse reactions. The problem of breathing, headache and a situation of dizziness are very common. The longer contact can cause same situations, but that include acute pain and chronic irregularity and cancer of various types.

2.4.2 Public Health

In many locales, general wellbeing worries occupy the premise in terms of strong waste administration programs, as strong waste administration would be the best way to keep up general wellbeing. Strong waste that is not legitimately gathered as well as arranged can produce creepy crawlies, and searching creatures, and in this manner various sicknesses can be observed. UN-Habitat carried out studies demonstrate that in the zones with less waste produced, the occurrence of looseness of the bowels and intense respiratory diseases are observed more (Lawrence and Woods, 2014).

2.4.3 Environmental Protection

Inadequately gathered or shamefully discarded waste can detrimentally affect the earth. In low- and centre pay nations, Municipal solid waste regularly discarded in low-lying ranges and area contiguous ghettos. Absence of supported regulations permits conceivably irresistible medicinal and dangerous waste which can combine with MSW and which will have damaging effects for waste collectors as well as to the earth.

Natural dangers incorporate sullying of groundwater and surface water expense of unused materials and their ecological effect expands, the approximate estimation of auxiliary materials relies on the increment (Hoornweg and Bhada-Tata, 2012).

2.5 Solid Waste Collection

Waste collecting is the accumulation of strong waste from purpose of creation (private, modern business, organizational) to treatment and transfer. City strong waste gathered in a few ways

such as

1. waste collector collect trash from every house. The client for the most part pays a charge for this administration.

2. Group Bins Users convey their trash to group canisters that put at settled focuses in an area or region. The district, or its assign, as per a set timetable, grabs MSW.

3. Control side Pick-Up. Citizens throw the rubbish straightforwardly out of the houses as indicated by a refuse get plan set with the nearby powers (optional house-to house gatherers not common).

4. Self-Delivered Generators convey disposals straightforwardly to transfer locales and exchange stations, or procure outsider administrators.

5. Contracted or Delegated Service Businesses procure companies (or metropolitan office districts) who orchestrate gathering plans and accuses of clients. Regions regularly permit private administrators and might assign gathering zones to support accumulation efficiencies (Tchobanoglous and Kreith, 2012).

2.6 Elements of Waste Monitoring System

A regular waste monitoring and management system from a developing country can have different elements and described as (Zurbrügg, 2003):

i. waste gathering from residential societies and storage.

ii. Recycling and reuse on residential level (animal feeding also included).

iii. Solid waste collection from primary sources and take it to community bin or stations.

iv. Organization of community bins or transfer station.

v. collection and transportation of waste from secondary sources to waste disposal area.

vi. Finally the disposal of waste in landfills

The handling and storage of waste usually is the main element of the systems and is done by the household originators (Bashir & Banday, 2013).

By these steps we can manage the waste, first we collect then we handle or process it and then finally disposal (Zurbrügg, 2003). Where majorly peoples are performing for the entire work that can be reduced and by this the living standards can be improved.

2.7 Related Work

Literature review takes an overview on the relevant smart waste collection as well as monitoring literature. More recently, cities become more populate so with expanding the size of the cities thus cities need to be smarter for living so smart services in city such as intelligent and smart traffic lights and system, better and smart health care, and waste collection by smart

ways, smooth education system, smart energy etc. Amount of solid waste will increase so this causes negative impact in the living society and spread pollution in the air as well as on ground and create health issues. Therefore, it is very important to optimize the collection process and manage waste solid smarter and more efficient.

There are different studies on this, carried by multiple authors related to solid waste management. The result from many of these studies was outstanding but with the passage of time now their results are getting older, now with new technology we can improve the results and develop more solutions. Different researches have been achieved for the solid waste generated by different sectors.

The researchers discussed about.

2.8 Waste Composition

Wealth status and consumer patterns significantly influence waste composition. A higher material of biodegradable and slow matters, causes or produces dense materials and high humidity. These dense features importantly influence the accuracy of management system. The recycling system that are working on low-density remaining's such as in advance countries to accommodate industrial waste cannot work or perform accurately with dense mater. Moreover, the waste matter can be rapidly Detroit by high moist or high-water content.

2.8.1 Existing aspects for monitoring and evaluation weighing of waste

There are lot of mechanisms to count the total weight of waste, but one of them is under which is mostly used. A weight machine is deployed on each collection truck, each time a waste bin is loaded to waste collection truck, the employee's needs to do weight and write it precisely with the already assigned unique tag to each waste bin. By this method total of each bin can also be summed and a total sum can also be retrieved and useable for different statistical studies. In entire process the weight of waste bin subtracted afterward, and we get the accurate total weight of solid waste.

2.8.2 Study on residual waste, dry recyclable and food waste for waste composition

After the collection of statistics, analysis can be done four times in a year in different seasons for possible investigation of behavior change in waste composition. The collected statistics are used for waste composition study for different location in the city. The recommendation of method is done by SWA tool (Olsson, Lymberis, & Whitehouse, 2004) and the study in detail is written by by (Dahlén & Lagerkvist, 2008). Further errors were reduced by resampling and for residual waste the data is collected precisely and to make it error prone they have used sub-sampling for dry recyclables and food waste. During the study different hazardous items found in waste are also separated like bulky waste or batteries. The same or related method is also used by (Battese, 1995) for composition of waste analysis for all four different sessions and the method is developed in collaboration with Lulea University of technology.

2.8.3 Analyses for bulky waste and hazardous waste composition

The bulky waste when collected through the mobile container, it is processed at that time and categorized as hazardous waste and normal, the delivered weight was recorded. All the material needs to be sorted and ratio of weight extracted, the source ratio is also important, so it is also considered and measured. Data is presented in a shape or sorted and unsorted recyclable material like packaging/non packaging material, newspapers and other food items. To relate the total disposal waste everything needs to be related to finalize most of the analysis.

2.9 Integrated Technologies and Approaches

These are different approaches that are commonly used to gather information and maintain waste management. Most of the techniques are old but some techniques are integrated with new technology.

2.9.1 Wireless Sensor Network (WSN)

The WSN is new and emerging field using wireless sensor, in this every sensor generate data about the area where the sensor deployed and send to main servers on a network, the data gives information after processing. Currently there are lot of sensors for different domain and different types of data collection, here they use sensors that can generate data about physical condition about the area or object. Wireless sensor network helps humans to interact with the remote location, a node contains sensor, microcontrollers for small computation, transceiver and limited energy source to power-up the sensors and circuit. These IOTs were initially designed to help in military operations but after seeing its benefits and wide application, WSN now useable in every field of life. Due to its increased application everyone is interested in WSN, now their application is available as smart home, smart patient management, smart farming, smart agriculture fertilization and many more (M. A. Al Mamun, Hannan, Islam, Hussain, & Basri, 2015).

2.9.2 ZigBee

ZigBee is a network result of a study done in 2013, it becomes standard for WSN based on 802.15.4 wireless standard IEEE. It offers the architecture and infrastructure related to WSN network. ZigBee is very low in consuming the batteries results in long life cycle with low duty cycle. It has wide support that can contain more than 65,000 IOT's on high performance and low latency. It is specifically designed for low power consumption with larger number of supported nodes covering wide area. (M. A. Al Mamun et al., 2015)

2.9.3 GSM/GPRS

This is the standard that we are using from many decades for cellular communication developed in Europe. Telecommunication standard institute in Europe researched and invented this technique, its basic service is telephone as voice communication, but now we have many different services associated with it. It uses GSM network to carry the digital signals, voice message converted to digital text and sent to other side on the network, it uses circuit switching

for working with wide number of end nodes. It have other technical detail that might not needed here (Islam, Arebey, Hannan, & Basri, 2012). Further GPRS developed by doing more research on the GSM technology where packet switching is involved (A. Al Mamun, Hannan, & Hussain, 2013). GPRS is used to use the internet and other internet services, in voice communication multiple connections are not possible but in GPRS multiple connections are possible simultaneously In GPRS one channel can be shared with multiple participants that is not possible in GSM. GPRS is truly support wide coverage and by using it every user can remain online whole time and this is a method for real-time communication (Islam et al., 2012).

2.9.4 Radio Frequency Identification (RFID)

This technology is old but its application was not common before few years, but now peoples are taking interest in this technique and using it in different application for secure identification and processing. This technology was used in world war II. The working of this technology is too simple to understand, on one side it have reader that reads all the information from tags, on other side it have integrated circuit which includes antenna. The communication takes place through antenna when the devices become available to reader. It can be used wirelessly or by physical interaction. RFID circuits have information which we needs to transmit through reader. Mostly it is used for secure authentication and identification through radio waves but within short range. Radio waves transmit signals to reader that further transmitted to main system for processing, after authentication the information system response in different ways according to application. This technology is used in variety of applications in different industries. Mostly it is used as employees or students identification, but it is also used in cargo system or supply chain management, contactless payments, livestock or superstore management like barcode and many more (Islam et al., 2012).

2.9.5 Geographic Information System (GIS)

This technology has no competition currently, it is a mixture of hardware and software, that gets and process location data and provide us location referenced information (Maguire, 1991).GIS has wide variety to view, visualize, interpret, demand and understand geographical data and show relationship, trend and patterns on maps and globes, it can also reports and visualize charts. A GIS avails us the answers by solving our problems, it uses our data and process it in a way that is rapidly understandable and shareable (Islam et al., 2012; Khan & Samadder, 2014). This technology is new and advance so it can easily integrate able with current and upcoming enterprise systems and management solutions, it is mostly used to understand and identify location based and movement information by showing the information with the help of digital maps and geographical maps (Chalkias & Lasaridi, 2009).

2.9.6 Web Camera

A camera is a device that captures a scene and save it, now we have digital cameras that captures and save it digitally in its memory for later use. That image can be transmitted over

the network and can be save in the computer to process (Poh, McDuff, & Picard, 2011). To manage the waste this technology is also in use, it is quite common in surveillance so we can monitor the bins in real-time and act accordingly. By connecting camera to network, real-time images can be retrieved from the camera and processed to act accordingly. This technique can be more accurate but expensive from sensors network (Islam et al., 2012).

2.10 Existing Models/Solutions

2.10.1 Automated Solid Waste Bin Monitoring System

There are different models exist in this domain, the first system we are referencing here uses wireless sensor network for data gathering and employed a different network to transmit data from nodes to main database. This system remains online whole time with low consumption and used to minimize the cost and keep the surroundings safe and health (M. A. Al Mamun et al., 2015).

By taking a 240L waste bin and employee a sensor node inside that is Wasp mote. The controller inside this sensor is ATmega1281 because of its low consumption, during online it consumer 15mA and during sleep mode it consumes 55uA and it also have integrated sensor for accelerometer. For communication it contains radio transceivers which works on already discusses technology Zigbee. This standard is used because it can facilitate a larger network for longer life and with low consumption, this network uses standards from IEEE 802.15.4.

The actual ultrasonic sensor working as checker for measuring the level of waste in the basket known as XL-Max sonar, its model number WRA1 MB7070, manufactured by Maxbotix. Another sensor which is Load censor by Hanyu used to predict the weight of waste in the bin. The last two sensors which are used to measure the humidity and temperature inside the basket known as 808H5V5 and MCP9700A. Finally to integrate all these sensors as one working object the board from Libelium is used known as smart metering v2.0.

It is considered that to maintain clean environment in the city, there is a basic need to maintain clean and empty waste bins in the city or community, so it compulsory to empty the bins as they filled up. Here in this study they are using ultrasonic sensors with other technology to check the level of waste and send that information to main administrator, that information later used by the truck drivers for efficient route selection that reduce cost. The collected data is then processed for future to better predict the bin placement and its size around the whole city. The identification technology is used under this system is RFID, each basket has RFID tag embedded in it, by this technology every waste bin can be identified as a unique entity and located in the city.

The older system working now a days has different disadvantages. Each bin has to be check each time either it is filled or not, that results in high cost solution. If the basket does not emptied on required time than the environment become polluted and smelly. When the bin was emptied by the staff, the process conveyed to main server by network and stored in SQL

database. On every step the information is stored and retrieved through the network from SQL database because that is a fast and reliable way of storing and getting data back from database, also on server we can process that data for current and future use.

This data is analyzed for different decisions. Occasionally, the data from sensor nodes are captured and stored in database that is used to check the level of waste in the bins also used which bins was emptied recently and which is required to do so. By this means staff members who go and contact with bins will contact fewer times and they all will stay more healthy and away from diseases.

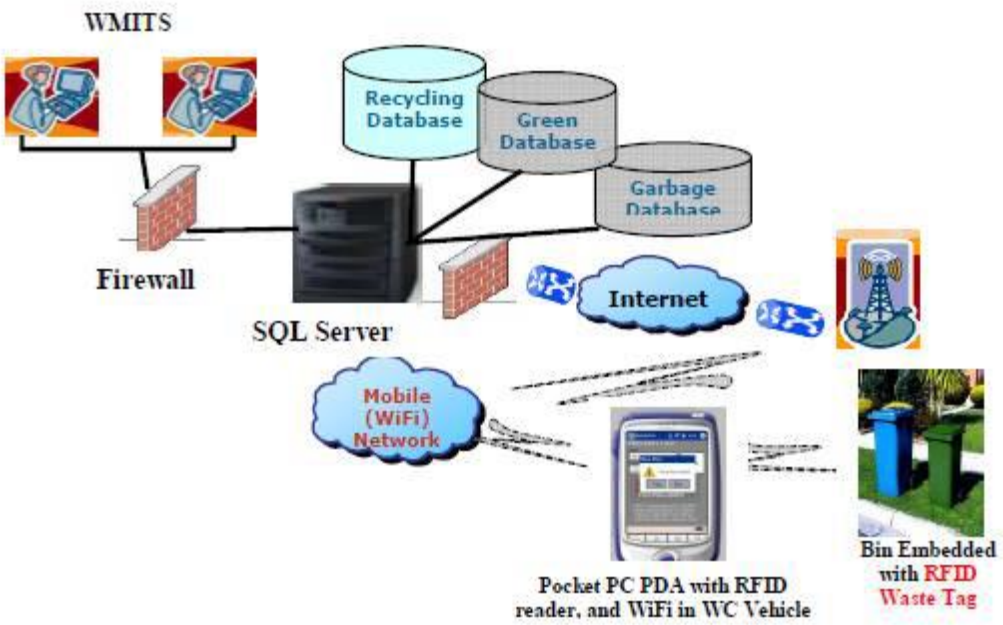

Figure 2. 1System Architecture for Automated Solid Waste Bin Monitoring System

The process of collecting, tracking and managing could be monitored by developing complete system that is IOT based. One of the approach to provide solution to increase the reliability, accuracy and efficiency of the system is LoRa technology. LoRa technology is used for long data communication, when compared to Wi-Fi or bluetooth. Here the sensors are used to collect the data from the dustbin and is sent to the gateway through LoRa technology The data from gateway is collected and is uploaded to internet in the cloud, that using the message queue telemeter transport (MQTT). SWM can be divided into transportation, collection and separation and transportation. The working of this planned project architecture address separation of solid waste that can be done at the initial level.

2.10.2 Citizen

It can separate the waste according to its characteristics, wet waste and dry waste (biodegradable and other material e.g. plastic, glass, papers) and dump the waste in the dustbin located at different places respectively. Here the IR sensors is used to track the level of the

waste gathered. A gas sensors is used to detect the hazardous gases. LED lights is used for notifications. The sensors and actuator are embedded on microcontroller that collects the sensor data and sends it through transceiver module called LoRa.

The gateway collects the various sensor data from garbage bin placed at different location. Here data is locally processed and then data is sent to cloud over TCP/IP using MQTT protocol. MQTT protocol collects the data and NoSQL database stores the data. Rule engines is used for analytics and display the gather data on admin console by google maps and suitable algorithm the trucks can be alerted to collect waste in required location. Report is generated using data analytics and console, on other side the concerned authority can analyze and view the entire process.

One of the main problem faced in today's world is trash management and increase of trash and overflow of trash from the trash bins result bad smell and harmful gases causes various diseases which in turn affects our green environment. To overcome the above issue an intelligent system for garbage was developed. RFID (radio frequency identification) is a technique that is used for verifying and identifying the process which helps the garbage alert system by providing automatic identification of filled garbage in the bin and sends message to clear the garbage. E-monitoring performs remote monitoring to clear the wastes, therefore it reduces the manual work. An android app receives notifications through Wi-Fi/GSM.

2.11 E-monitoring System

In traditional approach, whenever the garbage bin is filled the wastes are cleared but they are not periodically removed. Where as in convention method, there is use of RFID technology which will overcome the above-mentioned issue.

E-monitoring system consists of two parts:

- ✓ Embedded system
- ✓ Web based software system interface

2.11.1 Embedded system

It comprises of microcontroller, RFID reader, liquid crystal display (LCD) and GPRS/GPSM.

2.11.2 Web based software system

It consists of GPSM, a central server, database server and webserver. The aim of this system is to develop a better monitoring system for proper municipal solid waste.

2.12 Smart Dustbin

If the wastes are not disposed properly it leads to air and soil pollution. The harmful gases and the bad smell will adversely affect human beings. To overcome this a smart dustbin was designed. The objective is to overcome improper waste management.

2.12.1 Design of Dustbin

The smart dustbin consists of piston, compression plate, lid of opening and leaf switch. The piston moves back and forth in vertical direction. Compression plate is used to compress the waste. Dustbin opening is closed by lid. Leaf switch could be placed upside down using hole on the plate.

2.12.2 Arduino UNO

It is a microcontroller board consisting of 14 digital I/O by connecting battery task can be achieved.

2.12.3 Ultrasonic sensor HC-SR04

It offers a 2cm – 400cm non-contact measurement function. It converts electrical energy into sound to send pulse. In RFID technology the combination of antenna and microphone are attached on RFID tag it is a small device that stores and sends the data to RFID reader that receives electrical energy after getting transformed from radio frequency.

2.12.4 System implementation

The system is designed to avoid the overflowing of wastes from dustbin by transmitting the alerts to microcontroller.it uses RFID technology to identify and verify process. The function of each parts of the system are enunciated earlier. The block diagram is shown below

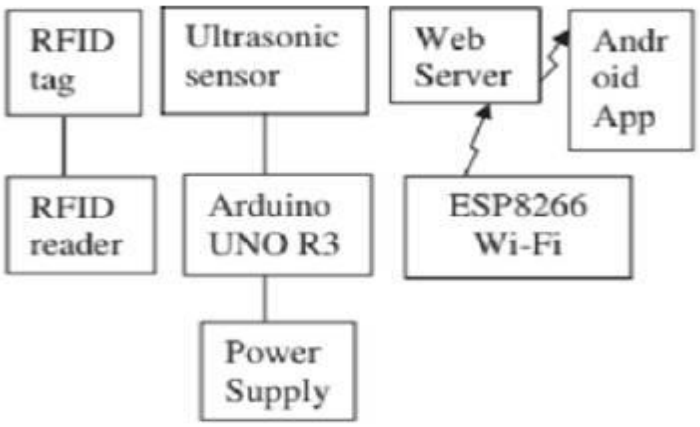

Figure 2. 2

The alert system is used for maintenance in the garbage system. When this is deployed a green environment and pollution free can be achieved. It also decreases the manual work in municipality and pollution monitoring system.

For a healthy environment we need to monitor and clear the garbage waste regularly to stay healthy. In the old system where people are hired to check and empty the filled bins has led to human error and neglect. In current duration, we barely have short duration of time to break and record things manually, even it would also possible that we get ignore to do neatness. We should remember the concept of smart connected bins, these smart bins have the backend power of cloud computing and machine learning. Cloud manages the data for the whole duration and machine learning performs the decision making and other required things. We can implement

decision forest regression on data gathers on cloud from sensors to make current and future decisions. These decisions are smarter and by following these decisions we will save fuels.

2.13 Proposed system

Garbage is a waste generated due to the various activities, such as industry waste, wet waste like vegetable waste, dry waste, commercial waste, house hold wastes etc. Improper utilization of the garbage may pose several environment issues namely generation of various hazardous gases which leads to the various health issues. While carrying the garbage, it must be carried and disposed by following various types of protocols. The processing of garbage involves the carrying the garbage from one place to other through trucks and cranes. But while carrying the gases, the people who is responsible to collect the waste must follow some of the rules and regulations. So that it should not affect the people of the society and our green environment. But at the time of processing in the cities is important. Because, in current days the garbage collection is not been collected properly due to lack of coordination among authorities, specialized vehicles and other means.

So, the garbage which is on the road or land is degrading itself and emits a bad smell and also poisonous gases. Because in the garbage collectors, it's not cleaned properly and causes the different diseases like cholera, skin diseases etc. The proper utilization of garbage can help us to get some gases. Some may harm and some are useful. The useful gases which are emitting from the garbage can be utilized for commercial purpose also. The gases which are emitting from the garbage can cause various diseases and harm the environment.

So, to know the status of the garbage at various places and at the main container, this is designed and implemented in various places and tested. Earlier, people of the society and the concerned authorities used to know that some sort of gases are emitting from the garbage. But they don't know the exact values which are emitting from the garbage. Also, they are not getting any data. The people of the society must inform for the concerned officials back to back once the garbage is collected. To address the problem here about detection of various hazardous gases which are emitting from garbage causes diseases like asthma, cholera, typhoid, malaria etc.

The gases which are emitting from the garbage should be monitored. A hardware or any other means must be installed in the place of garbage. The sensors are going to deploy in the garbage. The sensors must be low cost, less power consumption sensors. With those sensors, sense the gases which are emitting from the garbage and send the same information and it must be stored in the public cloud. Also, information must be displayed in the web side accordingly. An SMS must be sent to the authorized person.

2.13.1 Ultrasonic Sensor

There are different techniques by which we can sense the quantity of garbage in the bin, the most favorable is ultrasonic sensor module which can be configured with Arduino and a GSM module can also be integrated for remotely accessing.

This special module uses sound waves that can be reflected back by objects and allow logic unit to interpret about the quantity of material in any box.

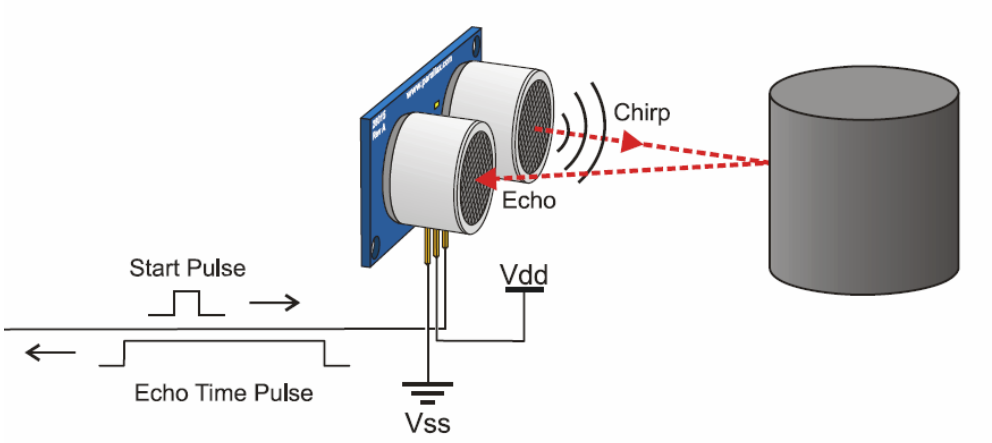

Figure 2. 3: Internal circuit view for Module

The image below describes the working of ultrasonic sensors, it generates sound wave of high frequency and waits for it. When the echo comes back, it measures the time between sending and receiving. This interval determines the distance traveled by sound wave and by the same method this device can give us the level of bin.

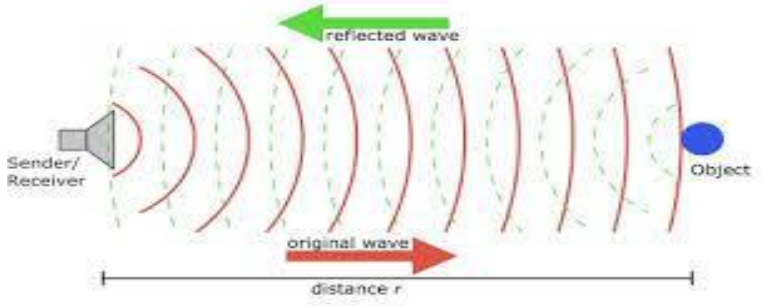

Figure 2. 4: Soundwave reflection

2.13.2 ARDUINO Board

Arduino is a community which work to design open source hardware and software on community standards by using microcontrollers, sensors and different types of kits. Their Arduino product have different variants and computational power with low resource consumption, this device has some extra pins for configuring different input and output devices and sensors. On board computational power is limited so to process more data we need to send data on cloud or servers. These are interactive devices that are useable and already used by many projects.

The different set of analog I/O and digital pins provided by this system that can be used for communication to various devices or sensors. This board have Universal Serial Bus on different variants, for programming it has support of C and C++, the story of this project starts in year 2005. The aim of this project was to introduce a highly useable multifunctional device with the

support of expansion by using minimum resources. Currently it is widely used in motion detectors, simple robots and commonly used by school projects and hobbyists.

Figure 2. 5: Arduino Board

2.13.3 GSM Module

GSM is global system that is used by communication through mobile, this is the standard developed in Europe and now used by all over the world. It starts from EDGE and now we are using 5G networks. These networks now support every type of communication, from voice to text and video calls. The latest network has fast data transmission rate by which we can operate device remotely in real-time. GSM have different frequencies to operate, the below picture is showing a simple module that can be configured with Arduino.

Figure 2. 6: GSM Module

Chapter 3

3.0 Research Gap

This chapter provides an overview of the subject under consideration. It will help in explaining about Research Gap in which I mention 50 papers with their feature and parameter their methods.

3.1 Survey Papers

There are many surveys which is used for collecting information about the waste we discus 3 papers which are related to our requirement.

3.1.1 Paper 1

In this paper, we present a comprehensive and thorough survey of ICT-enabled waste management models. Specifically, we focus on the adoption of smart devices as a key enabling technology in contemporary waste management. We report on the strengths and weaknesses of various models to reveal their characteristics. This survey sets up the basis for delivering new models in the domain as it reveals the needs for defining novel frameworks for waste management. This paper addresses the study of the waste management problem in the city of St. Petersburg, Russia. St. Petersburg is a city of 5 million citizens covering a total area of 1,439 square kilometers, a density of 3,391 citizens per square kilometer. On average, solid waste produced in the city is 1.7 million tons per year. The daily amount of municipal solid waste generated is 0.93 kilograms per citizen. Daily, the municipality of St. Petersburg uses 476 waste collection trucks with a capacity of 5 tons per truck. The fuel consumed in one year is, on average,1.8 million liters. The average costs spent for fuel in one year for waste collection is more than 1 million US dollars.

Categories	Components / Hardware	Features
Physical Infrastructure	Bins Fleet of Trucks Depots Dumps Pneumatic Pipes	Recycling of Inorganic Waste Processing of Organic Waste Bins Location Bins Type
IoT Technology	RFIDs Near Field Communication (NFC) Sensors Wireless Sensor Networks Actuators Cameras GPS	
Software Analytics	DSS GIS Dynamic Scheduling Dynamic Routing	Architecture Social Context Experimental Data

Figure 3. 1:Taxonomy of Waste Management

This survey focusses on energy efficient IOT that enable various model like waste management

is one of them. the survey attention on waste management. the model proposes a taxonomy to perform surveyed model. we focus incorporate ICT models for collection of waste and also focus on weakness and strength of model.

In future work it focusses on IOT base model for trash collection with high capacity waste collection trucks as mobile depots. also trash bins are situated in residents comfort areas. we focus bin placement in future we place bins somewhere where consumption of energy is high.

3.1.2 Paper 2

In this paper, an IoT-based smart garbage system (SGS) is proposed to reduce the amount of food waste. In an SGS, battery-based smart garbage bins (SGBs) exchange information with each other using wireless mesh networks, and a router and server collect and analyze the information for service provisioning. Furthermore, the SGS includes various IoT techniques considering user convenience and increases the battery lifetime through two types of energy-efficient operations of the SGBs: stand-alone operation and cooperation-based operation. The proposed SGS had been operated as a pilot project in Gangnam district, Seoul, Republic of Korea, for a one-year period. The experiment showed that the average amount of food waste could be reduced by 33%.

Type	Pros	Cons
Plastic garbage bags	(i) Convenient discharge (ii) High adaptability in poor environments	(i) Inaccurate measurements (ii) Odor problems (iii) Spoils the beauty of the city
Chips and stickers	(i) Remedies for the shortcomings of plastic garbage bags (ii) Various charge commissioning methods	(i) Inaccurate measurements (ii) Elaborate charge commissioning system required (iii) Inconvenient discharge and bin management
RFID-based garbage collection system	(i) Accurate weight measurement (ii) High impact on food waste reduction	(i) Causes server overload owing to data concentration (ii) Low mobility from a fixed power supply (iii) User inconvenience caused by complex discharge process

Figure 3. 2: Pros and Cons

In this paper we cover Korea and the problem is food waste management and food volume their disposal and wastage of food.

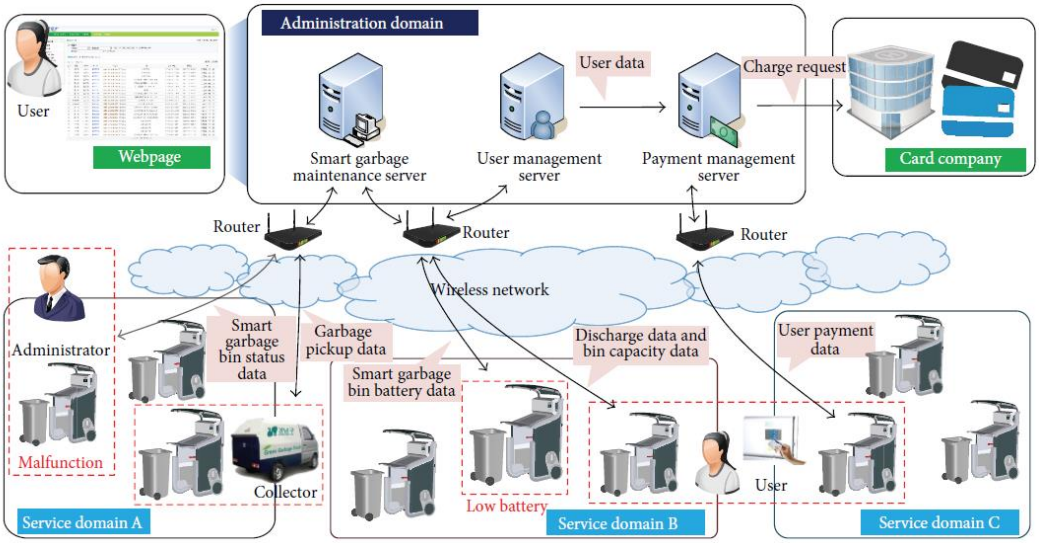

Figure 3. 3:Overview

3.1.2.1 Service Management Module

In service management model we focus information which obtain from SGB it include user information that putting and provide service like web base and mobile service, data analyzer analyze data and go to complain statistics weight manager manage waste food price RFID card manager manage card information.

3.1.2.2 Maintenance Management Module

In this module the management give information of SGB, battery status checked by battery manager communication manager manage communication and area manager manage area information.

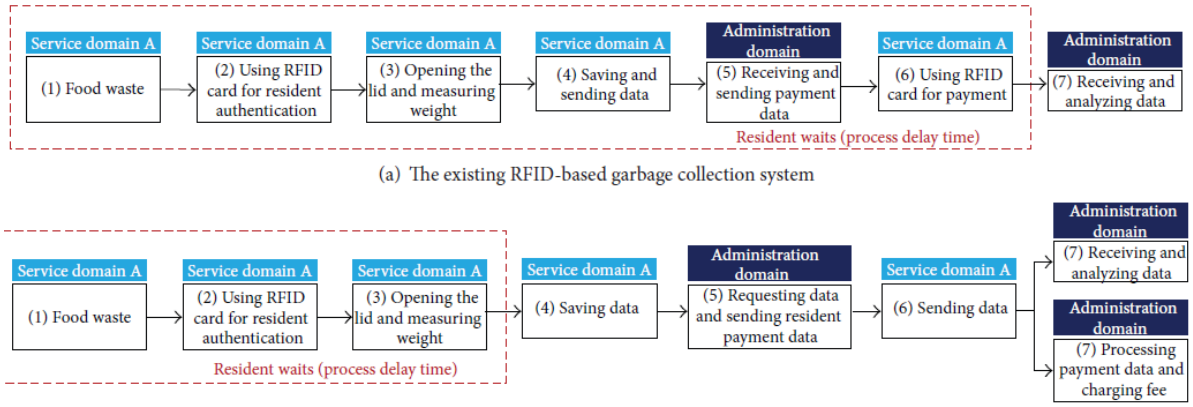

Figure 3. 4: Track of System

3.1.2.3 Charge Management Module

In this module we deal charge process. There are three charge component charge protocol, a charge policy security management. Charge protocol deals overall external charges, charge policy deals all prepayment policies, and security deals encryption charges.

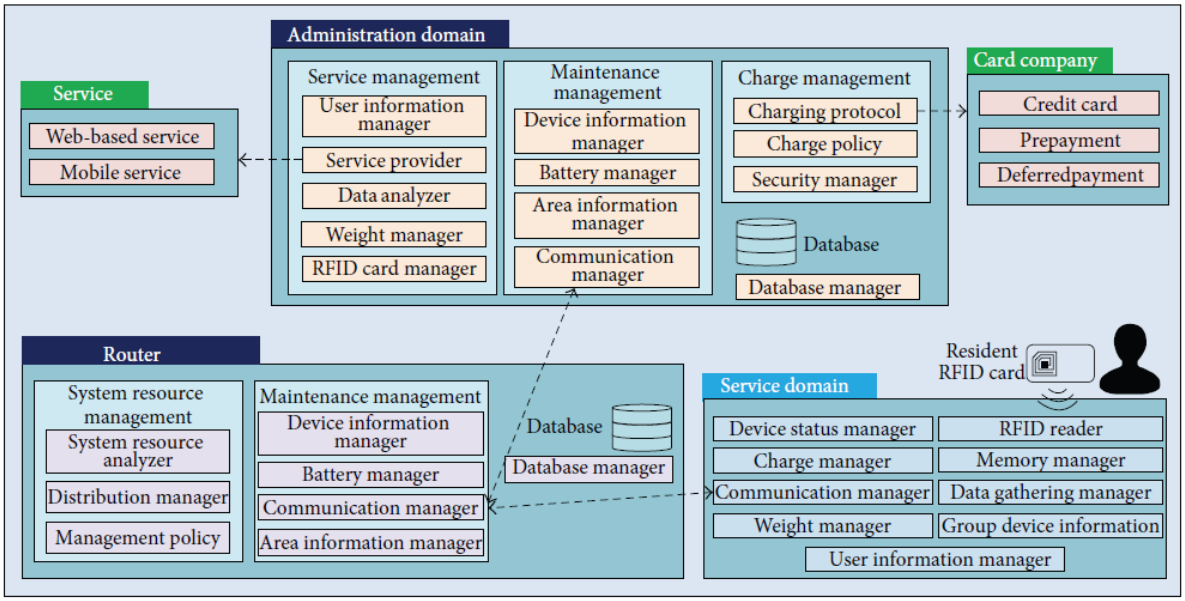

Figure 3. 5: The proposed smart garbage system

we proposed an IoT-based SGS for replacing existing RFID-based garbage collection systems. To provide differentiation from passive collection bins and other types of RFID-based food garbage collection systems, we also proposed components required in external and public environments and designed the SGS based on these components. The basic system structure of a SGB is a centralized structure in which information gathered in each bin is transferred to the server; we also designed a HSGB for improving the battery efficiency of each SGB.

3.1.3 Paper 3

in this paper we implement an integrated system which automate the trash bin for solid waste management. There are many issues in cities like improper waste collection and mostly peoples are lack of knowledge about proper disposal of waste. These issues generate serious problems in environment like pollution, health issues, in many countries many smart sensing methods used to detect the bins level and give efficient waste collection. This paper implements a model application in which we focus trash bins status, short path truck routes, sensor RFID mobile communication GIS for location detection. For efficient trash collection we use IOT base model. due to increase in papulation the waste also increases in urban areas. waste disposal is main problem for all cities. In this paper we purpose an efficient IOT base model with GIS location and sense the trash level and automate the waste bin management also our goal is to make our cities is smart, green and healthy. and hygienic environment.

The system provides more complexities and the flooding of the overflow of garbage by using ultrasonic sensor using GSM module. Filling level sensing module defines the process of considering the solid waste filling level by using ultrasonic sensor, this sensor produces the high-frequency sound waves and evaluates the echo which is received back by the sensor and intimation is done by GSM, an ultrasonic pulse takes to transmit and receive its reflected echo between the sensor and the sensed material level, the bin total capacity is calculated when the

current weight is equal to total capacity and intimate corporation to pick up, weight estimation module is calculated by the load cell and it is a transducer that creates an electrical magnitude which is directly proportional to the force being measured and used to calculate the weight of bins.

METHOD	ALGORITHM	MERITS	REMARKS
Traditional method and dynamic on-demand solution	Optimization algorithm, Artificial Intelligent (AI), Shortest Path Spanning Tree Algorithm (SPST)	Travelling distance between two location is accurate and speed up the route optimization process	Demerits-As this uses traditional method, this become semi-static so problem of segregating different kinds of waste is not possible
Top-K query Dynamic Scheduling	Dynamic Scheduling Algorithm	More Accuracy is achieved than static scheduling	Demerits- cost of CPU overhead is high
Dynamic Scheduling Method	Optimal Vehicle Routing Algorithm	Routing Cost is Managed	Only 80% accuracy is achieved for five iteration
Dynamic Routing Protocol	Genetic Algorithm (GA)	Effective tool to deal with TSP of various implementation	optimization can be improved
Heuristic Approach	Ant Colony Algorithm (ACA)	Travelling Salesman Combinatorial optimization problem is solved.	Vehicle Routing Problem (VRP)

Figure 3. 6: Discussion on List of Methods and Algorithms of Waste Bin Management

One of the most significant aspects is Ultrasonic sensors sense the waste filling status by reflecting echo inside the dustbin and no false alarm is produced, so the exact status is sent to the corporation for the collection of litter bins. Hence the paper presents highly advanced and fully automated system to collect and manage waste efficiently.

3.2 Existing Surveys

3.2.1 Links of Existing Survey

https://pide.org.pk/pdf/enveco/questionaire/Waqas_Hadir_Questionaire

http://shodhganga.inflibnet.ac.in/bitstream/10603/149973/14/14%20annexures%20ii.pdf

http://www.pinellascounty.org/solidwaste/PDF/2018_Residential_Recycling_Awareness_Survey.pdf

https://su-plus.strathmore.edu/bitstream/handle/11071/5659/A%20Smart-bin%20prototype%20for%20in-house%20waste%20management.pdf?sequence=3&isAllowed=y

Household Details

Name of the respondent: .....

Are you the head of the household? Yes/No

Name of the head of the house hold: .....

Total members of the Household .....; Male.....; Female..... Children (6-14).....

Kids (1- 5 years).....; Infants (<1 year).....

Education of the HH head..... : Highest education among the members of the HH.....

0. Illiterate; 1. Primary; 2. Middle; 3. Matric; 4. FA/FSc; 5. BA/BSc/BCS; 6. MA/MSc; 7. Above

Total number of HH who are employed.....

Employment status of Head of Household Head

1 Unemployed 2. Street Vendor/Small Informal Business

3 Government Employee 4. Own Business

5 Private Employee 6. Other

Average Monthly Household Income

1. Less than RS. 10,000 2. RS. 10,001-20,000 3. RS. 20,001-50,000

4. RS. 50,001-100,000 5. Greater than RS. 100,000

Do the members of the HH (>12 years) watch T.V.

1. Every day 2. Once a week 3. Once a month 4. Almost never

Do you think that media has raised your awareness about water, sanitation and solid waste management?

Yes 1 No 0 *(if yes cont. to Q.11)*

What type of mass media component was more effective in generating your awareness?

1. Radio 2. Television 3. Newspaper 4. Social media

Figure 3. 7: Household Details

3.3 Our Survey:

- There are Three Section of survey.
    - General Information of respondent.
    - Satisfactory level with your waste collection provider
    - Smart Methods of Waste Collection
- Link Of Survey :
  https://goo.gl/forms/WlKpnbZoil1kafRJ3

General Information of respondent.

In this section we cover general information about respondent and the waste generated, waste disposal method and the waste cost and service.

3.3.1 Questions:

Age Group:

1. Younger than 25
2. 25-40
3. 40- 60
4. 60 or above

Address Area

1. Bahria Town
2. DHA
3. Banni Chowk Rawalpindi
4. Sadaq Abad Rawalpindi
5. Sadaq Abad Rawalpindi
6. Aride Agriculture University
7. NUST Islamabad
8. Bahria University
9. G9/ 3 near Karachi Company
10. G8 Islamabad

Employment status / occupation:

1. Student
2. Government Employee
3. Private Employee
4. Own Business
5. Other

What do you store your household rubbish in? {RQ3}

1. Plastic bags
2. Cardboard boxes
3. Rubbish bin/ drum
4. No storage—direct disposal to dump

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

Where do you dispose your generated waste? {RQ3}

1. Near by container
2. Open spaces
3. Near home
4. Other

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

Can you roughly identify percentage composition of your generated waste?

1. Plastic
2. Solid
3. Paper
4. Batteries
5. organic waste
6. Glass

Note: This question addresses my research questions No 1 (How waste can be measured in Pakistan?)

Do you separate different type of waste at your home? {RQ2}

1. Yes 2. No

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

Do you organize your waste as per the instructions of your collection service provider? {RQ2}

1. Yes 2. No

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

Are there any large bins in your area? {RQ3}

1. Yes 2. No

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

Do you have regular garbage collection in your area? {RQ2}

1. Yes 2. No

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

If yes, do you use it? {RQ2}

1. Yes 2. No

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

How often do you use the collection service? {RQ3}

1. Daily 2. Ones a week
3. 2 to 3 times a week 4. Other

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

Which collection service do you use? {RQ3}

1. Public 2. Private

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

Satisfactory level with your waste collection provider

In this section we cover the satisfaction level of present services, dissatisfaction, issues and main reasons and problems in waste collection.

How much do they charge per month? {RQ4}

1. RS 100 to 250 2. RS 250 to 500
3. RS 500 to 750 4. RS 750 to 1000
5. Other

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

What is the main reason for your level of satisfaction/dissatisfaction? {RQ4}

1. Costs 2. Unreliability 3. Improper collection

4. Reliable 5. Cooperative 6. Other

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

Do people dump their waste alongside the garbage bins instead of putting it inside those? {RQ4}

1. Yes 2. No

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

If Yes, Why, in your opinion, people behave like this? {RQ4}

1. Difficult to put waste inside the bin due to height of the bin
2. Difficult to put waste inside the bin due to waste and litter spread around the bin
3. Stray animals (dogs, mouse and birds etc)

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

Please identify some of the main problems with the current solid waste management system? {RQ4}

1. Waste lying around 2. Odor, Rats, Flies etc
3. Improper Collection of Waste 4. Recycling
5. No Organization 6. No Automation
7. Other

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

What is the distance between your house and dumping site? {RQ2}

1. 50 meter or below 2. 100 to 250 meter
3. 250 to 500 meter 4. 500 meter or above
5. Other

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

Has anyone in your household suffered from any of these listed diseases during the last six weeks? {RQ3}

1. Yes 2. No

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

If Yes which diseases? {RQ2}

1. Diarrhea 2. Dysentery 3. Dengue
4. Typhoid 5. Ringworm 6. Scabies
7. Cholera 8. Malaria 9. Cough
10. Asthma 11. Skin disease 12. Other

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

Are there recycling campaigns organized by the local Government? {RQ4}

1. Yes 2. No

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

Are there waste reduction campaigns within the schools? {RQ4}

1. Yes 2. No

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

Smart Methods of Waste Collection

In this section we cover the Smart waste methods, there presence in Pakistan and there advantages etc. Smart Waste Bins is used to identify status of waste bins if it is empty or filled so as to customize the waste collection schedule accordingly and also save the cost. There are many types of Smart Waste Bins like (Wireless sensors, dynamic routing, RF-ID, intelligent sensor, and IR Sensors bins)

Any smart bins in area? {RQ2}

1. Yes 2. No

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

If yes which type? {RQ2}

1. Wireless sensors 2. Dynamic routing 3. Simple RFID
4. Intelligent sensor 5. IR Sensors bins 6. Other

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

Do they offer recycling as well? {RQ3}

1. Yes 2. No

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

If there are no smart bins are you interesting to install? {RQ3}

1. Yes 2. No

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

Trash bins for domestic household and corporate user are easy to monitor on Gas emission and Fill level? {RQ2}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

The Current method of bin monitoring is efficient? {RQ3}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

The system allows for the system user/operator to specify the fill level they consider optimal? {RQ3}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

The household user or management personnel are promptly alerted when a bin fills up or emits a lot of gas? {RQ4}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

The current process of bin management is user friendly? {RQ3}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 3 (Which SWM methodologies exist and which are ideal to be implemented in Pakistan?)

The current process and system for bin monitoring provides a dashboards and reports for household user to monitor bin status patterns? {RQ2}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

The current system allows user to check current bin status at any time? {RQ2}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 2 (Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?)

I believe the current systems and processes, if any, for bin monitoring are secure and the data is safely kept? {RQ4}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

If a proper computer system is implemented, I believe that domestic and corporate bin monitoring would be made easier? {RQ4}

1. Strongly Agree 2. Agree 3. Neutral
4. Disagree 5. Strongly Disagree

Note: This question addresses my research questions No 4 (How SWM can resolve Pakistan's existing waste management issues?)

P. No	Recycling	IOT	Bins	Cost Effective	Citizen Involvement	Real Time Monitoring	RFID	Wireless Sensor	Methods Using in paper	Reference of Papers
1.	✓			✓		✓			Internet + Recycling	(Wang, Han et al. 2018)
2.		✓	✓			✓	✓		Expert Systems with Applications	(Ramos, de Morais et al. 2018)
3.	✓	✓					✓	✓	Cyber-Physical Systems in the re-use	(Sharpe, Goodall et al. 2018)
4.	✓			✓					smart-M3 platform	(Exposito and Velasco 2018)
5.		✓	✓	✓				✓	Application Resource Manager (ARM)	(Chaware, Dighe et al. 2017)
6.		✓	✓	✓		✓		✓	Net logo Multi-agent platform	(Likotiko, Nyambo et al. 2017)
7.		✓	✓	✓	✓	✓			Decision algorithms	(Al Mamun, Hannan et al. 2016)
8.		✓	✓	✓	✓	✓		✓	rule-based decision	(Al Mamun, Hannan et al. 2015)
9.		✓	✓	✓					open-source project Smart-M3	(Catania and Ventura 2014)
10.		✓	✓	✓			✓	✓	decision making algorithm	(Chowdhury and Chowdhury 2007)
11.		✓	✓	✓	✓			✓	ZigBee	(Al Mamun, Hannan et al. 2013)
12.		✓	✓					✓	ArcGIS” and Dijkstra algorithm	(Sanjeevi and Shahabudeen 2016)
13.		✓	✓				✓	✓	cross-layer commit protocol	(Alkhamisi, Nazmudeen et al. 2016)
14.				✓					Genetic Algorithm	(Fujdiak, Masek et al. 2016)

15.			✓						segregation of various medical wastes	(Ali, Mahmood et al. 2015)
16.		✓	✓					✓	Intelligent Trash Management	(Sathish, Prakash et al. 2017)
17.		✓	✓		✓			✓	IR remote frameworks	(Navghane, Killedar et al. 2016)
18.		✓	✓					✓	GSM framework	(Bhor, Morajkar et al. 2015)
19.		✓	✓	✓				✓	Embedded System	(Reddy, Naik et al. 2017)
20.			✓	✓	✓				Separation of wet and dry waste	(Kumar, Kumaran et al. 2017)
21.		✓	✓					✓	sensor motes	(Rao)
22.		✓	✓	✓				✓	Near Infrared Reflectance	(Thakker and Narayanamoorthi 2015)
23.		✓	✓					✓	special signaling equipment	(Borozdukhin, Dolinina et al. 2016)
24.		✓			✓	✓			internet-based platform	(Thompson, Afolayan et al. 2013)
25.		✓	✓					✓	Cooja simulator	(Fallavi, Kumar et al. 2017)
26.			✓	✓		✓			Ant colony system algorithm (ACS)	(Anagnostopoulos and Zaslavsky 2014)
27.			✓	✓		✓			Top-k query	(Anagnostopoulos, Zaslavsy et al. 2015)
28.		✓	✓			✓	✓	✓	robust dynamic routing algorithm	(Anagnostopoulos, Zaslavsky et al. 2015)
29.			✓	✓					heuristic approach	(Mes, Schutten et al. 2014)
30.			✓	✓					integer programming model	(Ghiani, Laganà et al. 2012)
31.		✓	✓	✓			✓		embedded with low cost devices	(Devi, Chaurasia et al. 2018)
32.		✓	✓	✓			✓		wireless sensor networks	(Lata and Singh 2016)
33.		✓	✓	✓		✓	✓	✓	Integrated	(Islam, Arebey et

									system	al. 2012)
34.		✓	✓	✓		✓	✓	✓	RFID and sensor Model	(Chowdhury and Chowdhury 2007)
35.		✓	✓					✓	Near Infrared (NIR) Spectroscopy	(Thakker and Narayanamoorthi 2015)
36.		✓	✓					✓	Microcontroller Atmel328	(Navghane, Killedar et al. 2016)
37.			✓	✓	✓				data sharing model	(Keerthana, Raghavendran et al. 2017)
38.		✓	✓	✓	✓			✓	dynamically manage waste collection mechanism	*(Shyam, Manvi et al. 2017)*
39.		✓	✓	✓				✓	Message Queue Telemetry Transport	(Bharadwaj, Rego et al. 2016)
40.	✓	✓	✓	✓				✓	Smart Recycle Bin	(Wahab, Kadir et al. 2014)
41.		✓	✓	✓				✓	wireless networking technologies to optimize	(Idwan, Zubairi et al. 2016)
42.	✓	✓	✓	✓			✓		radio frequency identification	(Al Mamun, Hannan et al. 2015)
43.		✓		✓					lower RPM with noiseless collection	(Catania and Ventura 2014)
44.		✓	✓	✓				✓	battery-based smart garbage bins	(Chowdhury and Chowdhury 2007)
45.	✓	✓	✓				✓		analytic framework	(Al Mamun, Hannan et al. 2013)
46.		✓	✓	✓				✓	*Embedded System*	(Sanjeevi and Shahabudeen 2016)
47.		✓	✓	✓	✓			✓	IR Sensors and RF modules	(Alkhamisi, Nazmudeen et al. 2016)
48.		✓	✓	✓				✓	Garbage collection system using IoT	(Fujdiak, Masek et al. 2016)
49.		✓	✓	✓	✓			✓	SMART	(Ali, Mahmood et

									DUSTBIN	al. 2015)
50.		✓	✓	✓	✓			✓	IOT based System	(Sathish, Prakash et al. 2017)

Table 4.1

In the following papers we want to define some research gap in which we notify the parameter like Recycling, IOT (internet of things), Smart Bins, Cost Effective, Citizen Involvement, Real Time Monitoring, RFID, other Wireless Sensor, Methods Using in paper

In our 1st paper some features like recycling, cost efficient, real time monitoring is available and RFID, wireless sensor, citizen involvement is not available and "Internet + Recycling" method is used in this paper.

In our 2nd paper some features like IOT, Large Bin, real time monitoring and RFID is available and recycling, cost efficient, citizen involvement is not available and "Expert Systems with Applications" method is used in this paper.

In our 3rd paper some features like Recycling, cost efficient is available and IOT, Large Bin, real time monitoring and RFID and citizen involvement is not available and "Cyber-Physical Systems in the re-use" method is used in this paper.

In our 4th paper some features like IOT, Large Bin, real time monitoring and RFID is available and recycling, cost efficient, citizen involvement is not available and "smart-M3 platform" method is used in this paper.

In our 5th paper some features like IOT, Large Bin, real time monitoring and RFID is available and recycling, cost efficient, citizen involvement is not available and "Application Resource Manager (ARM)" method is used in this paper.

In our 6th paper some features like IOT, Large Bin, real time monitoring, cost efficient, citizen involvement and RFID is available and recycling is not available and "Net logo Multi-agent platform" method is used in this paper.

In our 7th paper some like IOT, Large Bin, real time monitoring, cost efficient, citizen involvement is available and recycling, RFID is not available and "Decision algorithms" method is used in this paper.

In our 8th paper some features like IOT, Large Bin, real time monitoring, cost efficient, citizen involvement is available and recycling, RFID, wireless sensors not available and "rule-based decision" method is used in this paper.

In our 9th paper some features like IOT, Large Bin, cost efficient, and RFID is available and recycling, real time monitoring, citizen involvement is not available and "open-source project Smart-M3" method is used in this paper.

In our 10th paper some features like IOT, Large Bin, cost efficient, citizen involvement, and RFID is available and recycling, real time monitoring is not available and "decision making

algorithm" method is used in this paper.

In our 11th paper some features like IOT, Large Bin, cost efficient, citizen involvement, and RFID is available and recycling, real time monitoring is not available and "ZigBee" method is used in this paper.

In our 12th paper some features like IOT, Large Bin, and RFID is available and recycling, cost efficient, real time monitoring, citizen involvement is not available and "ArcGIS" and Dijkstra algorithm" method is used in this paper.

In our 13th paper some features like IOT, Large Bin, real time monitoring, and RFID is available and recycling, cost efficient, citizen involvement is not available and "cross-layer commit protocol" method is used in this paper.

In our 14th paper some features like Large Bin, is available and recycling, cost efficient, citizen involvement, real time monitoring, and RFID, IOT is not available and "Genetic Algorithm" method is used in this paper.

In our 15th paper some features like Large Bin, is available and recycling, cost efficient, citizen involvement, real time monitoring, and RFID, IOT is not available and "segregation of various medical wastes" method is used in this paper.

This research Gap is literature review that indicate my work and my requerment what I want to implement what I want to notis in my paper which parameter is handald which paper and which is best paper and so on

Islamabad Waste Management Company:

In Islamabad CDA (Capital Development Authority) deals the waste management. For my research purpose and research question no 1(How waste can be measured in Pakistan?) I went to CDA supervisor in G9 sector and gather information of waste generation and others interview questions are following

General Questions:

Total employee work in G9 for waste collection: 221

Attendance = 6 am

Round in sector on bike

Collection in residential areas 1 time

Collection in Markaz areas 2 time.

Round supervisor on bike and notes which bin is full which is not that collect.

Totally manual

Smart Bins Information:

Any Smart Bin: NO

Any Other Smart Method of collection: NO

Want to install: If its help full

Interview Results:

Totally manual work

Lots of Labouré work

Manual visit and notice the bin is fill.

Lots of fuel cost for collection

Perceptions:

If smart bin installs it notify the bin is full. notification and area map show fuel consumption reduce Labouré work minimize and time reduce.

Chapter 4

4.0 Methodology

This chapter renders the core of the solution framework proposed in thesis. In this chapter, a collection of model research design survey their questions model, purpose solution and interviews are mention.

4.1 Overview

This chapter covers the organized framework utilized in the study. The analysis style is guided by the projected objectives of the analysis made public in chapter one, the character of the matter to be studied, and analysis styles utilized in previous, connected analysis work reviewed in chapter a pair of. The chapter justifies the analysis framework and the technique. It focusses at the analysis style, the population targeted, sample size, sampling techniques, forms of information, information assortment techniques, information analysis and take a look at style.

4.2 Research Design

(Yin, 2003) defines analysis style because the logical sequence that connects the empirical information to a study's initial analysis queries and ultimately to its conclusions. it's a concept that guides the man of science within the method of collection, analyzing and deciphering observations. per (Hevner, March, Park, & Ram, 2004) an ancient analysis style may be a blue print or a concept on however a pursuit study is to be completed; operationalization variables to facilitate measurement; choosing a sample of interest to study; collection information to be used as a basis for testing hypotheses; analyzing the results. This analysis study uses Semi-experimental analysis style with a quasi-experiment analysis study accustomed estimate the causative impact of associate intervention on its target population while not random assignment

This analysis proposes to develop a Smart-Bin epitome which will settle for device values information as input and use the analysis within the derived model so as to find the Fill-level, and gas emission levels of in-house waste bins. so as to try and do this a proper experimental style, specifically verity experimental style is adopted. True experimental style is characterized by the random choice of participants and therefore the random assignment of the participants to teams within the study.

The man of science conjointly has complete management over the extraneous variables (Cobb, Confrey, DiSessa, Lehrer, & Schauble, 2003). It will be with confidence determined that the result on the variable is directly because of the manipulation of the experimental variable.

4.2.1 System Analysis and System Requirements

This study employs Rapid application development (RAD) methodology, a software development methodology for iterative development and rapid development of prototypes rather than large amounts of up-front planning (Larman, 2004). Since the researcher aimed at providing quick results, rapid application development gave excellent development processes with the assistance of other development approaches (Abrahamsson, Warsta, Siponen, & Ronkainen, 2003). The lack of extensive pre-planning allowed the software to be written much faster, and made it easier to change requirements as illustrated.

Rapid application development process started with development of preliminary data models and business process models in the Requirements Planning stage using structured techniques. Requirements were then verified by designing and prototyping, to eventually refine the data and the process models. These stages were repeated iteratively; further development results in combination of the business requirements, technical design statement and Testing were used for constructing the prototyped systems.

The study also employed a multiple technique methodology of obtaining requirements from possible clients. The requirements elicitation process was achieved by administering Questionnaires and building of prototypes. This combination enabled the researcher to acquire a complete picture from the

4.2.2 Questionnaires

The Requirements elicitation questionnaires were much more informal and were a great tool to gather requirements from stakeholders in remote locations or those who will have only minor input into the overall requirements. The questionnaires were very vital since the researcher gathered information from hundreds of users thus easing reach to the large masses and provided fast response through sharing by mail, Facebook, WhatsApp, Skype and other social platforms

4.2.3 Prototyping

Prototyping is a relatively modern technique for gathering requirements. In this approach, the study gathered preliminary requirements that were used to build an initial version of the solution — the prototype. This was later shown to the client, who would then give additional requirements.

The application would then undergo the application changes and cycle around with the client again. This repetitive process continued until the product met the critical mass of business needs.

4.2.4 System Design

The Smart Bin System design was achieved basing on the collected User requirements, and a detailed analysis of the existing methods of bin monitoring. These Requirements and the results of the analysis were synthesized to come up with a structured system design of the proposed prototype.

The Structured system design was employed and its aim was to obtain a blueprint of the system being developed. In this stage the study employed use of workflow diagram, use case diagrams, sequence diagram, Data Flow diagrams and Class Diagrams.

The Hardware components include arduino shield, sensors and a wireless module for data communication. The development was done on a windows environment using the arduino IDE employing C++ language of development.

4.3 System Implementation

This phase allowed the logical and hardware development of the system whereby the systems specifications developed are turned into a working system prototype. It involved converting the developed designs to actual system functionalities whereby the workflow diagram, use case diagrams, sequence diagram, Data Flow diagrams and Class Diagrams are used as inputs to the implementation phase.

In this phase, we employed several software development tools. The Arduino IDE was used as the Development environment, the ThingSpeak cloud resource was used as the web API interface for communication between the terminal nodes (sensors) of the system with the end user device through the application logic code running in the Arduino microcontroller module. Also, the virtuino mobile application was used for end user aggregation setup and dash boarding interface.

On completion of Implementation, it was important to perform tests to ensure the end product produced matches the business user requirements gathered and is working logically as expected. The study employed both Developmental tests to confirm the program logic works as expected and Beta testing to verify proper working in an ideal environment with real data.

4.3.1 Target Population and Sampling Frame

The study population comprised of households within Nairobi County Kenya and its neighboring counties. As at December 2009, the total population for Nairobi, Kiambu, Machakos and Kajiado counties stood at 1,892,224 households (KNBS, 2010). This study employed convenience non probability sampling method due to the limited cash and time constraints.

Convenience sampling is described as a random selection of sampling units within the segment of the population with the most information on the characteristic of interest. It is a sampling technique in which researcher relies on own judgment when choosing members of population to participate in the study. It is a non-probability sampling method and it occurs when elements selected for the sample are chosen by the judgment of the researcher. Convenience sampling works best in this study as it obtains a representative sample by using a sound judgment, which resulting in saving time and money.

4.3.2 Data Collection Methods

This study employs both Primary and secondary sources of data collection techniques. Primary data collection is used from the sensor data collected to the IoT cloud infrastructure, and the secondary data was obtained questionnaires served to the identified sample.

Questionnaires were chosen as the best instruments for this study as they provide an economical and convenient approach for data collection. This was necessary due to the time limitations. Questionnaires also provide anonymity of the respondents, and since the responses are gathered in a given standardized way, questionnaires provided a more objective approach. The respondents of this study were a total of 96 household representatives

Additionally, to primary data, the research proposes to also collect secondary data from previous research, much of the data collected in Chapter 2 of this study.

The Requirements analysis questionnaire was conducted to identify the missing functionality of the currents methods of bin monitoring and aid us formulate new requirements. Thus, aiding the research answer the objective (I). The System Usability questionnaire on the other hand helped us achieve the Developmental and Beta testing methodologies employed in the study.

4.4 System Requirements

From the User requirements study carried out in this study, the researcher was able to identify the gaps and user needs that formed the basis for the below identified user and system requirements

4.5 User Requirements

I. A system that would be able to monitor on Gas emission, and Fill level in the shortest time possible.

II. A system that would notify or present this information to the relevant people.

III. A user friendly and interactive system.

IV. A secure system with access restrictions and privacy.

V. A system that can provide historical usage reporting.

Several functional, non-functional and technical requirements emerged from the analysis of data obtained in this research study. These requirements informed the architectural design and the various components crucial for the Smart-Bin solution to solve the research problem.

4.6 Functional Requirements

These are the core system requirements the system must fulfill in order to be regarded as having solved the research problem. They include:

4.6.1 Setting optimal fill level

This allows for the system user/operator to specify the fill level they consider optimal, after which exceeding this limit will result in notifications/ alerts for collection

4.6.2 Set optimal gas-content level

This allows for the system user/operator to specify the gas content level they consider optimal, after which exceeding this limit will result in notifications/ alerts for collection

4.6.3 Check bin status

This allows the user to view at any time, the gas, fill-level of the monitored bin via a web or mobile phone browser.

4.6.4 Notifications

This feature will allow the home user to be able to be notified whenever the fill-level or gas content level surpasses the stated optimal levels.

4.6.5 Reporting

This feature allows the system to generate reports when required.

4.7 Non-Functional Requirements

Non-functional requirements include constraints and qualities. The qualities are properties or characteristics of the system that its stakeholders care about and hence will affect their degree of satisfaction with the system (Malan & Bredemeyer, 2001). The non-functional requirements include:

4.7.1 Security

This aspect refers to the act of providing trust of the information, that the Confidentiality, Integrity and Availability of the information are not violated, e.g. ensuring that data is not lost when critical issues arise. It ensures that only the allowed user is allowed access to view edit and download bin status reports and data. The online server will only allow administrative users with authorized credentials to log in and view all the configurations and reports of the system

4.7.2 User Support

This offers a help section where a user can learn more on how to use the system. It also offers instant notifications to the users to make them aware of significant events taking place in the system.

4.8 System Architecture

The System Architecture can be presented in three main tiers; Presentation layer, application layer and the data layer. The presentation layer presents data to the user. In the figure 4.1, the mobile application and the web browser client interfaces presents this layer. The application layer performs the application logic. It provides a link by which the clients in the presentation layer can access data in the data layer. It consists of the cloud-based server and the code running in the Arduino microcontroller.

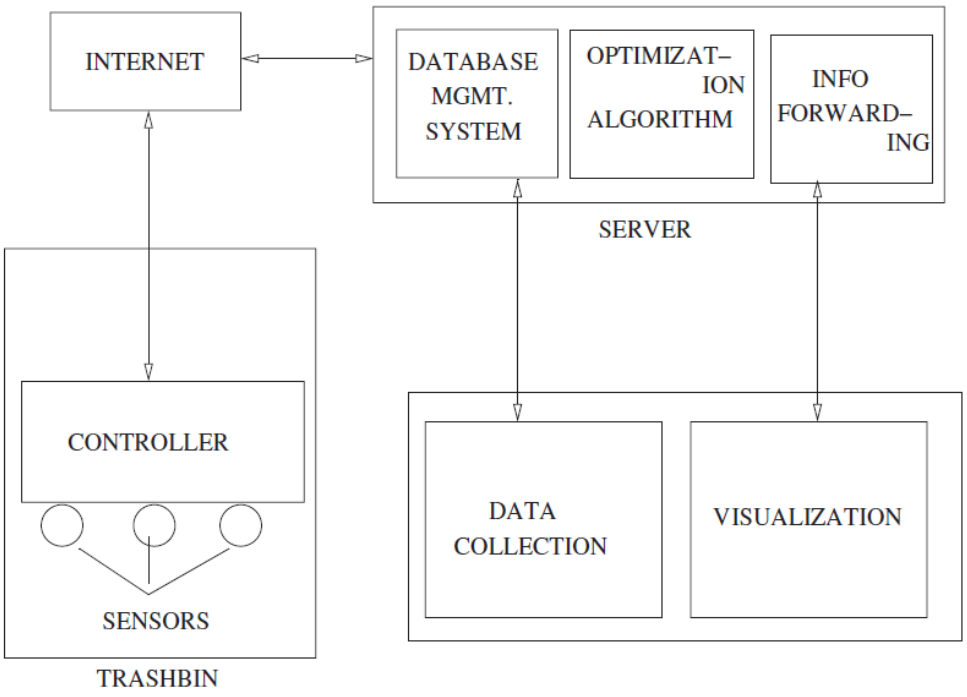

Figure 4. 1: System Architecture for Waste management and Collection

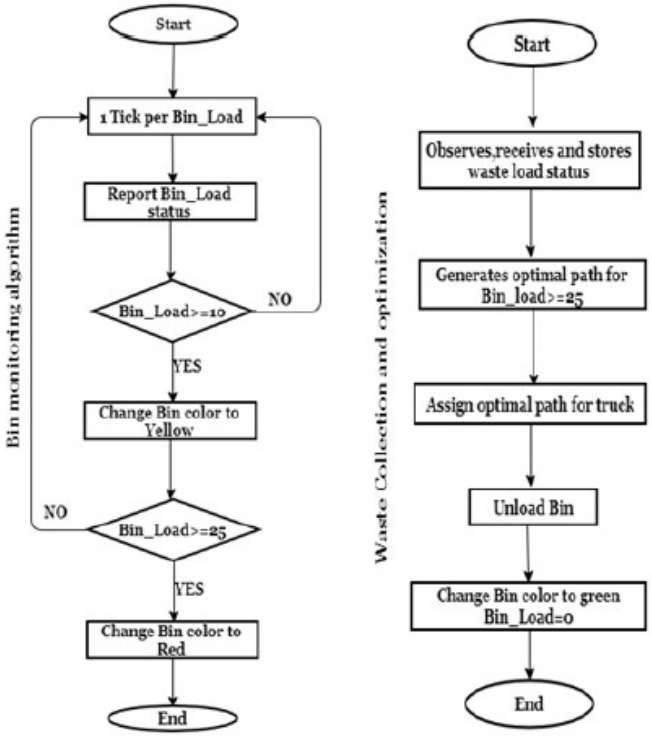

Figure 4. 2: Flow Charts related to our System

This system architecture diagram and flow chart define my purpose solution which I want to implement in future it cover all my requirements like Recycling, IOT (internet of things), Smart Bins, Cost Effective, Citizen Involvement, Real Time Monitoring, RFID, other Wireless Sensor.

Chapter 5

5.0 Experiment Settings

This chapter describes about survey Areas, Statistical Analysis, Relational databases and Machine learning Tools, methods used for statistical analysis.

5.1 Survey Areas:

In this portion, we are working on 10 different areas of Islamabad and Rawalpindi city. Those areas are Bahira Town, DHA, Banni Chowk Rawalpindi, Sadiq Abad Rawalpindi, Arid Agriculture University, NUST Islamabad, Bahira University, FAST University, G9/ 3 near Karachi Company Islamabad, G8 Islamabad, the population are quickly increasing, as a result, different kinds of wastes are getting formed at a very fast rate. Lack of economic funds, uneducated work force, unsuitable skill and lack of awareness of the public are the major problem to control waste management for the fast-growing area of Rawalpindi city.

Figure 5. 1: Pins on Map

Collection Areas Categories:

- ✓ Developed Areas
  - Bahria Town
  - DHA
- ✓ Undeveloped Areas
  - Banni Chowk Rawalpindi
  - Sadaq Abad Rawalpindi
  - G9/ 3 near Karachi Company Islamabad
  - G8 Islamabad
- ✓ Educational Sector
  - Arid Agriculture University
  - NUST University
  - Bahria University
  - FAST University

We cover 10 different areas of Rawalpindi and Islamabad and categorize Developed Areas, Undeveloped Areas, Educational Sectors and so On. 574 Respondent response our survey.

5.2 Statistical Analysis:

Statistics is basically a science that involves data collection, data interpretation and finally, data validation. Statistical data analysis is a procedure of performing various statistical operations. It is a kind of quantitative research, which seeks to quantify the data, and typically, applies some form of statistical analysis. Quantitative data basically involves descriptive data, such as survey data and observational data.

We have **574** respondent survey data we apply Statistical Analysis on our data.

Apply Statistical Methods:

1. Simple Excel Graph and states.
2. Convert Data into Database and apply Relational Queries.
3. Machine Learning Tools.

Simple Excel Graph and states:

In this method we simply perform excel tool and quantify our data with different areas with different states and measurement their quality and show the graphs.

Convert Data into Database and apply Relational Queries.

In this method we convert our 574-respondent data in to Database (PhpMyAdmin) and apply relational queries

For Examples.

We find relationship of Interest of smart bin installation with Educational areas

Query:

```
SELECT `Address`, `interesting_install_smartbin` FROM `survey` WHERE `Address` IN ('Aride Agriculture University','NUST Islamabad','Bahria University','COMSATS University','FAST University') ANd
```

```
interesting_install_smartbin = 'Yes' ;
```

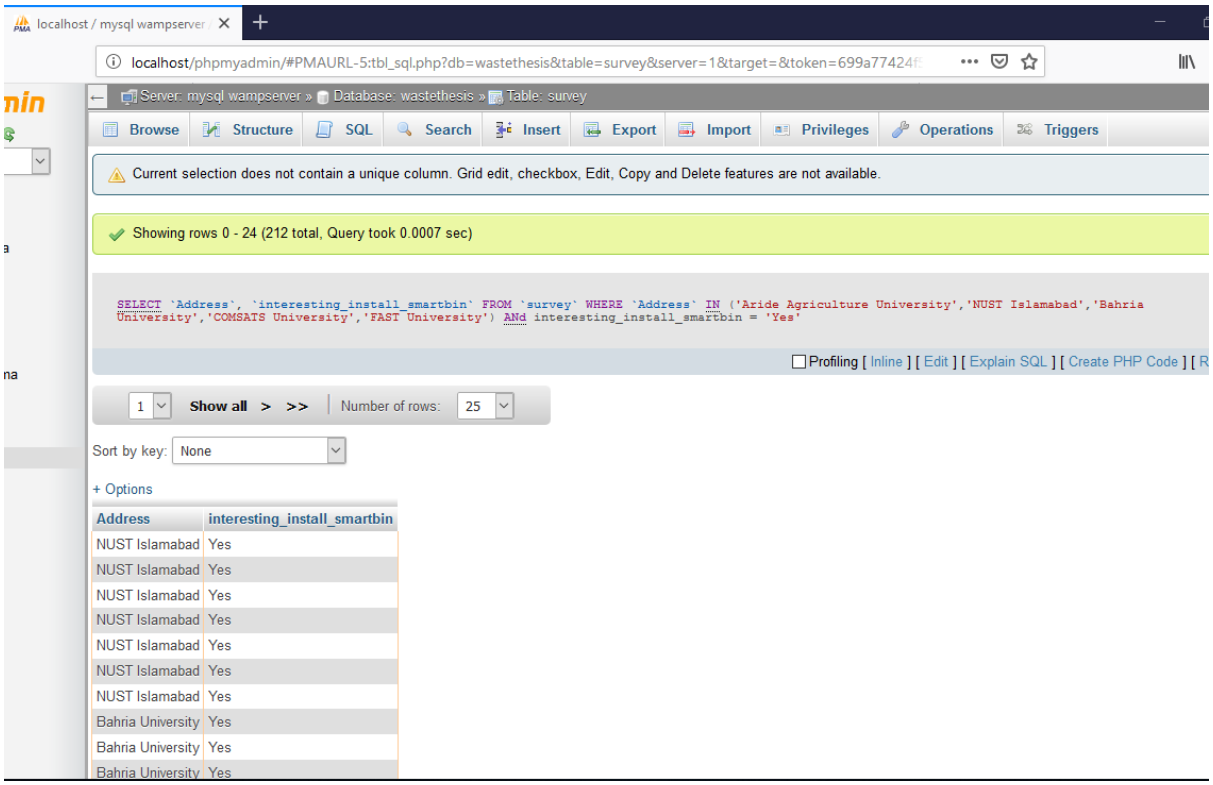

Figure 5. 2: php my admin

Results: there are 243 results of Educational Areas and from which 212 respondent want to install Smart Bin and other 31 respondent give negative response they do not want to install. And so on.

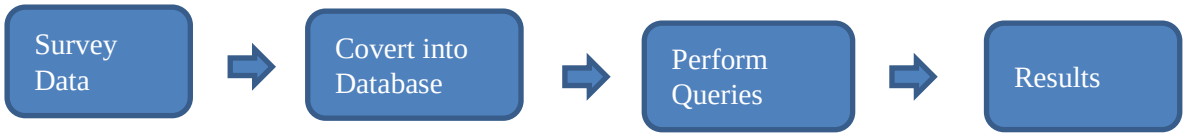

Figure 5. 3: Survey to results

5.3 Machine Learning Tools.

In this method we use Rapid minor for statistical analysis and apply models.

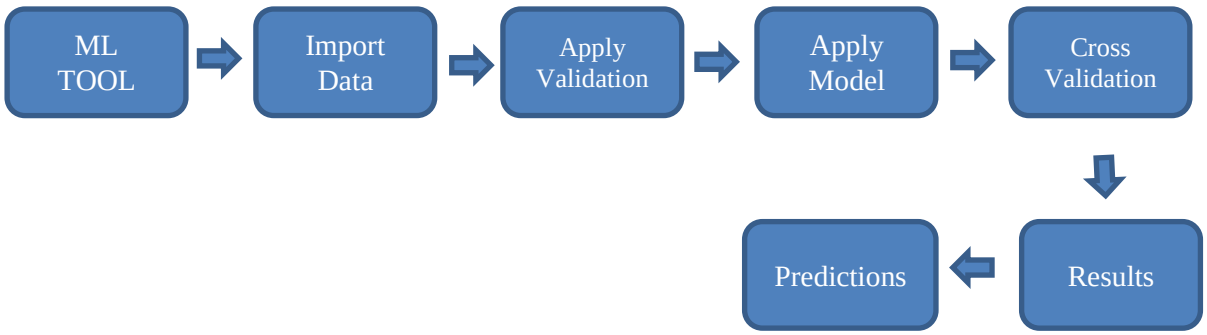

Figure 5. 4: ML Tools to Results

Models:

There are following models which use in RapidMiner

- ✓ Naive Bayes
- ✓ Generalized Linear Model
- ✓ Logistic Regression
- ✓ Deep Learning
- ✓ Decision Tree
- ✓ Random Forest
- ✓ Gradient Boosted Trees (XGBoost)

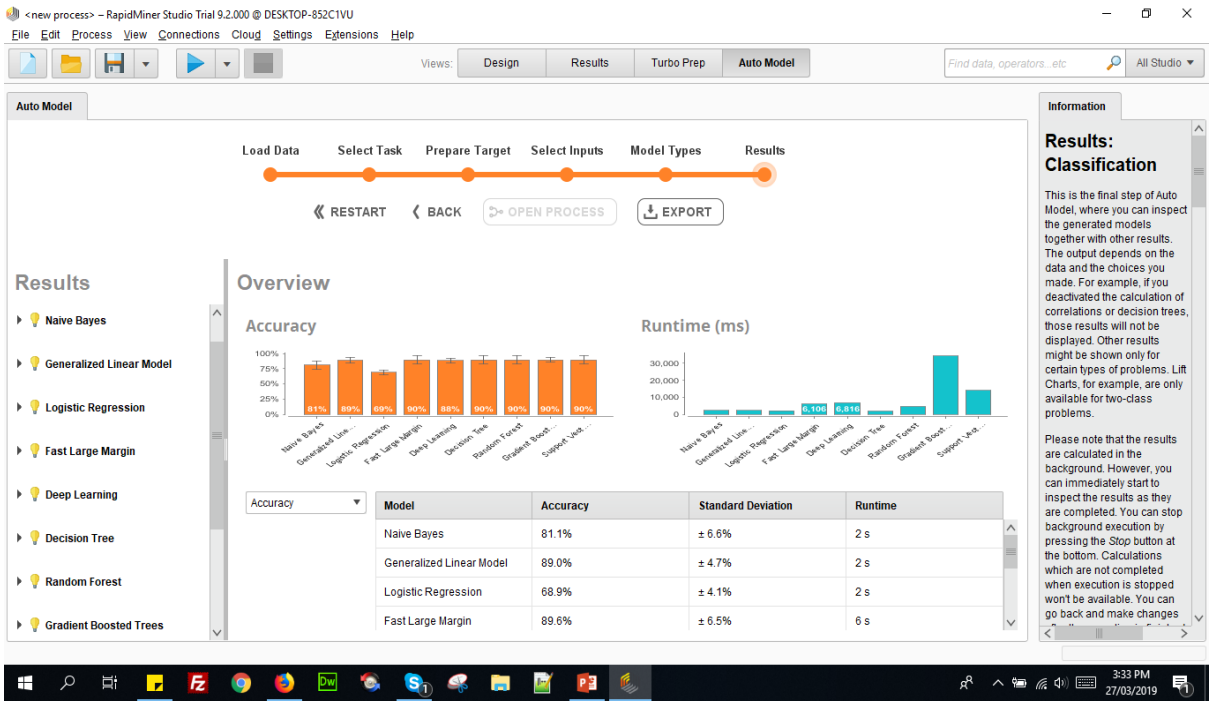

Figure 5. 5: RapidMiner View

Naive Bayes:

Naïve Bayes is a probabilistic machine learning model use for classification tasks. This classifier assumes strong, or simple, independence between attributes of data sets. It is mostly use in machine learning tool because it easy to implement and use mostly for spam filters, text analysis and medical diagnosis. There are following feature of Naïve Bayes model.

- ✓ High-bias
- ✓ Low-variance classifier
- ✓ Small data set
- ✓ Inexpensive
- ✓ Text categorization,

- ✓ Spam detection,
- ✓ Sentiment analysis

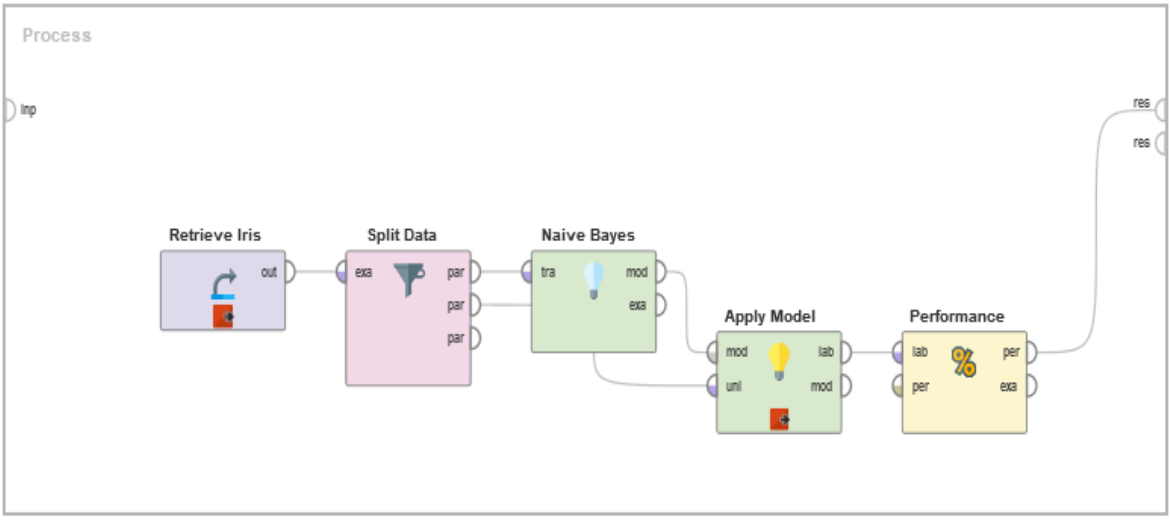

Figure 5. 6: Naive Bayes

Generalized Linear Model

Generalized linear models (GLMs) is a flexible generalization of an ordinary linear regression which allows for response variables that have error distribution models other than a normal distribution.

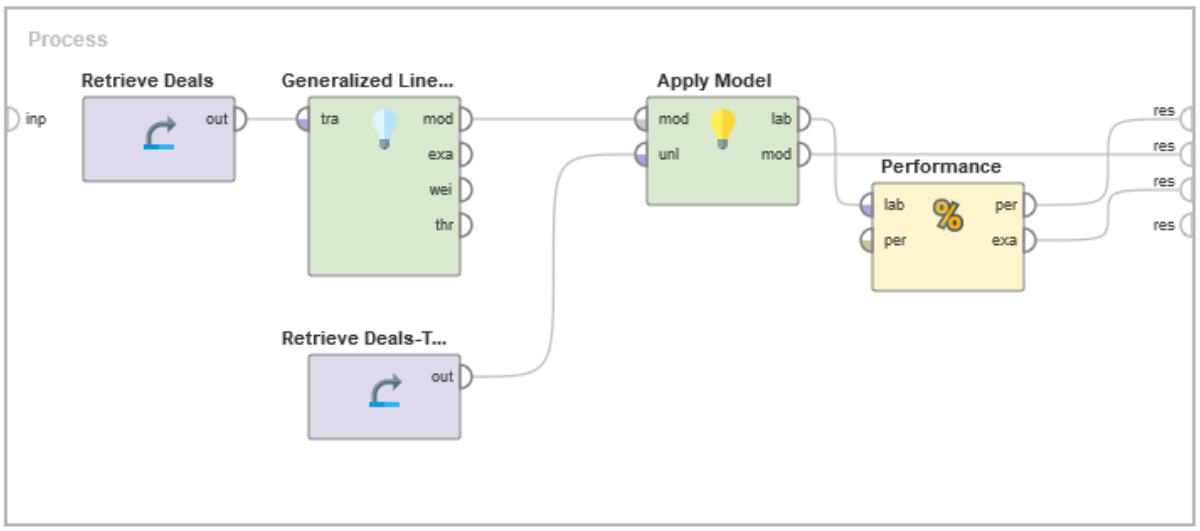

Figure 5. 7: GHT

Logistic Regression

Logistic Regression is used statistical model that in its basic form uses a logistic function to model a binary dependent variable, although many more complex extensions exist.

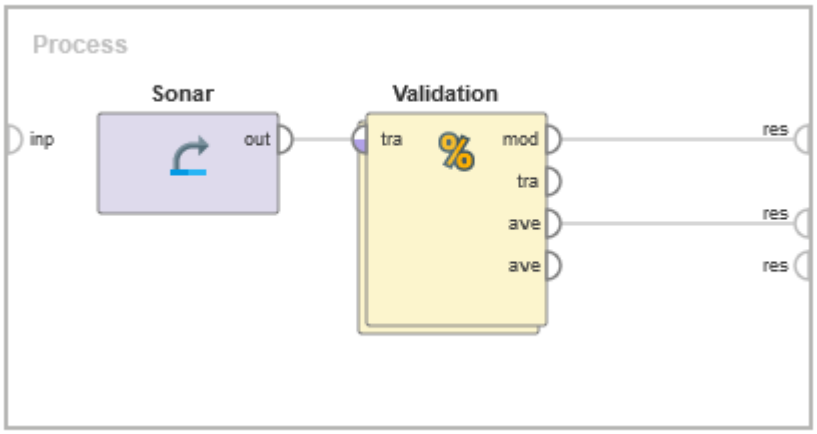

Figure 5. 8: Validations

Deep Learning:

Deep Learning is based on a multi-layer feed-forward artificial neural network that is trained with stochastic gradient descent using back-propagation. The network can contain many hidden layers consisting of neurons with tanh, rectifier and maxout activation functions.

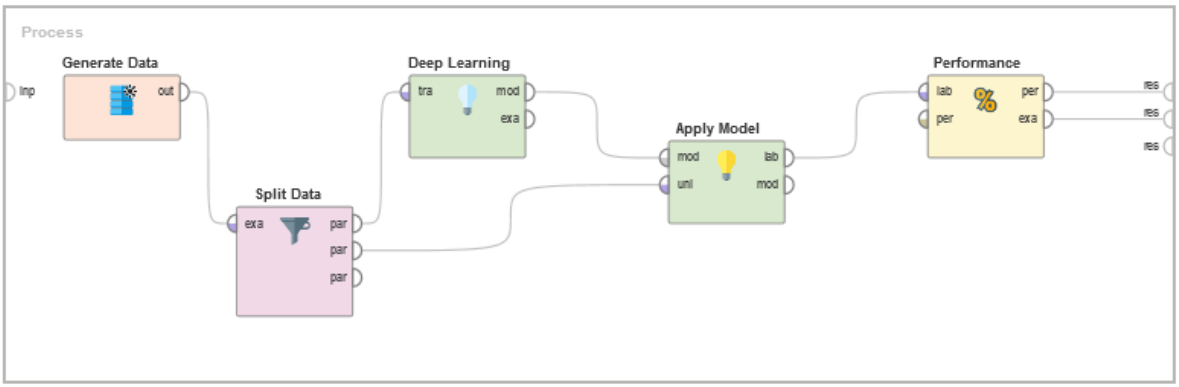

Figure 5. 9: Deep Learning

Decision Tree:

A decision tree is a decision support tool that uses a tree-like model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility

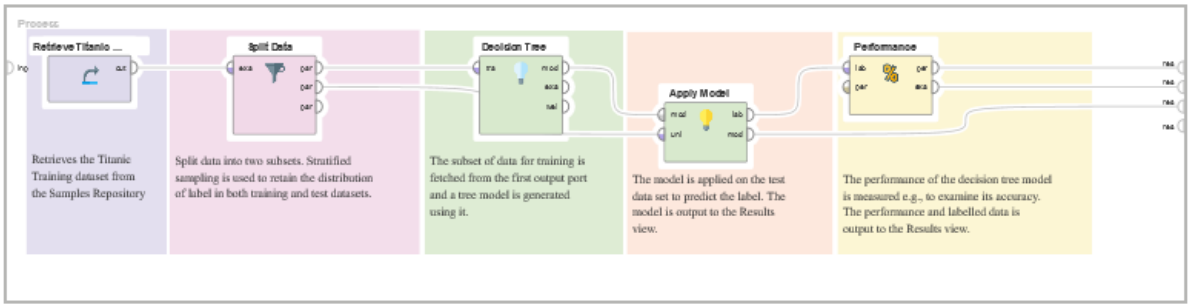

Figure 5. 10: Decision Tree

Random Forest:

A random forest is an ensemble of a certain number of random trees, specified by the *number of trees* parameter. These trees are created/trained on bootstrapped sub-sets of the Example Set provided at the Input Port. Each node of a tree represents a splitting rule for one specific Attribute. Only a sub-set of Attributes, specified with the *subset ratio* criterion, is considered for the splitting rule selection. This rule separates values in an optimal way for the selected parameter *criterion.*

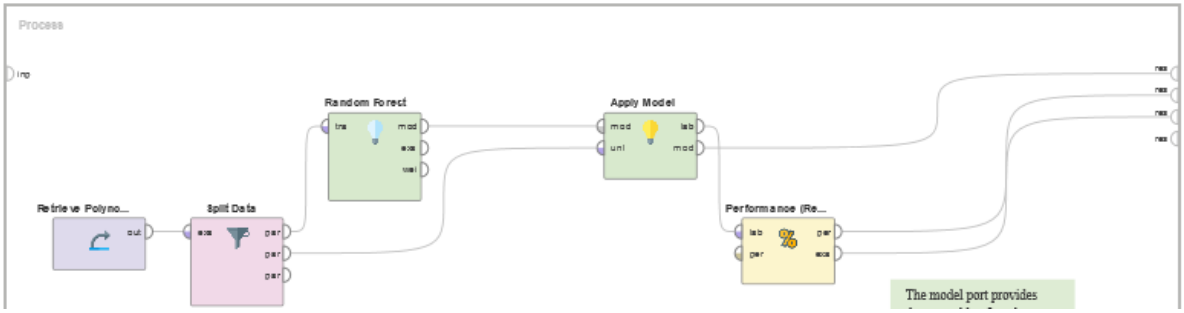

Figure 5. 11: Random Forest

Apply Models:

In Rapid minor we apply all model butt Naive Bayes is the best model which justify our requirements and give best results. This method applies for small set of data. And also apply all parameter in survey data

For examples

Data Set: 574 respondents

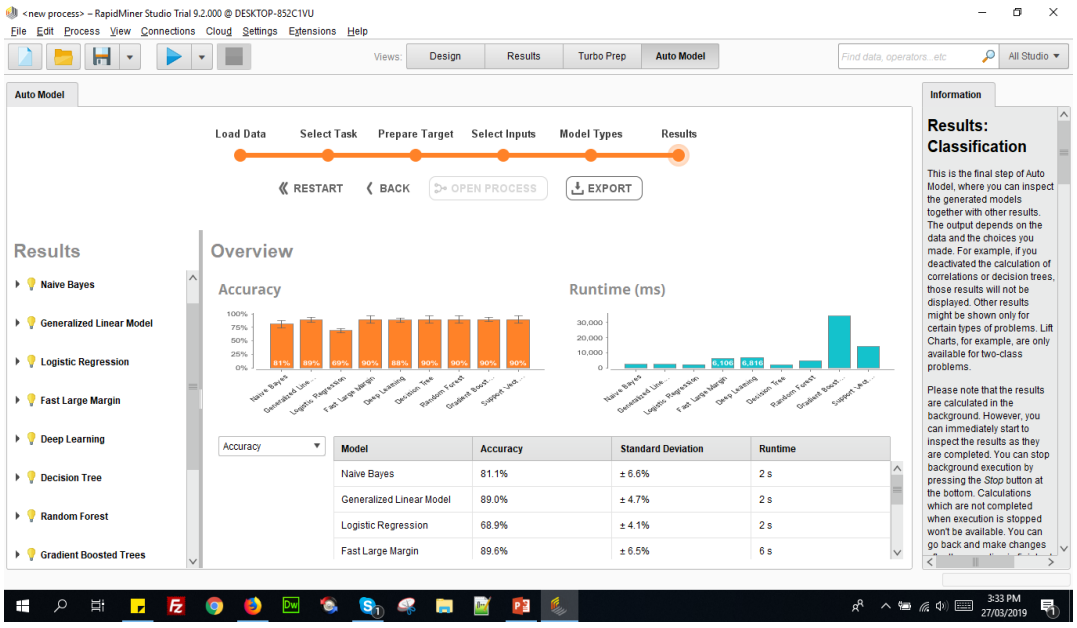

Figure 5. 12: RapidMiner Classifications

Accuracy:

Relative number of correctly classified examples or in other words percentage of correct predictions

Standard Deviation:

The Weight by Deviation operator calculates the weight of attributes with respect to the label attribute based on the (normalized) standard deviation of the attributes. The higher the weight of an attribute, the more relevant it is considered. The standard deviations can be normalized by average, minimum, or maximum of the attribute.

Predictions:

he attributes plays the largest role in forming that prediction. This operator takes a model and an Example Set as input, and generates a table highlighting the attributes that most strongly support (green) or contradict (red) each prediction.

Example:

Relation Between Area and Smart Bin Installation:

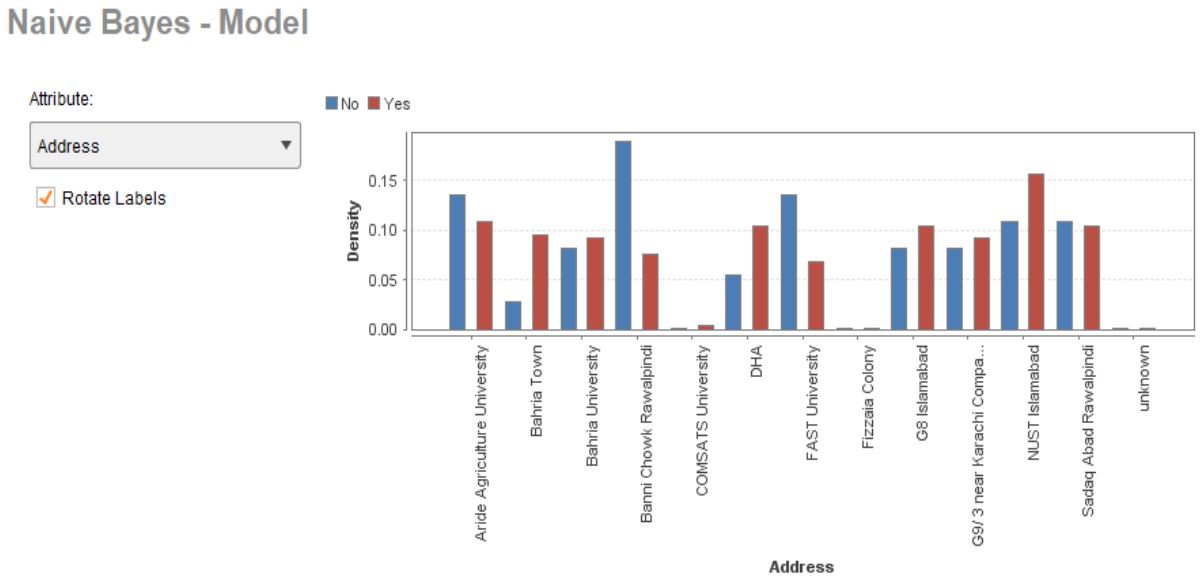

Figure 5. 13: Results Naive Bayes Model

Results:

Areas who want to install Smart Bin Mostly

- ✓ Bahria Town
- ✓ Bahria University
- ✓ DHA Islamabad
- ✓ G8 Islamabad
- ✓ G9 Islamabad

- ✓ NUST University

In this relationship the tool predicts that these areas want to install smart bins. and so, on .

Chapter 6

6.0 System Analysis and Design

This chapter describes how we have collected data from different locations and what experiments we have done and what are the results. Different charts are representing different results.

6.1 Study Area

In this portion, we are working on 10 different areas of Islamabad and Rawalpindi city. Those areas are Bahira Town, DHA, Banni Chowk Rawalpindi, Sadiq Abad Rawalpindi, Arid Agriculture University, NUST Islamabad, Bahira University, FAST University, G9/ 3 near Karachi Company Islamabad, G8 Islamabad, the population are quickly increasing, as a result, different kinds of wastes are getting formed at a very fast rate. Lack of economic funds, uneducated work force, unsuitable skill and lack of awareness of the public are the major problem to control waste management for the fast-growing area of Rawalpindi city.

6.1.1 MSW Generation and Characteristics

Many issues depend on manufacturing waste in city areas like environmental condition, weather conditions and waste collection system. For future waste management scheduling, we need excellence and valued wastes. A percentage variation of the wastes given in Table 1

Table 6. 1: MSW composition at Islamabad Rawalpindi (2018)

% categories	Plastic	Paper	Solid	Batteries	Organic	Glass
0%	01.74%	03.48%	09.93%	42.85%	14.63%	29.44%
1 – 20 %	18.46%	35.19%	22.47%	42.16%	16.20%	49.47%
21-40%	44.77%	34.32%	33.97%	09.75%	32.05%	16.02%
41 – 60%	24.39%	17.42%	20.03%	02.78%	19.33%	03.13%
61-80%	08.88%	06.79%	11.14%	01.04%	14.98%	0.34%
81-100%	01.04%	01.74%	0.08%	0.00%	01.56%	01.04%

The Survey as from table indicated that in different areas different types of waste generated in

different percentage. Like in some areas plastic waste generated 44.77 present and in other 01.04 present and so on.

From table, In Rawalpindi and Islamabad city MSW state that the highest percentage of waste is Metal/Organic food waste. Due to lack of consumption of raw foods this mainly happens. It reported in MSW that the existence of large organic fraction for many other developing countries such as India (40-60%) (Sharholy et al., 2008), Turkey (43%-64%) (Keser et al., 2012), China (57%-62%) (Chen et al., 2010), Nigeria (52%-65%), Nepal (60-70%) (Pokhrel and Viraraghavan, 2005). As of late, level of plastics as bundling waste is changing because of huge scale process sustenance generation in Rawalpindi. Additionally, fast food culture that spreads broadly all through the city is rolling out improvements in nourishment propensity and in addition the arrangement of waste things.

6.2 Survey Information

There are Three Section of survey.

- ✓ General Information of respondent.
- ✓ Satisfactory level with your waste collection provider
- ✓ Smart Methods of Waste Collection

6.2.1 General Information of respondent

In this section we have covered the general information of the respondents about age, gender, waste service etc.

6.2.1.1 Age Groups

As illustrated in figure 6.1 below, Age group which is in general information of respondent of our survey it indicates the research question 1 in which we measure the waste measurement through survey. We make for group like younger than 25 ,25-40, 40-60, and 60 to above which cover all age group of our requirements.

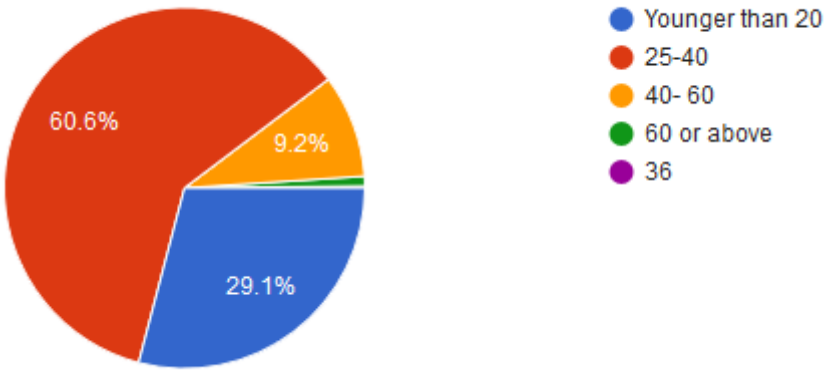

Figure 6. 1 Age Groups

There are 576 respondents in which they are divided into different age groups. There age groups are 29.1% of younger than 20 year of age and 60.6% 25 to 50 year of age 9.2% 40 to 60 year of age and others are 60 or above year of age group in this survey

6.2.1.2 Gender:

As illustrated in figure **6.**2 below, Gender which is in general information of respondent of our survey it indicates the research question 1 in which we measure the waste measurement through survey. From this question we measure which gender mostly response to our survey.

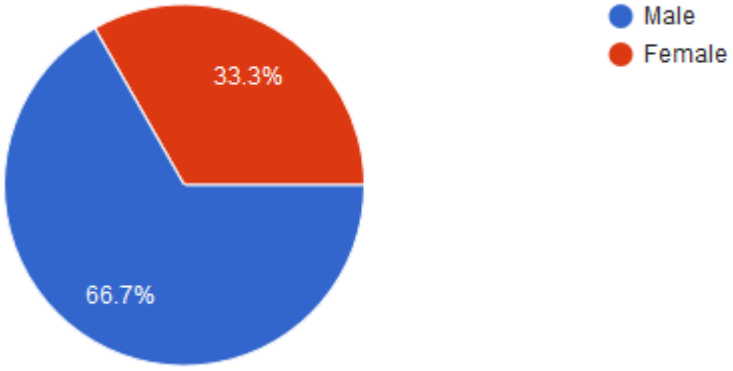

Figure 6. 2: Gender

There are 574 respondents in which they are divided into different gender. In this 66.7 % are male and 33.3 % are female respondents in this survey

6.2.1.3 Areas/ Locations

As illustrated in figure **6.**3 below, Address (Areas) which is in general information of respondent of our survey it indicates the research question 1 in which we measure the waste measurement through survey. We cover 10 different areas of Islamabad Rawalpindi like (Bahria University, Bahria Town, DHA, G9 sector, G8 sector, NUST University, Fast University, Sadaq Abad Rawalpindi, Bani Chowk Rawalpindi, Aride Agriculture University). This question covers our measurement requirements of research also issues, hurdles, and so on

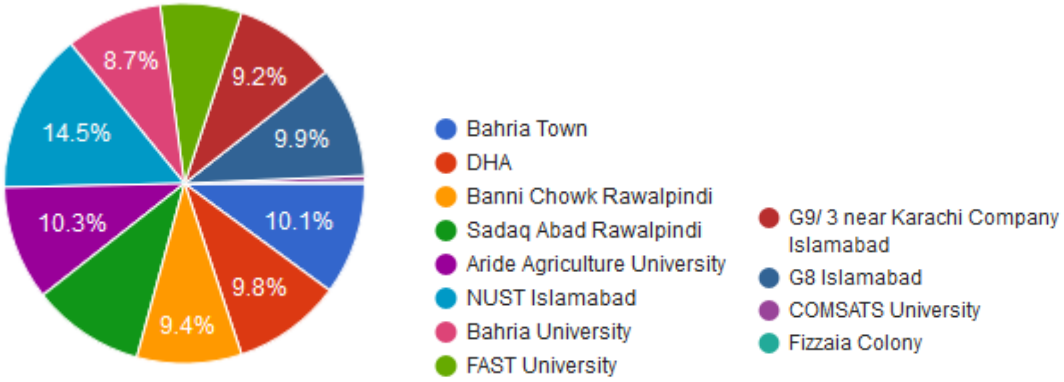

Figure 6. 3: Areas/ Locations

There are 574 respondents in which they are divided into different Areas. There area groups are 14.5% of NUST Islamabad and 10.3. % of Arid Agriculture university 10.1 % of Bahria Town and so.

6.2.1.4 Employment Status / Occupation

As illustrated in figure **6.**4 below, Employment Status / Occupation which is in general information of respondent of our survey it indicates the research question 1 in which we measure the waste measurement through survey. We cover 4 different occupations (Student, Employee, Private Employee, Own Business) from this question we measure which occupation mostly response to our survey.

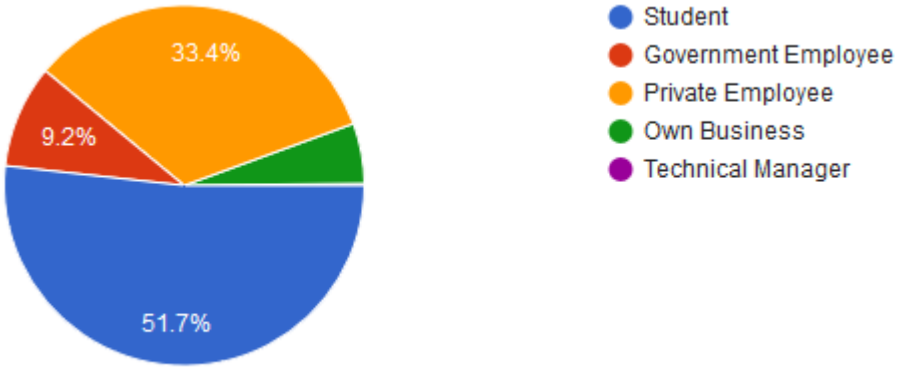

Figure 6. 4: Employment Status / Occupation

There are 574 respondents in which they are divided into different Occupation. Their Occupation are 51.7% of student and 9.2% of Government Employee and 33.4% of Private employee and others ate Own Business in Occupation in this survey

6.2.1.5 Type of rubbish storage

As illustrated in figure 6.5 below, rubbish storage type which is in general information of respondent of our survey it indicates the research question 3 in which we find the existing methodology work in Pakistan for waste collection. We cover 4 different storage type (Plastic bags, Cardboard boxes, Rubbish bin/ drum, no storage-direct disposal to dump) from this question we measure which storage type mostly used for storing the waste.

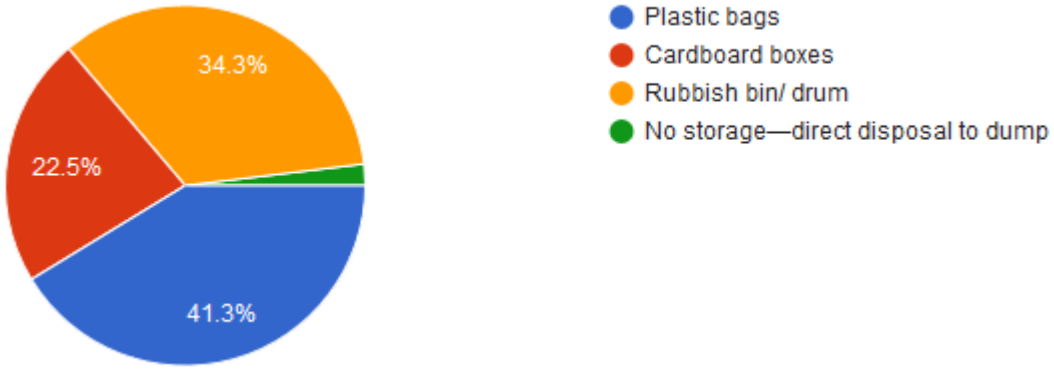

Figure 6. 5: Type of rubbish storage

There are 574 respondents in which they are divided into different Types of rubbish storage. The Survey as from figure indicated that 41% Majority of the sample responded that they store their household rubbish in plastic bags. And so on.

6.2.1.6 Location where they dispose your generated waste

As illustrated in figure **6.**6 below, Location where they dispose your generated waste which is in general information of respondent of our survey it indicates the research question 3 in which we find the existing methodology work in Pakistan for waste collection. We cover 4 different Location where they dispose your generated waste (Nearby container, Open spaces, home, Other) from this question we measure which location mostly used for dispose the waste.

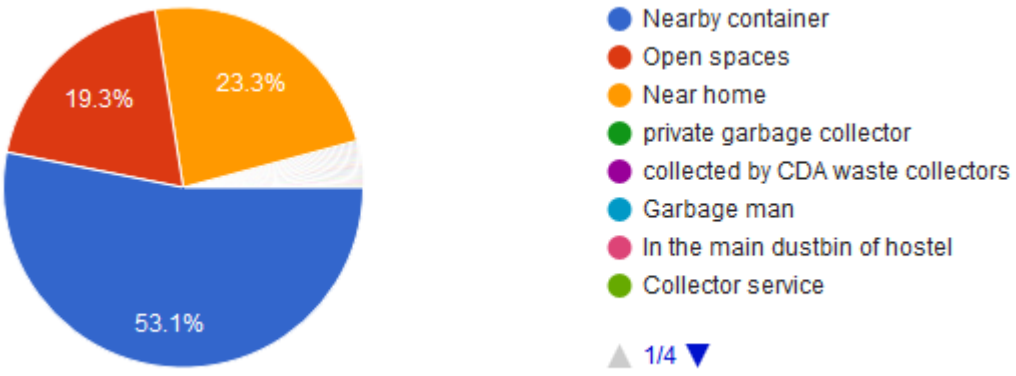

Figure 6. 6: Location where they dispose your generated waste

The Survey as from figure indicated that 53% Majority of the sample responded that dispose their generated waste nearby container and so on.

6.2.1.7 Percentage composition of your generated waste

As illustrated in figure **6.**7 below, Percentage composition of your generated waste which is in general information of respondent of our survey it indicates the research question 1 in which we find the existing methodology work in Pakistan for waste collection. We cover 6 different types of waste (Plastic, Solid, Paper, Batteries, organic waste, Glass) from this question we

measure which Percentage composition of your generated waste. In different areas waste generated in different percentage.

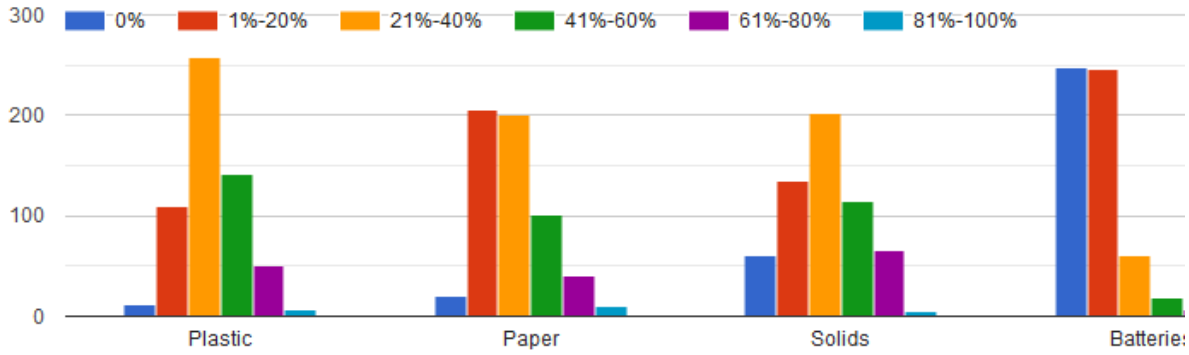

Figure 6. 7: Percentage composition of your generated waste

The Survey as from table indicated that in different areas different types of waste generated in different percentage. Like in some areas plastic waste generated 44.77 present and in other 01.04 present and so on.

6.2.1.8 Separate different type of waste at your home

As illustrated in figure **6.**8 below, Separate different type of waste at your home which is in general information of respondent of our survey it indicates the research question 1 in which we measure the waste measurement through survey. From this question we measure which separation of our generated waste at home to our survey.

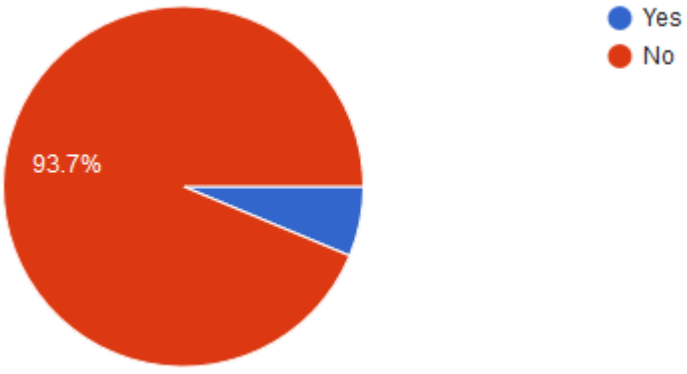

Figure 6. 8: Separate different type of waste at your home

The Survey as from figure indicated that 93% Majority of the sample responded that does not separate different type of waste

6.2.1.9 Any large bins

As illustrated in figure 6.9 below, Any Large bin in area which is in general information of respondent of our survey it indicates the research question 3 in which we find the existing

methodology work in Pakistan for waste collection. From this question we measure the information of large bin for waste gathering in areas to our survey.

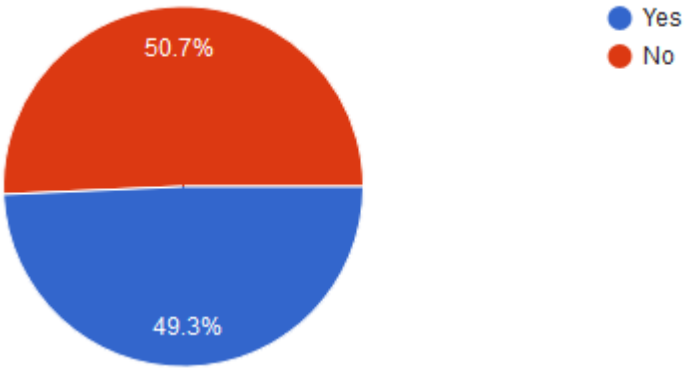

Figure 6. 9: Any large bins

The Survey as from figure indicated that 51% Majority of the sample responded have Large bins in their areas and other 49% areas lack of large bin for waste dispose.

6.2.1.10 regular garbage collection in your area

As illustrated in figure **6.**10 below, Regular garbage collection in your area which is in general information of respondent of our survey it indicates the research question 2 in which we find the existing methods hurdles, and why Smart methods are not yet implement in Pakistan. From this question we measure the information of regular collection of waste from our areas to our survey.

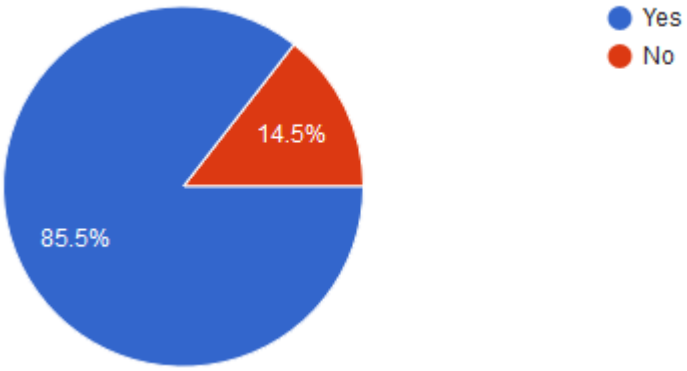

Figure 6. 10: regular garbage collection in your area

The Survey as from figure indicated that 86% Majority of the sample responded have system of regular garbage collection from their areas.

6.2.1.11 How often do you use the collection service

As illustrated in figure **6.**11 below, how often do you use the collection service which is in general information of respondent of our survey it indicates the research question 3 in which we find the existing methodology work in Pakistan for waste collection. We cover 4 different

use of collection service like (Daily, Ones a week, 2 to 3 times a week, never) from this question we measure the information of waste service uses from our survey.

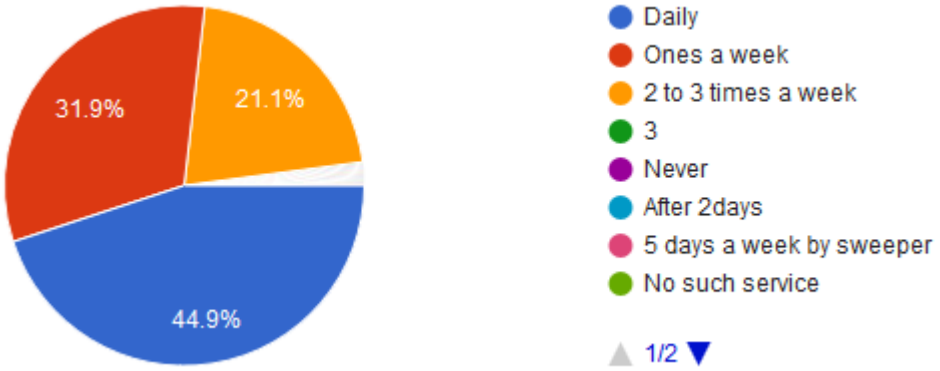

Figure 6. 11: How often do you use the collection service

The Survey as from figure indicated that 45% Majority of the sample responded use regular garbage collection daily from their areas.

6.2.1.12 Collection Service

As illustrated in figure **6.**12 below, collection service which is in general information of respondent of our survey it indicates the research question 3 in which we find the existing methodology work in Pakistan for waste collection. We cover 2 different use of collection service like (public, private) from this question we measure the information of waste service uses from our survey.

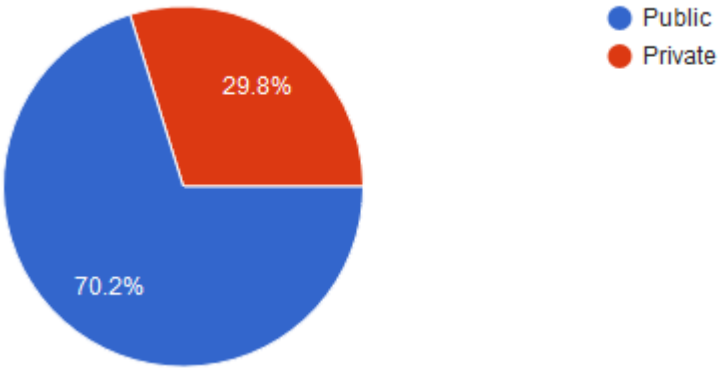

Figure 6. 12: Collection Service

The Survey as from figure indicated that 70% Majority of the sample responded use Public garbage collection from their areas.

6.2.2 Satisfactory level with your waste collection provider

In this section we cover the satisfaction level of present services, dissatisfaction, issues and main reasons and problems in waste collection. Some results are following

6.2.2.1 Charges per month

As illustrated in figure 6.12 below, Charges per month which is in general information of respondent of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues. We cover 4 different charges of collection per month (100-250, 250-500, 500-750, 750-1000) from this question we measure the cost service per month from our survey.

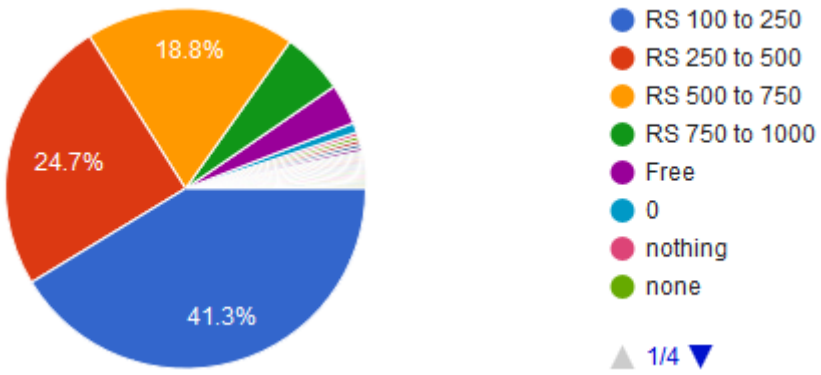

Figure 6. 13: Charges per month

The Survey as from figure indicated that in different areas Charge different Rupees per month for waste collections. Like 42% of areas charge 100 to 250 rupees per month and 24.7% charge 250 to 500 rupees per month and so on.

6.2.2.2 Satisfied with your current waste collection service

As illustrated in figure 6.13 below, satisfied with your current waste collection service which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues. From this question we measure the satisfaction of current method of waste collection from our survey.

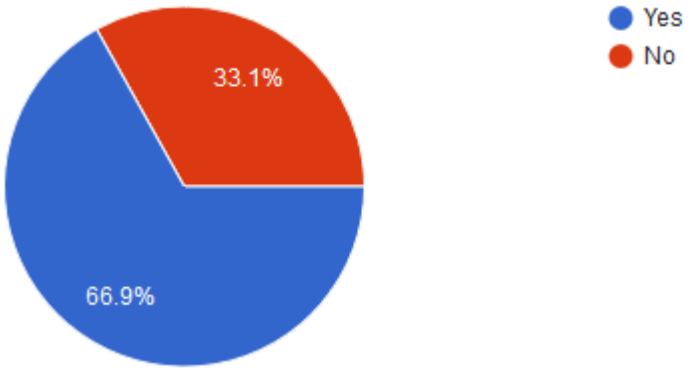

Figure 6. 14: Satisfied with your current waste collection service

The Survey as from figure indicated that 70% Majority of the sample responded are satisfy

with their current method of waste collections.

6.2.2.3 Main reason for your level of satisfaction/dissatisfaction

As illustrated in figure **6.**14 below, main reason for your level of satisfaction/dissatisfaction with your current waste collection service which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues. We cover 5 different reasons of satisfaction and dissatisfaction like (Costs, Unreliability, Improper collection, Reliable, Cooperative) From this question we measure the main reason of level of satisfaction dissatisfaction of current method of waste collection from our survey.

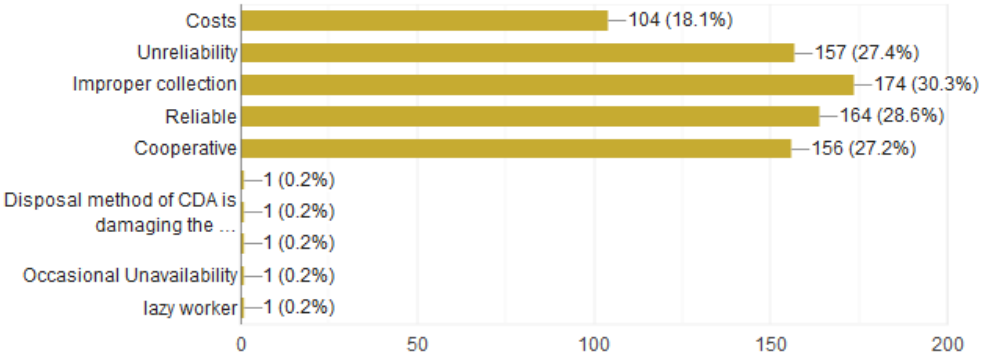

Figure 6. 15: Main reason for your level of satisfaction/dissatisfaction

The Survey as from figure indicated that 30% Majority of the sample responded dissatisfy because of improper waste collection

6.2.2.4 Waste alongside the garbage bins instead of putting it inside those

As illustrated in figure **6.**15 below, waste alongside the garbage bins instead of putting it inside which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues. From this question we measure that peoples through their waste alongside the garbage bin instead of putting it inside the bin from our survey.

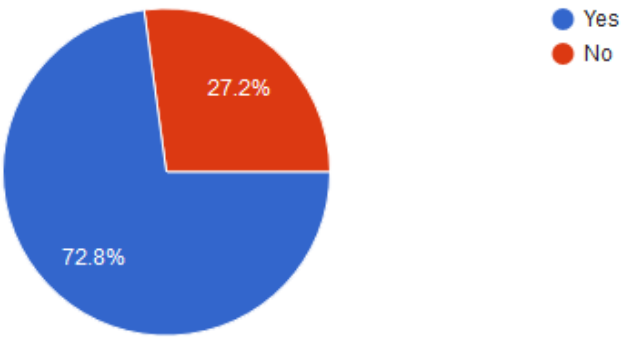

Figure 6. 16: Waste alongside the garbage bins instead of putting it inside those

The Survey as from figure indicated that 73% Majority of the sample responded putting their waste alongside the garbage bins instead of putting it inside.

6.2.2.5 opinion, people behave like this

As illustrated in figure **6.**16 below, waste alongside the garbage bins instead of putting it inside and there are some option why people behave like this which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues. From this question we measure that people's behavior main reason why they through their waste alongside the garbage bin instead of putting it inside the bin from our survey.

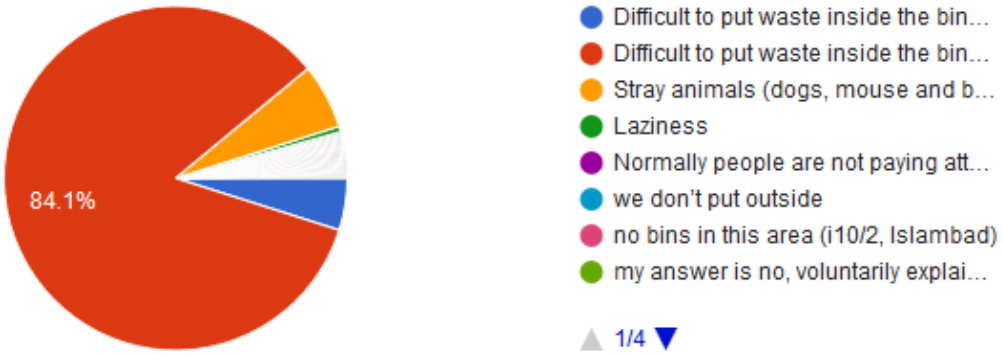

Figure 6. 17: opinion, people behave like this

The Survey as from figure indicated that 84% Majority of the sample putting their waste alongside the garbage bins instead of putting it inside Because it's difficult to put waste inside the bin due to waste and litter spread around the bin.

6.2.2.6 Main problems with the current solid waste management system

As illustrated in figure 6.17 below, Main problems with the current solid waste management system which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues.From this question we measure that some common problems which people face in current waste collection management from our survey.

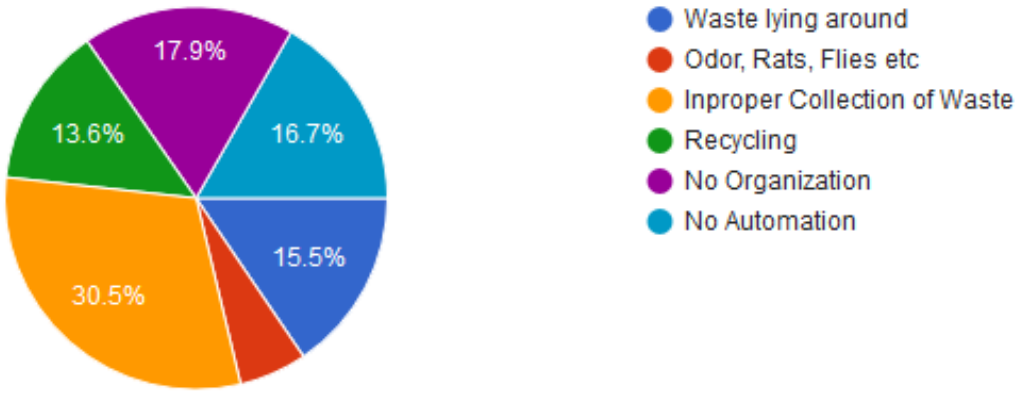

Figure 6. 18: Main problems with SWM

The Survey as from figure indicated that 31% Majority of the sample responded have improper collection of waste as a main problem of current waste management and so on.

6.2.2.7 Distance between your house and dumping site

As illustrated in figure 6.18 below, Distance between your house and dumping site which is in Satisfactory level with your waste collection provider it indicates the research question 2 in which we find the Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented? From this question we measure the distance of dumping site from our house from our survey.

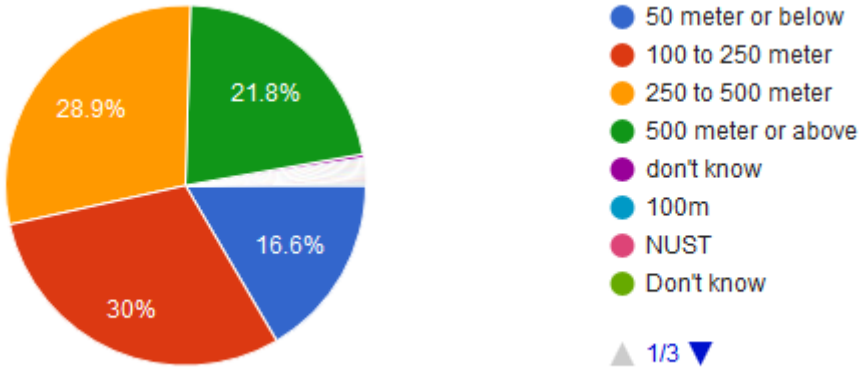

Figure 6. 19: Distance between your house and dumping site

The Survey as from figure indicated that 30% Majority of the sample responded distance of bin to their house is 100 to 250 meters.

6.2.2.8 Household suffered from any of these listed diseases

As illustrated in figure **6.**19 below, Household suffered from any of these listed diseases which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 3 in which we find the Which SWM methodologies exist and which are ideal to be implemented in Pakistan?. From this question we measure that due to improper waste collection diseases are supred and find is any one suffered with disease from last 6 week from

our survey.

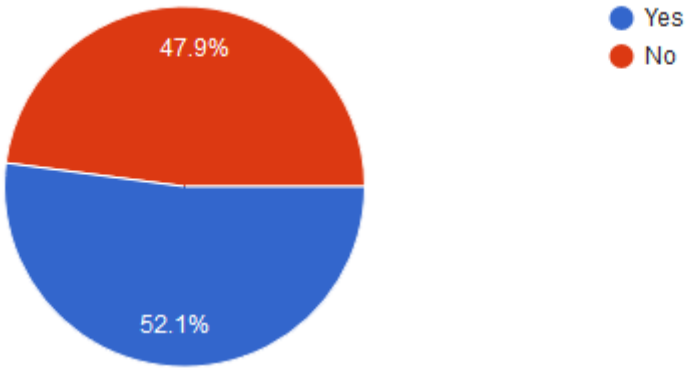

Figure 6. 20: Household suffered from any of these listed diseases

The Survey as from figures indicated that 52% Majority of the sample responded suffered with diseases of following list diseases.

6.2.2.9 Which diseases

As illustrated in figure 6.19 below, Household suffered from any of these listed diseases which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 3 in which we find the Which SWM methodologies exist and which are ideal to be implemented in Pakistan?. From this question we measure that due to improper waste collection diseases are supred and find is any one suffered with disease from last 6 week and which disease is common from our survey.

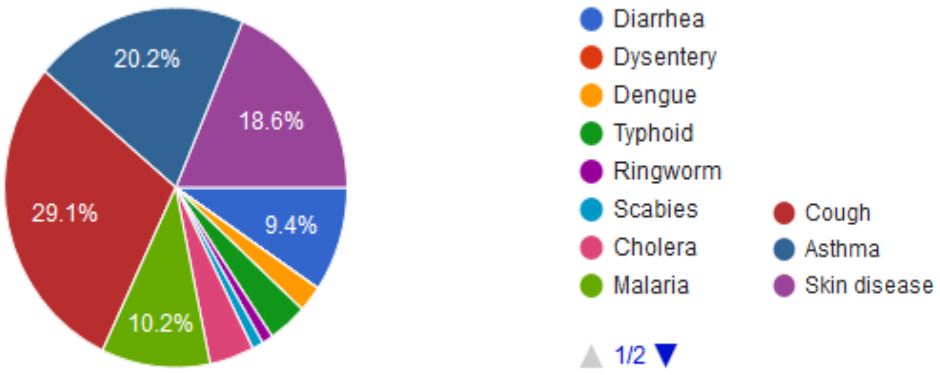

Figure 6. 21: Which diseases

The Survey as from figures indicated that 52% Majority of the sample responded suffered with diseases of following list diseases. And 29% of responded suffered with Cough and 20.2% suffered with asthma and so on.

6.2.2.10 Recycling campaigns

As illustrated in figure 6.21 below, Recycling campaigns which is in Satisfactory level with your waste collection provider of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues. From this question we measure that is any reuse or recycling campaign work in Pakistan from our survey.

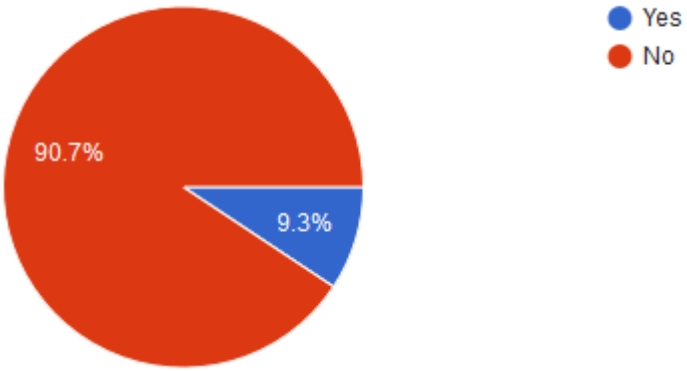

Figure 6. 22: Recycling campaigns

The Survey as from figure indicated that 91% Majority of the sample responded that there is no any comping's or recycling system in their areas.

6.2.3 Smart Methods of Waste Collection

Smart Waste Bins is used to identify status of waste bins if it is empty or filled so as to customize the waste collection schedule accordingly and also save the cost. There are many types of Smart Waste Bins like (Wireless sensors, dynamic routing, RF-ID, intelligent sensor, and IR Sensors bins)

6.2.3.1 Any smart bins in area

As illustrated in figure 6.22 below, Any smart bins in area which is in Smart Methods of Waste Collection of our survey it indicates the research question 2 in which we find the Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented? .From this question we measure that is any Smart waste Bin Smart method of collection in areas from our survey.

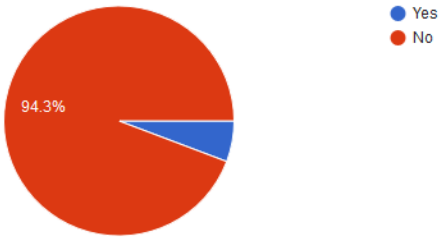

Figure 6. 23: Any smart bins in area

The Survey as from figure indicated that 95% Majority of the sample responded that no Smart

Bin in their areas.

6.2.3.2 Are you interesting to install

As illustrated in figure 6.23 below, Are you interesting to install which is in Smart Methods of Waste Collection of our survey it indicates the research question 3 in which we find the Which SWM methodologies exist and which are ideal to be implemented in Pakistan?. From this question we measure that peoples and unaware of smart waste collection method and its innovative and people want to install smart bins and their interest of installing from our survey.

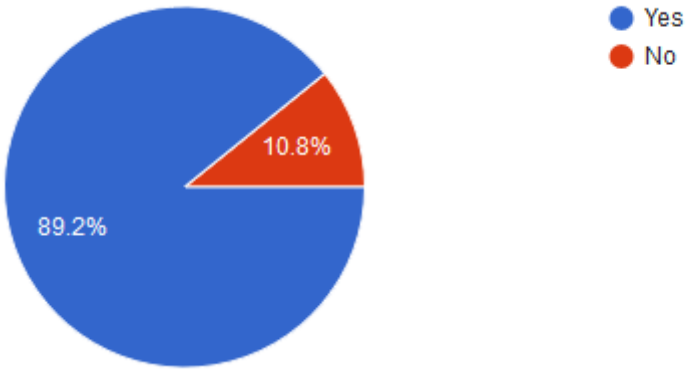

Figure 6. 24: Are you interesting to install

The Survey as from figure indicated that 82% Majority of the sample responded that have interest of installing smart bin in their areas.

6.2.3.3 Current method of bin monitoring is efficient

As illustrated in figure 6.23 below, Current method of bin monitoring is efficient which is in Smart Methods of Waste Collection of our survey it indicates the research question 3 in which we find the Which SWM methodologies exist and which are ideal to be implemented in Pakistan?. From this question we measure that peoples and unaware of smart waste collection method and its innovative and what people thinks that current method of waste is efficient or not from our survey.

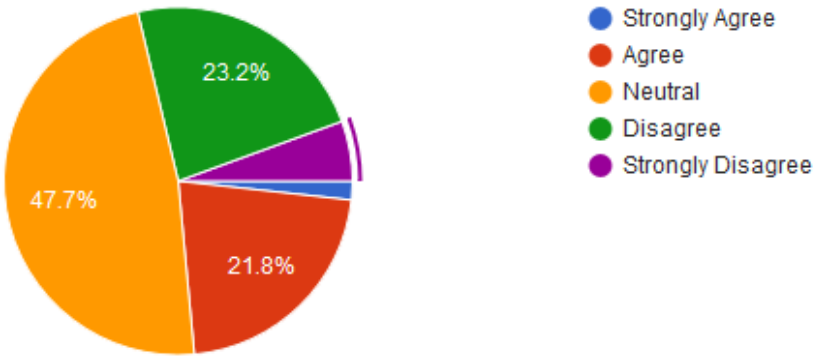

Figure 6. 25: Current method of bin monitoring is efficient

The Survey as from figure indicated that 48% Majority of the sample responded that the

Current method is not efficient its neutral and so on.

6.2.3.4 Fill level they consider optimal

As illustrated in figure 6.25 below, Fill level they consider optimal which is in Smart Methods of Waste Collection of our survey it indicates the research question 3 in which we find the Which SWM methodologies exist and which are ideal to be implemented in Pakistan?. From this question we measure that in smart method of waste bin show their fill level optimal and status and notification etc. is the current method show level fill or notify optimal level from our survey.

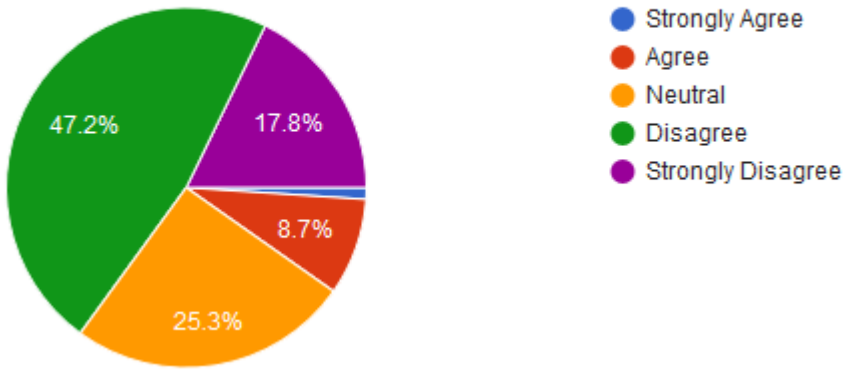

Figure 6. 26: Fill level they consider optimal

The Survey as from figure indicated that 47% Majority of the sample responded that the Fill level they consider optimal is Disagree and so on.

6.2.3.5 current process of bin management is user friendly

As illustrated in figure 6.26 below, current process of bin management is user friendly which is in Smart Methods of Waste Collection of our survey it indicates the research question 3 in which we find the Which SWM methodologies exist and which are ideal to be implemented in Pakistan?. From this question we measure that in smart method of waste bin show that current process of bin management is user friendly or not from our survey.

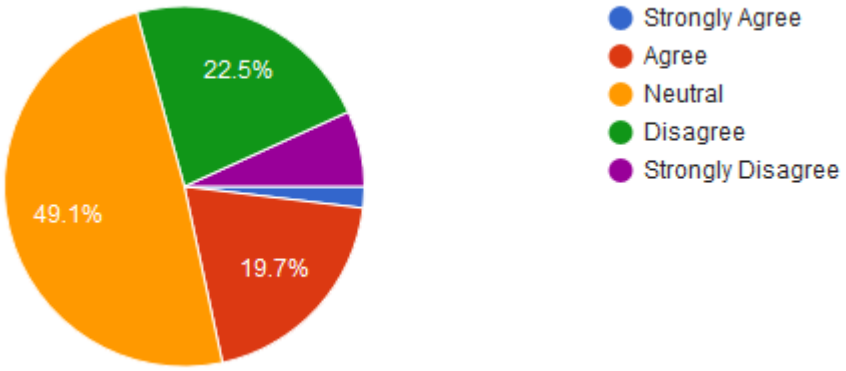

Figure 6. 27: current process of bin management is user friendly

The Survey as from figure indicated that 49% Majority of the sample responded that the Current method is not user friendly its neutral and so on.

6.2.3.6 An Implemented System can made entire process easier

As illustrated in figure 6.27 below, If a proper computer system is implemented, I believe that domestic and corporate bin monitoring would be made easier which is in Smart Methods of Waste Collection of our survey it indicates the research question 4 in which we find the How SWM can resolve Pakistan's existing waste management issues? From this question we measure that if a proper computerize smart method is implemented the bin monitoring and status level ease our work and ease our life with waste issues from our survey

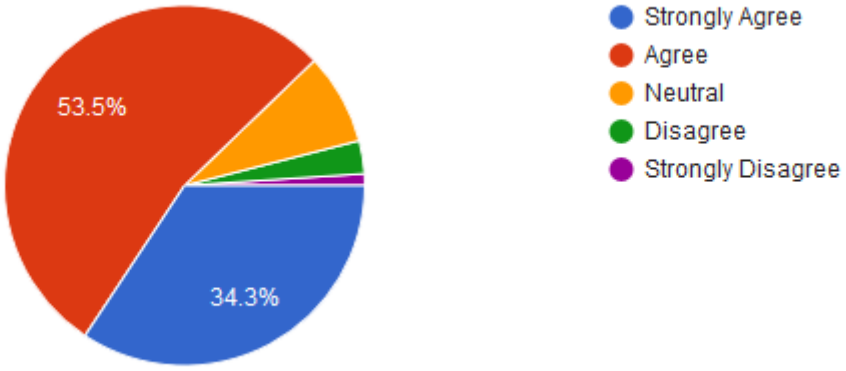

Figure 6. 28: An Implemented System can made entire process easier

The Survey as from figure indicated that 54% Majority of the sample responded that if we implement a proper computer system they believe that domestic and corporate bin monitoring would be made easier.

Chapter 7

7.0 Metrics for Evaluation and Results

The Metrics for Evaluation framework and its results are discussed in this chapter.

7.1 Statistical Results

In this chapter we explain 2 statistical methods and their results which are

1. Convert Data into Database and apply Relational Queries.
2. Machine Learning Tools.

7.1.1 Relation Between Smart Bins and Education (Universities data)

In this method we convert our 574-respondent data in to Database (PhpMyAdmin) and apply relational queries

Query:

```
SELECT `Address`, `interesting_install_smartbin` FROM `survey` WHERE `Address` IN ('Aride Agriculture University','NUST Islamabad','Bahria University','COMSATS University','FAST University')
```

Statistics:

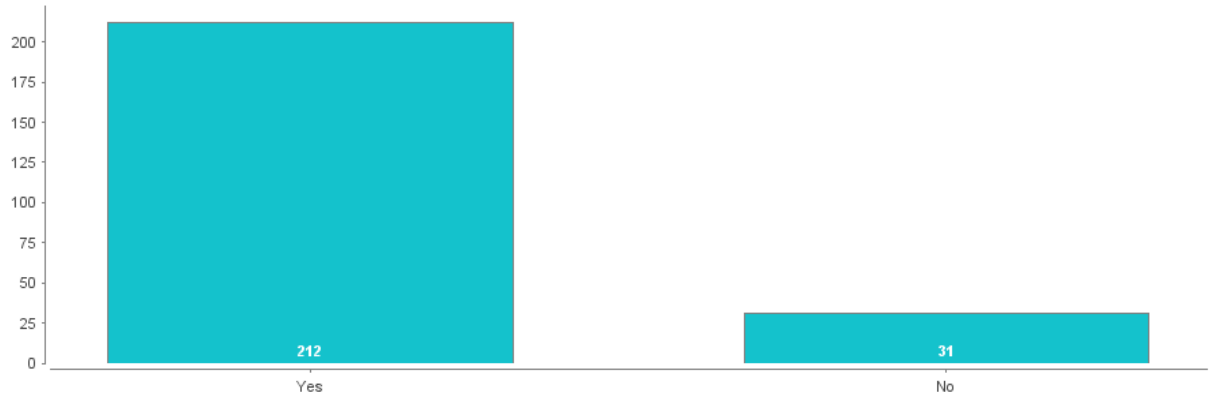

Figure 7. 1: Relation Between Smart Bins and Education

1st of all data convert into database and get results of rational query in which we find the relationship of educational sector who install the smart waste bin and we find total 243 and 212/243 want to install smart bin and other 31 is not interested to install smart bin.

ML Results:

Table 7. 1: Relation Between Smart Bins and Education

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.884615385	0.080752409	125
Generalized Linear Model	0.884615385	0.080752409	137
Logistic Regression	0.884615385	0.080752409	176
Fast Large Margin	0.884615385	0.080752409	373
Deep Learning	0.884615385	0.080752409	1048
Decision Tree	0.884615385	0.080752409	274
Random Forest	0.884615385	0.080752409	1244
Gradient Boosted Trees	0.781318681	0.077353583	15010
Support Vector Machine	0.884615385	0.080752409	660

Accuracy:

Relative number of correctly classified examples or in other words percentage of correct predictions

Standard Deviation:

The Weight by Deviation operator calculates the weight of attributes with respect to the label attribute based on the (normalized) standard deviation of the attributes. The higher the weight of an attribute, the more relevant it is considered. The standard deviations can be normalized by average, minimum, or maximum of the attribute.

After collect the states of relational query than apply ML Tool to get accuracy of our result and their correlations, standard deviation and prediction of our result. In the following table we apply ML tool which show their model accuracy, standards deviations and Runtime. Naive Bayes show 0.884615385 accuracy and 0.080752409 standard deviation and 125 run time. Generalized Linear Model show 0.884615385 accuracy and 0.080752409 standard deviation and 137 run time. Logistic Regression Model show 0.884615385 accuracy and 0.080752409 standard deviation and 176 run time. Fast Large Margin Model show 0.884615385 accuracy and 0.080752409 standard deviation and 373 run time. Deep Learning Model show 0.884615385 accuracy and 0.080752409 standard deviation and 1048 run time.

Decision Tree Model show 0.884615385 accuracy and 0.080752409 standard deviation and 274 run time. Random Forest Tree Model show 0.781318681 accuracy and 0.077353583 standard deviation and 15010 run time.

Note : We can find though simple Excel and query butt we apply ML Tool for Future point of view. Because when our data is larger than Query and Simple Excel does not give accurate results.

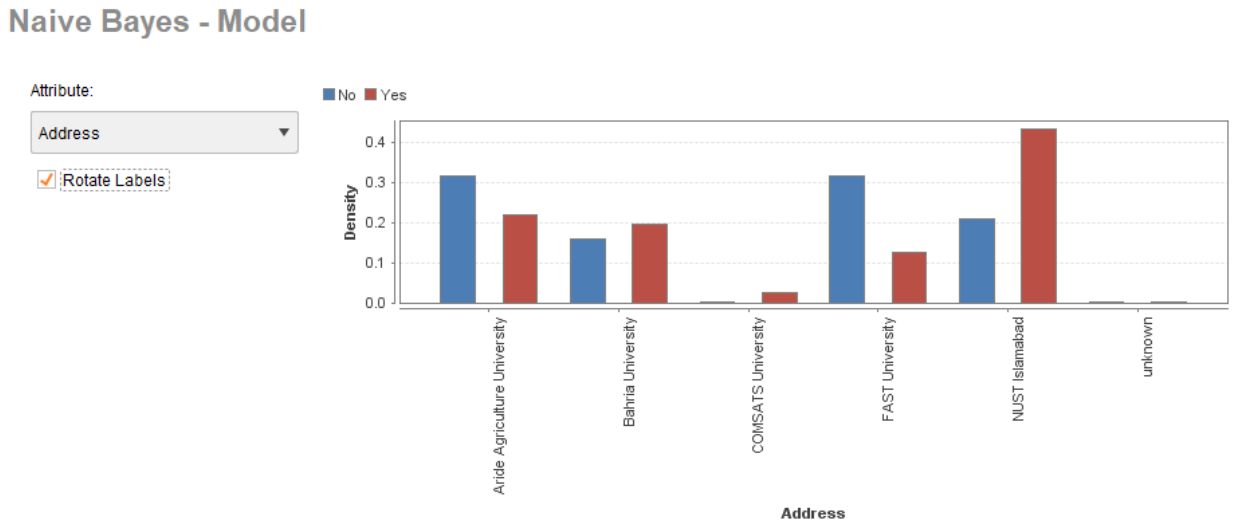

Figure 7. 2: Naïve Bayes

In this we find that thorough this relationship NUST Islamabad and bahria University mostly want to install smart bin.

Prediction

installing smart bins in education areas is 'Yes'

7.1.2 Relation Between Smart Bins and Areas of Rawalpindi

In this method we convert our 574-respondent data in to Database (PhpMyAdmin) and apply relational queries

Query:

```
SELECT `Address`,`interesting_install_smartbin` FROM `survey`
WHERE `Address` IN('Aride Agriculture University','Banni Chowk
Rawalpindi','Sadaq Abad Rawalpindi')
```

Figure 7. 3: Relation Between Smart Bins and Areas of Rawalpindi

1st of all data convert into database and get results of rational query in which we find the relationship of Rawalpindi Areas who install the smart waste bin and we find total 170 and 142/170 want to install smart bin and other 28 is not interested to install smart bin.

Table 7. 2: Relation Between Smart Bins and Areas of Rawalpindi

ML Result:

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.835556	0.092429	140
Generalized Linear Model	0.835556	0.116375	281
Logistic Regression	0.835556	0.092429	396
Fast Large Margin			
Deep Learning	0.835556	0.092429	937
Decision Tree	0.835556	0.092429	130
Random Forest	0.835556	0.092429	1411
Gradient Boosted Trees	0.835556	0.092429	8931
Support Vector Machine	0.835556	0.092429	520

After collect the states of relational query than apply ML Tool to get accuracy of our result and their correlations, standard deviation and prediction of our result. In the following table we apply ML tool which show their model accuracy, standards deviations and Runtime. Naive Bayes show 0.835556 accuracy and 0.092429 standard deviation and 140 run time. Generalized Linear Model show 0.835556 accuracy and 0.092429 standard deviation and 281 run time. Logistic Regression Model show 0.835556 accuracy and 0.092429 standard deviation and 396 run time. Fast Large Margin Model show 0.835556 accuracy and 0.092429 standard deviation and 937 run time. Deep Learning Model show 0.835556 accuracy and 0.092429 standard deviation and 130 run time.

Decision Tree Model show 0.835556 accuracy and 0.092429 standard deviation and 1411 run time. Random Forest Tree Model show 0.835556 accuracy and 0.092429 standard deviation and 8931 run time.

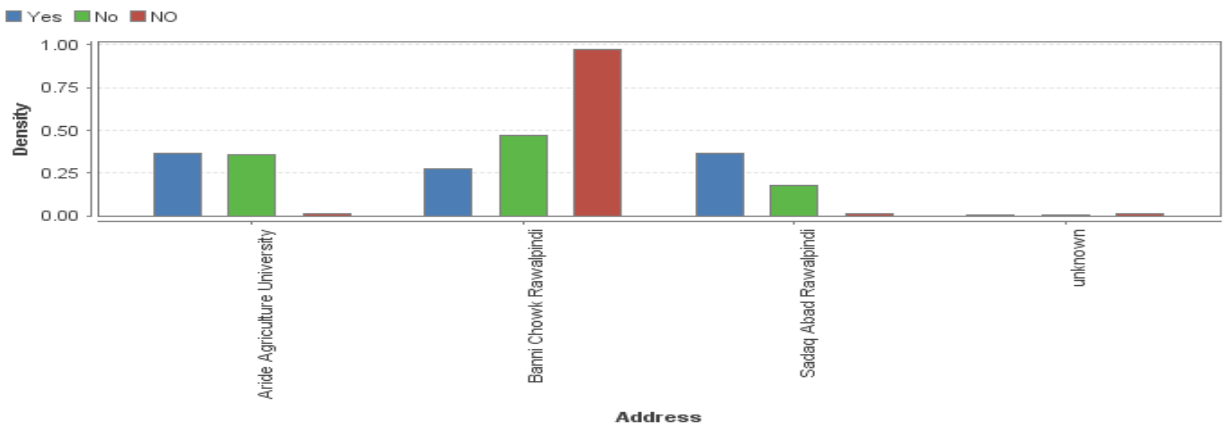

Figure 7. 4

In this we find that thorough this relationship Arid Agriculture University and Sadaq Abad Rawalpindi areas mostly want to install smart bin.

Prediction

Installing of Smart Bin In Rawalpindi Areas prediction is 'YES'

7.1.3 Relation Between Smart Bins and Area of Islamabad

In this method we convert our 574-respondent data in to Database (PhpMyAdmin) and apply relational queries

Query:

```
SELECT `Address`,`interesting_install_smartbin` FROM `survey`
WHERE `Address` NOT IN('Aride Agriculture University','Banni
Chowk Rawalpindi','Sadaq Abad Rawalpindi')
```

Figure 7. 5: Relation Between Smart Bins and Area of Islamabad

1st of all data convert into database and get results of rational query in which we find the relationship of Rawalpindi Areas who install the smart waste bin and we find total 414 and 380/414 want to install smart bin and other 34 is not interested to install smart bin.

ML Results:

Table 7. 3: Relation Between Smart Bins and Area of Islamabad

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.916304	0.028827	149
Generalized Linear Model	0.916304	0.028827	185
Logistic Regression	0.916304	0.028827	182
Fast Large Margin	0.916304	0.028827	497
Deep Learning	0.916304	0.028827	1161
Decision Tree	0.916304	0.028827	174
Random Forest	0.916304	0.028827	1807
Gradient Boosted Trees	0.86558	0.03462	14247
Support Vector Machine	0.916304	0.028827	1144

After collect the states of relational query than apply ML Tool to get accuracy of our result and their correlations, standard deviation and prediction of our result. In the following table we apply ML tool which show their model accuracy, standards deviations and Runtime. Naive Bayes show 0.916304 accuracy and 0.028827 standard deviation and 149 run time. Generalized Linear Model show 0.916304 accuracy and 0.028827 standard deviation standard deviation and 185 run time. Logistic Regression Model show 0.916304 accuracy and 0.028827 standard deviation and 182 run time. Fast Large Margin Model show 0.916304 accuracy and 0.028827

standard deviation and 497 run time. Deep Learning Model show 0.916304 accuracy and 0.028827 standard deviation and 1161 run time.

Decision Tree Model show 0.916304 accuracy and 0.028827 standard deviation and 174 run time. Random Forest Tree Model show 0.86558accuracy and 0.03462 standard deviation and 1807 run time.

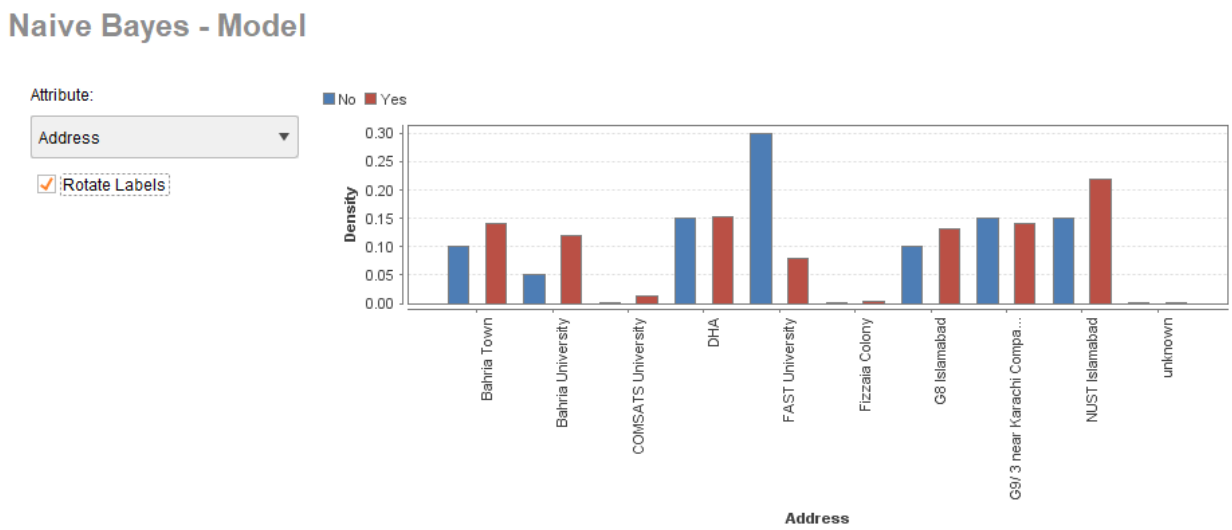

Figure 7. 6

In this we find that thorough this relationship NUST Islamabad, Bahria University, G8 Islamabad and Bahria Town mostly want to install smart bin.

Prediction

Installing of Smart Bin In Islamabad Areas prediction is ‘YES’

7.1.4 Relation Between Smart Bins and Unsatisfaction and suffering Disease

In this method we convert our 574-respondent data in to Database (PhpMyAdmin) and apply relational queries

Query:

```
SELECT `interesting_install_smartbin`,` suffered_ diseases`,`satisfied_collection` FROM `survey` WHERE `satisfied_collection` = 'No' And ` suffered_ diseases` =- 'Yes'
```

Statistics:

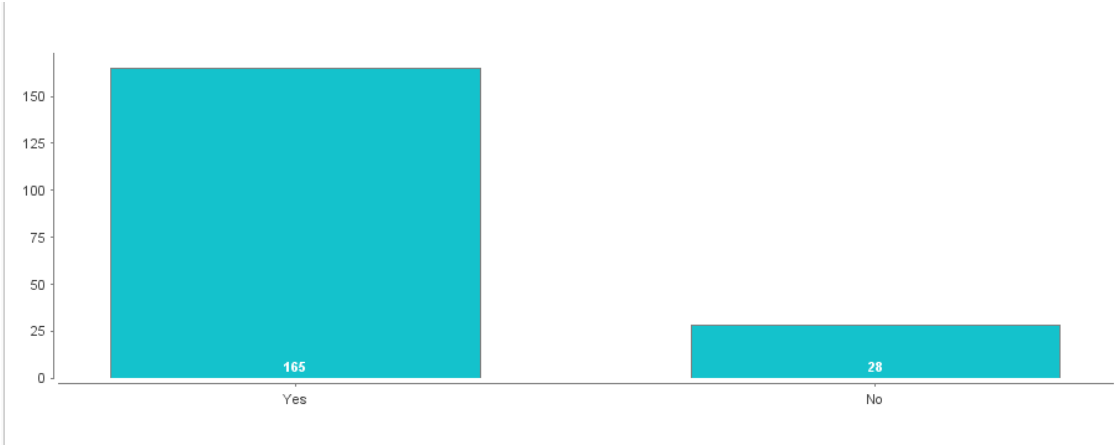

Figure 7. 7: Relation Between Smart Bins and Unsatisfaction

1st of all data convert into database and get results of rational query in which we find the relationship of Relation Between Smart Bins and Unsatisfaction and suffering Disease and we find total 193 and 165/193 want to install smart bin and other 28 is not interested to install smart bin.

ML Results:

Table 7. 4: Relation Between Smart Bins and Unsatisfaction

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.836364	0.040656	2596
Generalized Linear Model	0.836364	0.040656	23497
Logistic Regression	0.836364	0.040656	1230
Fast Large Margin	0.836364	0.040656	1172
Deep Learning	0.836364	0.040656	3720
Decision Tree	0.836364	0.040656	1082
Random Forest	0.836364	0.040656	2084
Gradient Boosted Trees	0.545455	0.11134	26384
Support Vector Machine	0.836364	0.040656	1206

After collect the states of relational query than apply ML Tool to get accuracy of our result and their correlations, standard deviation and prediction of our result. In the following table we apply ML tool which show their model accuracy, standards deviations and Runtime. Naive Bayes show 0.836364 accuracy and 0.040656 standard deviation and 2596 run time. Generalized Linear Model show 0.836364 accuracy and 0.040656 standard deviation standard deviation and 23497 run time. Logistic Regression Model show 0.836364 accuracy and 0.040656 standard deviation and 1230 run time. Fast Large Margin Model show 0.836364 accuracy and 0.040656 standard deviation and 1172 run time. Deep Learning Model show 0.836364 accuracy and 0.040656 standard deviation and 3720 run time.

Decision Tree Model show 0.836364 accuracy and 0.040656 standard deviation and 1082 run

time. Random Forest Tree Model show 0.836364 accuracy and 0.040656 standard deviation and 2084 run time.

Prediction

installing smart bins in satisfied_collection` = 'No' And ` suffered_ diseases` =- 'Yes' is ‘Yes’

7.1.5 Relation Between Disease and garbage type

In this method we convert our 574-respondent data in to Database (PhpMyAdmin) and apply relational queries

Query:

```
SELECT `service_type` ,` suffered_ diseases` FROM `survey` WHERE
` suffered_ diseases` = 'Yes'
```

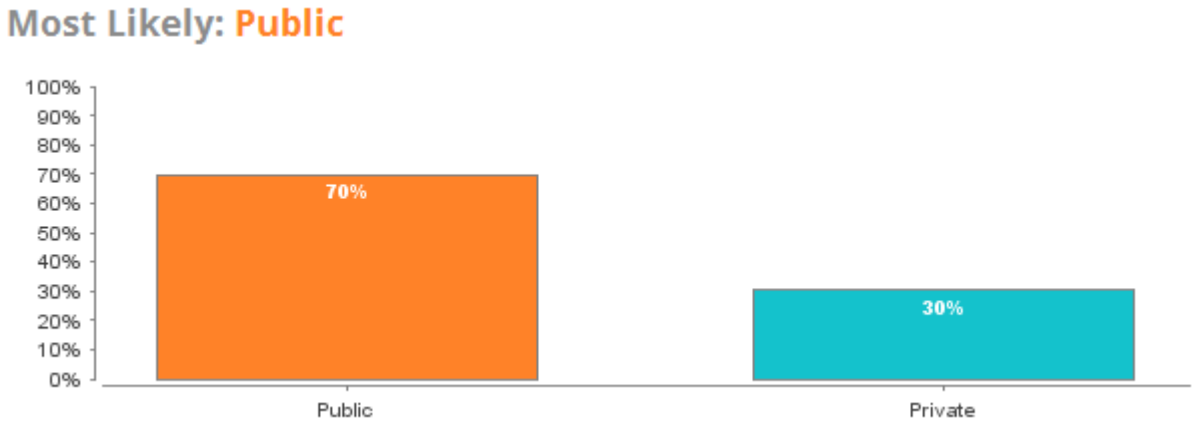

Figure 7. 8: Relation Between Disease and garbage type

1st of all data convert into database and get results of rational query in which we find the relationship of Relation Between Smart Bins and Unsatisfaction and suffering Disease and we find total 193 and 165/193 want to install smart bin and other 28 is not interested to install smart bin.

ML results

Table 7. 5: Relation Between Disease and garbage type

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.701307	0.020617	157
Generalized Linear Model			
Logistic Regression			
Fast Large Margin			
Deep Learning			
Decision Tree	0.701307	0.020617	278
Random Forest	0.701307	0.020617	1028
Gradient Boosted Trees			
Support Vector Machine			

Naive Bayes show 0.701307 accuracy and 0.020617 standard deviation and 157 run time. Decision Tree Model show 0.701307 accuracy and 0.020617 standard deviation and 278 run time. Random Forest Tree Model show 0.701307 accuracy and 0.020617 standard deviation and 1028 run time.

Prediction

Service type is public where suffering disease = 'yes'

7.1.6 Relation Between Disease, Area and Unsatisfaction of current waste

Query:

```
SELECT `Address`,` suffered_
diseases`,`satisfied_collection`,`type_diseases` FROM `survey`
WHERE `satisfied_collection` = 'No' And ` suffered_ diseases`
=- 'Yes'
```

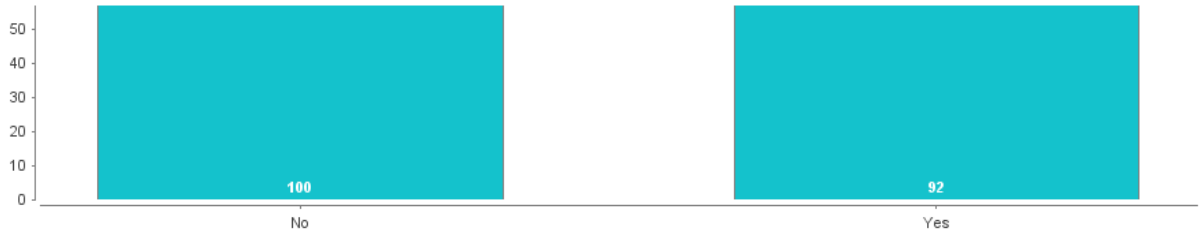

Figure 7. 9: Relation Between Disease, Area and

1st of all data convert into database and get results of rational query in which we find the relationship of Relation Between Disease, Area and Unsatisfaction of current waste and we find total 192 and 100/192 suffered diseases and other 92 is not suffered diseases.

ML result

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.727273	0.064282	134
Generalized Linear Model	0.763636	0.049793	121
Logistic Regression	0.763636	0.049793	132
Fast Large Margin			
Deep Learning	0.781818	0.049793	871
Decision Tree	0.509091	0.103652	96
Random Forest	0.690909	0.081312	3444
Gradient Boosted Trees	0.763636	0.081312	10354
Support Vector Machine			

Naive Bayes show 0.727273 accuracy and 0.064282 standard deviation and 134 run time. Generalized Linear Model show 0.763636 accuracy and 0.049793 standard deviation standard deviation and 121 run time. Logistic Regression Model show 0.763636 accuracy and 0.049793 standard deviation and 132 run time. Deep Learning Model show 0.781818 accuracy and 0.049793 standard deviation and 871 run time. Decision Tree Model show 0.509091 accuracy

and 0.103652 standard deviation and 96 run time. Random Forest Tree Model show 0.690909 accuracy and 0.081312 standard deviation and 3444 run time.

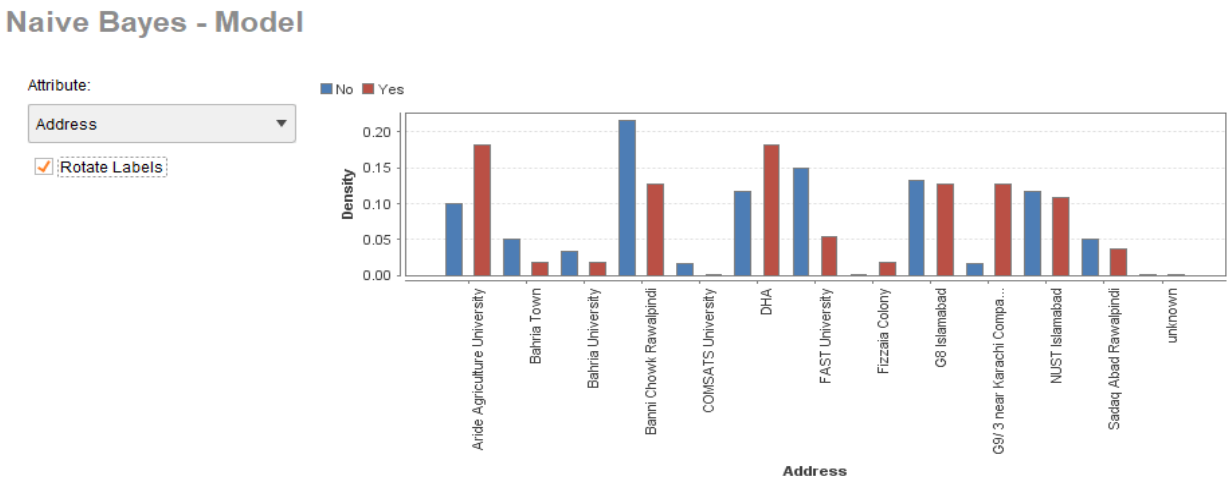

Figure 7. 10

In this we find that thorough this relationship Aride Agriculture university, DHA, G9 Islamabad and NUST Islamabad mostly want to install smart bin.

Figure 7. 11

In this we find that thorough this relationship NUST Islamabad, Bahria University, G8 Islamabad and Bahria Town mostly want to install smart bin.

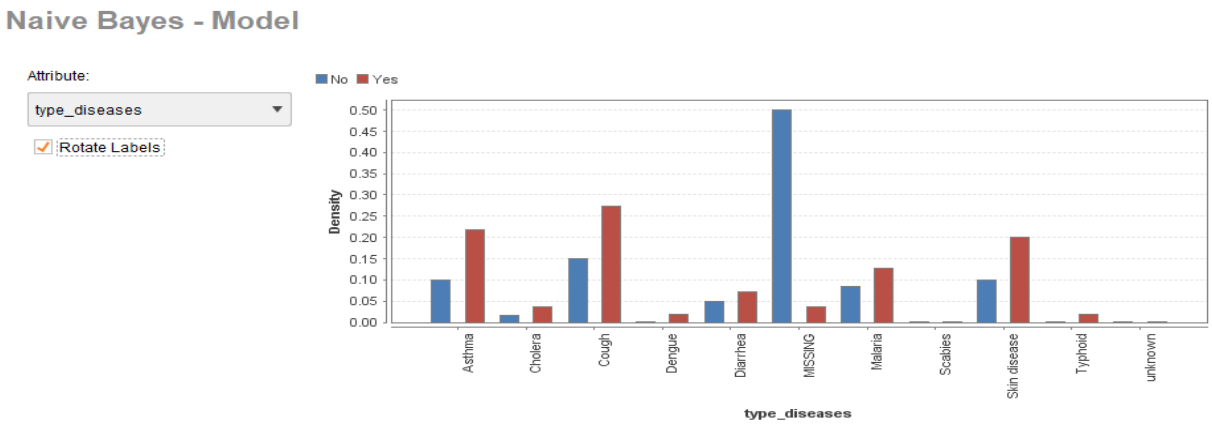

Figure 7. 12

In this we find that thorough that type of diseases is Asthma, Cough, Skin Disease, Typhoid.

Prediction

Installing of Smart Bin In Islamabad Areas prediction is 'YES'

7.1.7 Relation Between Disease type and Unsatisfaction of current waste

Query:

```
SELECT `satisfied_collection`,`type_diseases` FROM `survey`
WHERE `satisfied_collection` = 'No'
```

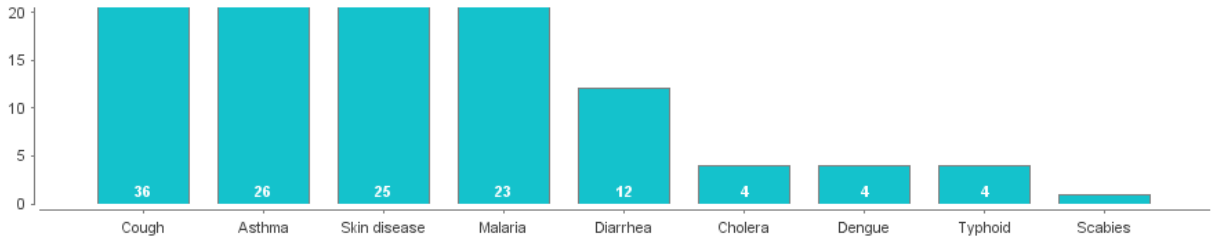

Figure 7. 13: Relation Between Disease Un-satisfaction of current waste

1st of all data convert into database and get results of rational query in which we find the relationship of Relation Between Disease, Area and Unsatisfaction of current waste and we find total 36 respondent suffered in cough and 26 respondent suffered in Asthma and 25 respondent suffered in skin disease and 23 respondent suffered in malaria suffered diseases and so on.

ML Results

Table 7. 6: Relation Between Disease type and Unsatisfaction of current waste

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.282143	0.054163	106

Generalized Linear Model	0.232143	0.107884	171
Logistic Regression	0.282143	0.054163	505
Fast Large Margin			
Deep Learning	0.282143	0.054163	607
Decision Tree	0.282143	0.054163	122
Random Forest	0.282143	0.054163	2457
Gradient Boosted Trees			
Support Vector Machine	0.282143	0.054163	626

Naive Bayes show 0.282143accuracy and 0.054163 standard deviation and 106 run time. Generalized Linear Model show 0.282143accuracy and 0.107884 standard deviation standard deviation and 171 run time. Logistic Regression Model show 0.282143 accuracy and 0.054163 standard deviation and 505 run time. Deep Learning Model show 0.282143 accuracy and 0.054163 standard deviation and 607 run time. Decision Tree Model show 0.282143 accuracy and 0.054163 standard deviation and 122 run time. Random Forest Tree Model show 0.282143 accuracy and 0.054163 standard deviation and 2457 run time.

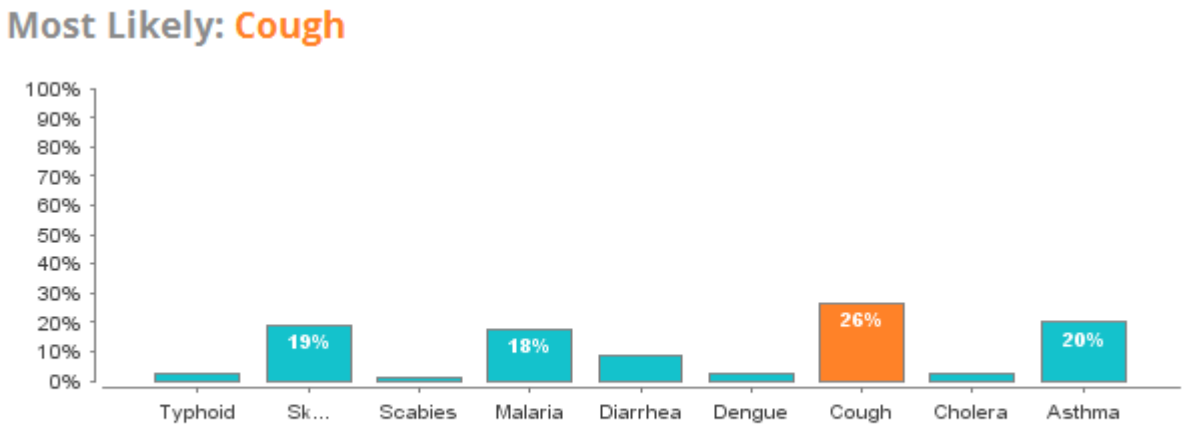

Figure 7. 14

In this we find that thorough Disease type is cough.

7.1.8 Relation of disease, unsatisfaction and current waste type

Query:

```
SELECT `suffered_ diseases `,` satisfied_collection `,` service_type` FROM `survey` WHERE `satisfied_collection` = 'No'
```

Figure 7. 15: Relation of disease, unsatisfaction and current waste type

1st of all data convert into database and get results of rational query in which we find the relationship of Relation of disease, unsatisfaction and current waste type we find total 192 and 99/192 suffered diseases and other 93 is not suffered diseases.

ML Results

Table 7. 7: Relation of disease, unsatisfaction and current waste type

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.490909	0.049793	66
Generalized Linear Model	0.490909	0.049793	150
Logistic Regression	0.490909	0.049793	180
Deep Learning	0.490909	0.049793	475
Decision Tree	0.509091	0.121967	100
Random Forest	0.490909	0.049793	4323
Gradient Boosted Trees	0.490909	0.049793	6227
Support Vector Machine	0.490909	0.049793	690

Naive Bayes show 0.490909 accuracy and 0.049793 standard deviation and 66 run time. Generalized Linear Model show 0.490909 accuracy and 0.049793 standard deviation standard deviation and 150 run time. Logistic Regression Model show 0.490909 accuracy and 0.049793 standard deviation and 180 run time. Deep Learning Model show 0.490909 accuracy and 0.049793 standard deviation and 475 run time. Decision Tree Model show 0.509091 accuracy and 0.121967 standard deviation and 100 run time. Random Forest Tree Model show 0.490909 accuracy and 0.049793 standard deviation and 2457 run time.

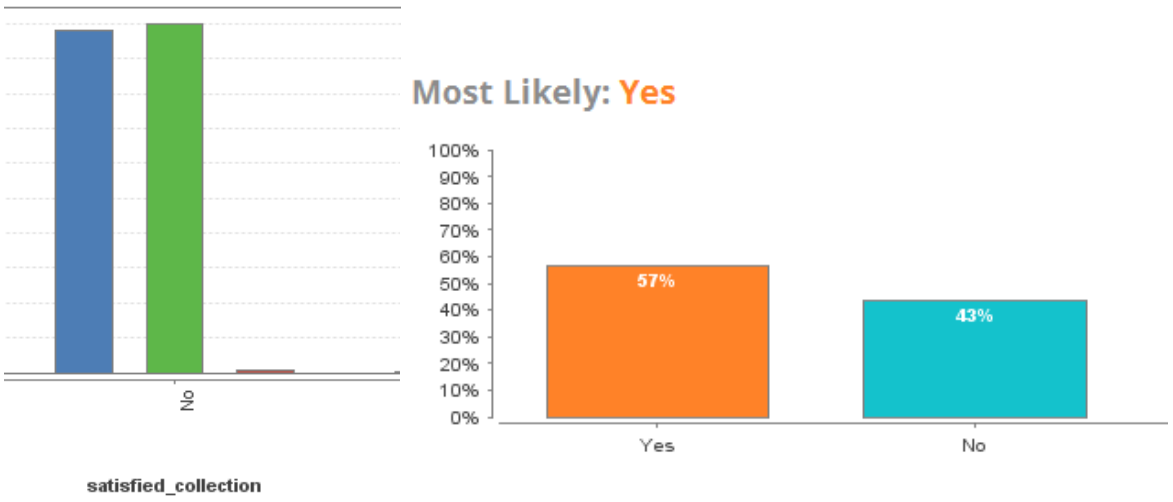

Figure 7. 16

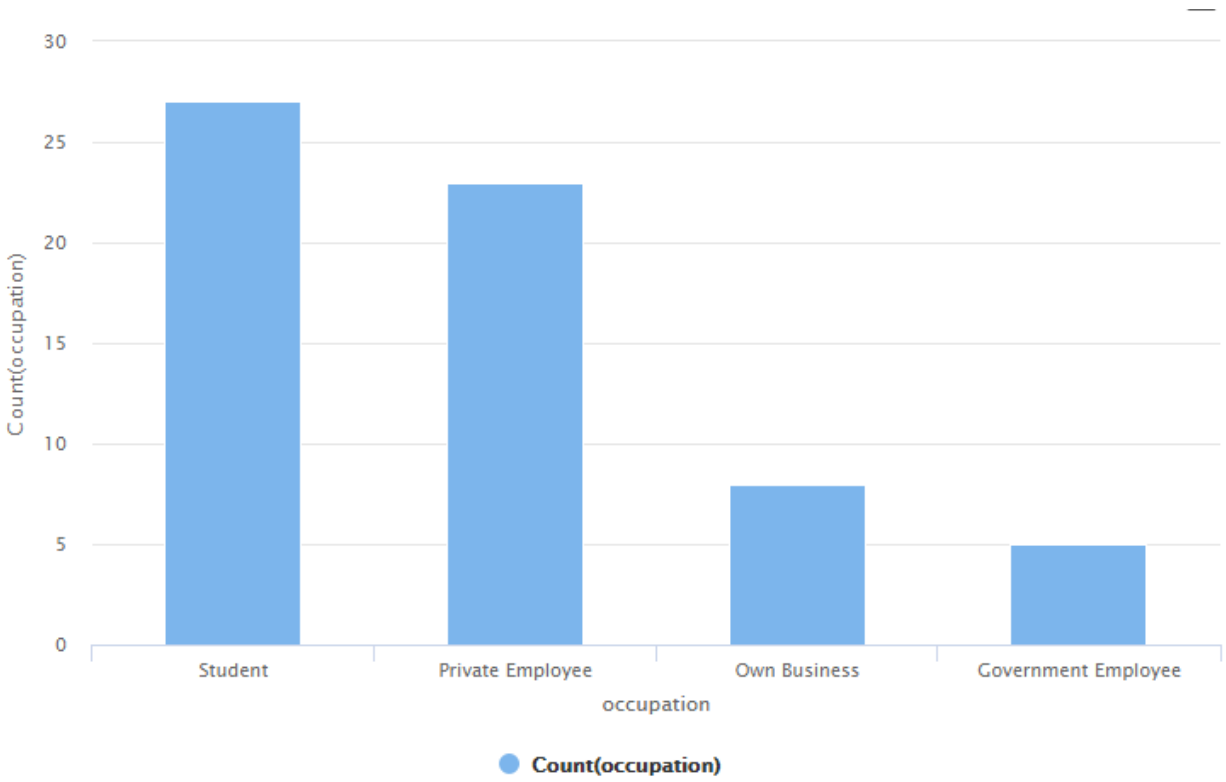

Figure 7. 17

In this we find that when we are unsatisfied from waste collection the diseases suffered mostly due to not proper waste collection of public method type.

7.1.9 Relation Between Disease and Regular service

```
SELECT ` suffered_ diseases`,`regular_collection` FROM `survey`
WHERE `regular_collection` = 'Yes'
```

Figure 7. 18

1st of all data convert into database and get results of rational query in which we find the relationship of Relation of Disease and Regular service we find total 574 and 260/274 suffered diseases and other 236 is not suffered diseases.

ML Result

Table 7. 8: Relation Between Disease and Regular service

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.537931	0.04511	92
Decision Tree	0.537931	0.04511	106
Random Forest	0.537931	0.04511	1637

Naive Bayes show 0.537931 accuracy and 0.04511 standard deviation and 92 run time. Decision Tree Model show 0.537931 accuracy and 0.04511 standard deviation and 106 run time. Random Forest Tree Model show 0.537931 accuracy and 0.04511 standard deviation and 1637 run time.

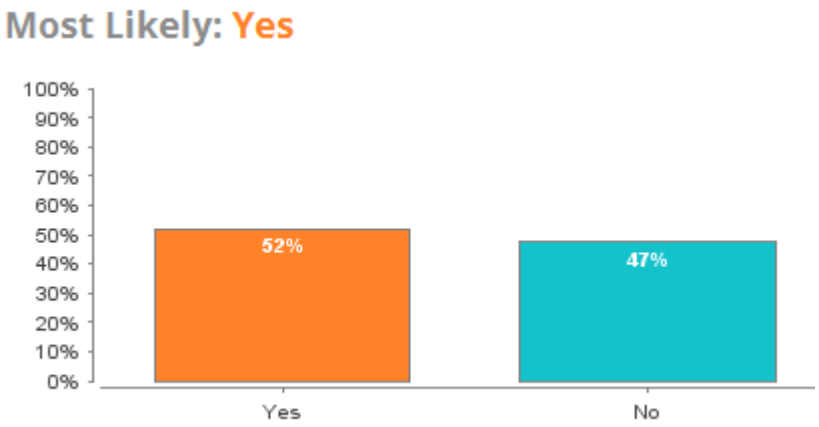

Figure 7. 19

In this we find that when we have Regular service in our areas the diseases also suffered.

7.1.10 Relation Between Disease and service type in public

```
SELECT `service_type`,` suffered_ diseases` FROM `survey` WHERE
`service_type` = 'Public'
```

Figure 7. 20

1st of all data convert into database and get results of rational query in which we find the relationship of Relation of Between Disease and service type in public `we find total 406 and 212/406 suffered diseases and other 194 is not suffered diseases.

ML Result

Table 7. 9: Relation Between Disease and service type in public

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.525725	0.078428	77
Decision Tree	0.525725	0.078428	122
Random Forest	0.525725	0.078428	1400

Naive Bayes show 0.525725 accuracy and 0.078428 standard deviation and 77 run time. Decision Tree Model show 0.525725 accuracy and 0.078428 standard deviation and 122 run time. Random Forest Tree Model show 0.525725 accuracy and 0.078428 standard deviation and 1400 run time.

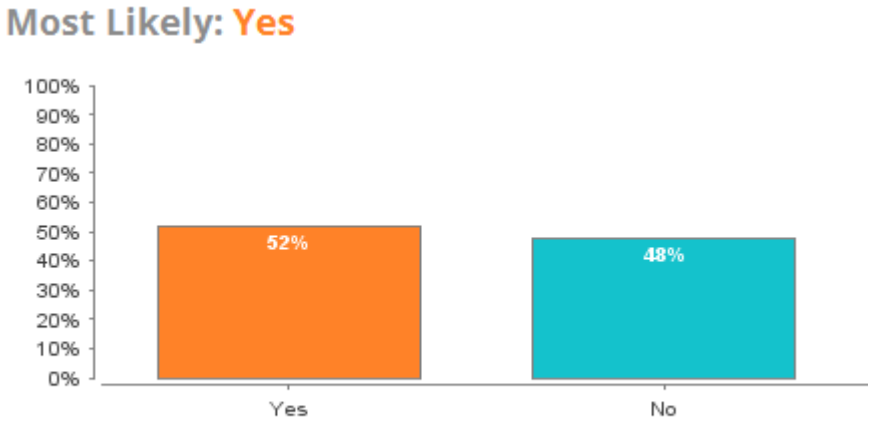

Figure 7. 21

In this we find that when we have service type public in our areas the diseases mostly suffered.

7.1.11 Relation Between Disease and Main reasons of unsatisfaction waste

```
SELECT ` suffered_ diseases`, ` main_problems_currentwaste` FROM
`survey` WHERE ` suffered_ diseases` = 'Yes'
```

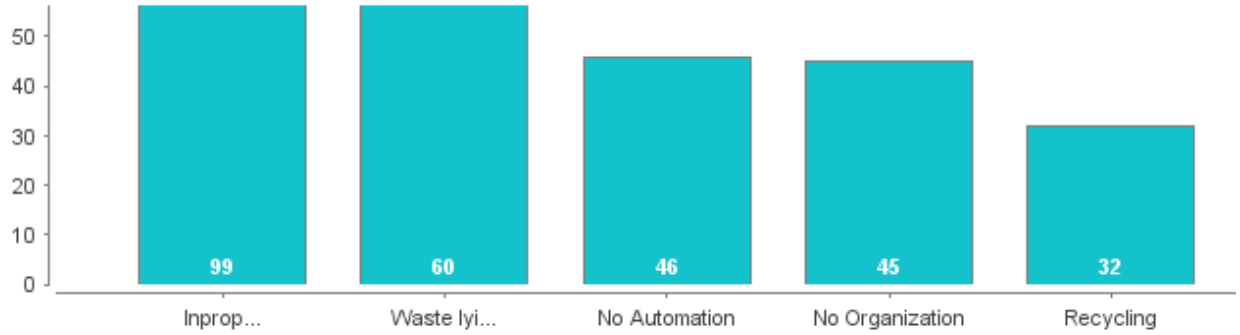

Figure 7. 22: Relation Between Disease and Main reasons of unsatisfaction waste

1st of all data convert into database and get results of rational query in which we find the relationship of Relation of Between Disease and Main reasons of unsatisfaction waste we find total 99 have improper waste collection 60 waste lying in ground 46 no automation and 45 No organization and 32 recycling as a main problem.

ML Result

Table 7. 10: Relation Between Disease and Main reasons of unsatisfaction waste

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.358824	0.05711	93
Decision Tree	0.358824	0.05711	126
Random Forest	0.358824	0.05711	2574

Naive Bayes show 0.358824 accuracy and 0.05711 standard deviation and 93 run time. Decision Tree Model show 0.358824 accuracy and 0.05711 standard deviation and 126 run time. Random Forest Tree Model show 0.358824 accuracy and 0.05711 standard deviation and 2574 run time.

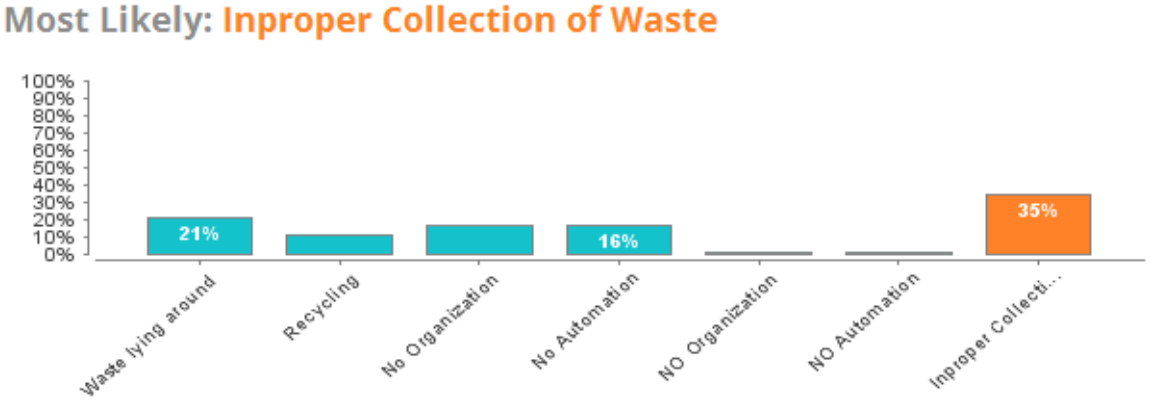

Figure 7. 23

In this we find that when we have service type public in our areas the diseases mostly suffered.

7.1.12 Relation Between Disease and large bin is 'NO'

```
SELECT ` suffered_ diseases`, `large_bins` FROM `survey` WHERE
`large_bins` = 'No'
```

Figure 7. 24: Relation Between Disease and large bin is 'NO'

1st of all data convert into database and get results of rational query in which we find the relationship of Relation of Between Disease and large bin is 'NO' we find total 294 and 154 suffered with disease and 140 are not suffered.

ML Results

Table 7. 11: Relation Between Disease and large bin is 'NO'

Model	Accuracy	Standard Deviation	Runtime
Naive Bayes	0.536765	0.090951	64
Generalized Linear Model	0.5125	0.07146	188
Logistic Regression	0.536765	0.090951	212
Deep Learning	0.536765	0.090951	755
Decision Tree	0.536765	0.090951	127
Random Forest	0.536765	0.090951	1080
Support Vector Machine	0.536765	0.090951	817

Naive Bayes show 0.536765 accuracy and 0.090951 standard deviation and 64 run time. Generalized Linear Model show 0.5125 accuracy and 0.07146 standard deviation standard deviation and 188 run time. Logistic Regression Model show 0.536765 accuracy and 0.090951 standard deviation and 212 run time. Deep Learning Model show 0.536765 accuracy and 0.090951 standard deviation and 755 run time. Decision Tree Model show 0.536765 accuracy and 0.090951 standard deviation and 127 run time. Random Forest Tree Model show 0.536765 accuracy and 0.090951 standard deviation and 1080 run time.

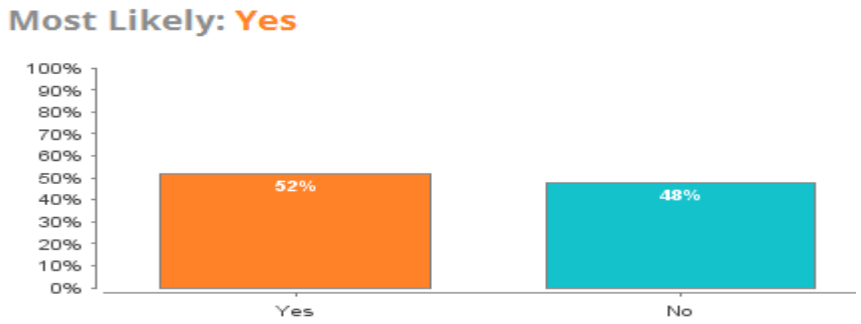

Figure 7. 25

In this we find that when large bins are not in areas than the diseases mostly suffered.

7.2 Statistical Analysis by Different Models

Here we have described the results that are processed by different models by using rapid miner tool.

Tool:

- ✓ Rapid miner

Apply models:

- ✓ Naive Bayes
- ✓ Generalized Linear Model
- ✓ Logistic Regression
- ✓ Deep Learning
- ✓ Decision Tree
- ✓ Random Forest
- ✓ Gradient Boosted Trees (XGBoost)

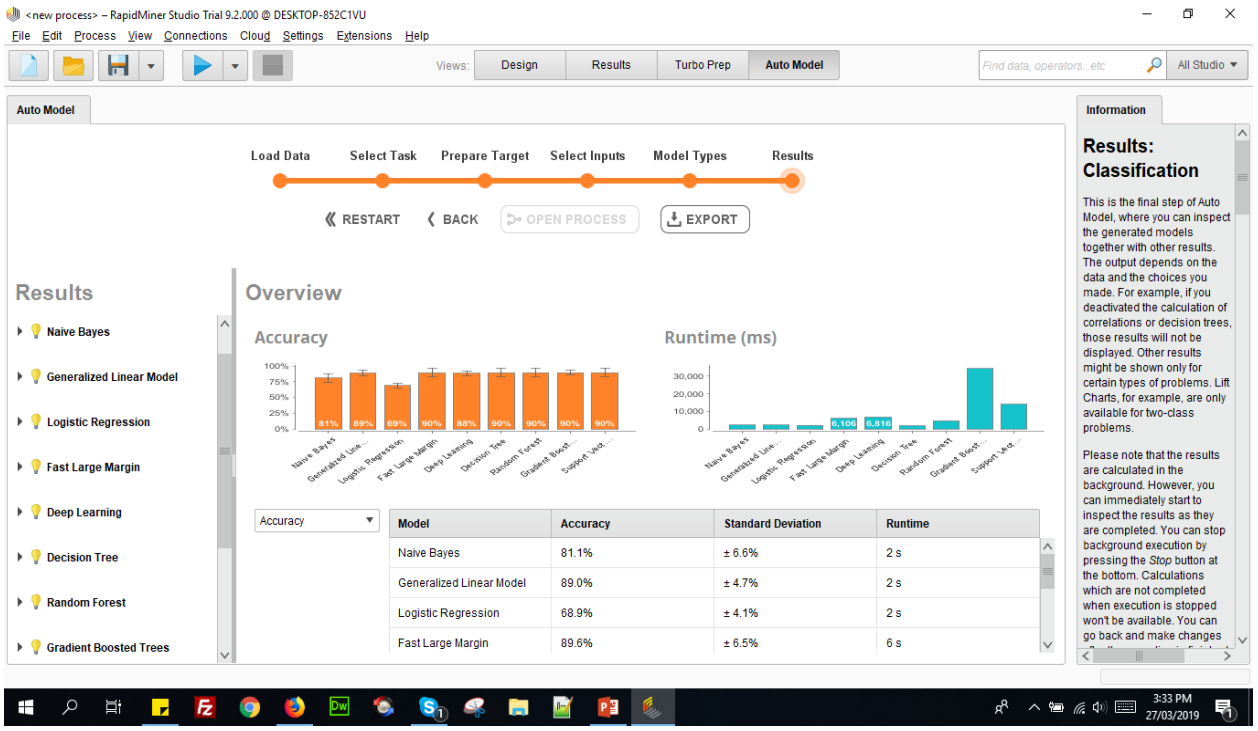

Figure 7. 26: RapidMinor

Naive Bayes Classification Model

Naive Bayes is a high-bias, low-variance classifier, and it can build a good model even with a small data set. It is simple to use and computationally inexpensive. Typical use cases involve text categorization, including spam detection, sentiment analysis, and recommender systems.

The Operator Split Data divides the original data set into two parts: one is used to train Naive Bayes, and the other to evaluate the model. The result shows that this simple model can generate a good fit to the Iris data set.

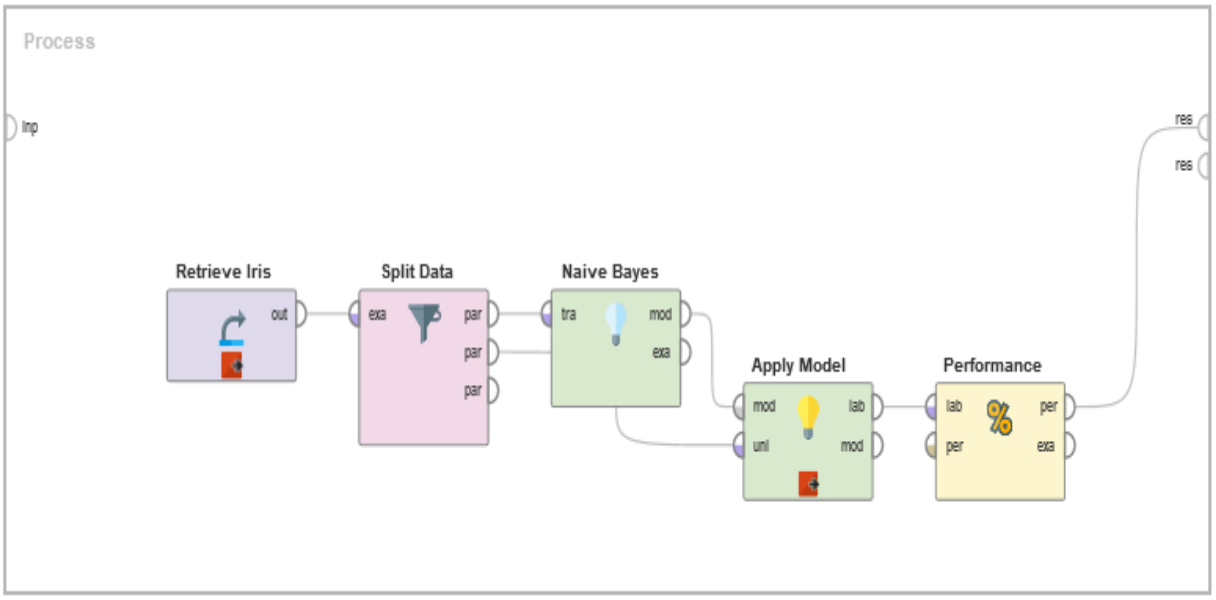

Figure 7. 27: Naive Bayes Classification Model

7.2.1 Relation Between Area and Smart Bin Installation

In this figure we show the result of Relation Between Area and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship was area where people want to install smart bin

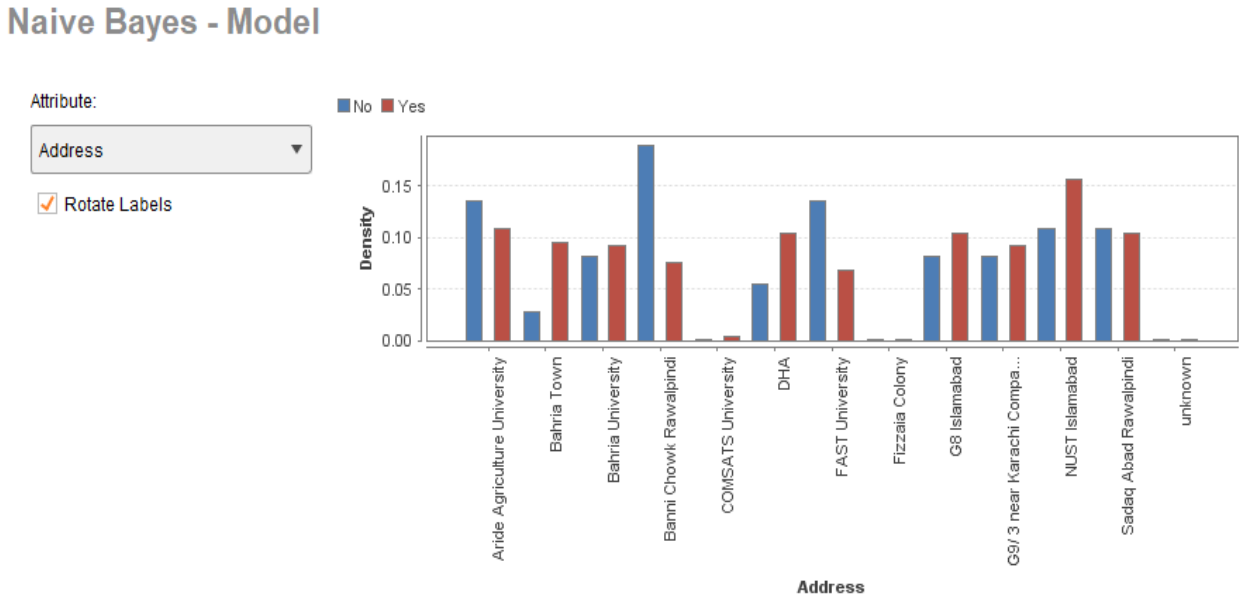

Figure 7. 28: Relation Between Area and Smart Bin Installation

Through this model it shows 6 Areas like (Bahria Town, Bahria University Islamabad, G8

Islamabad, G9 Islamabad, NUST University) want to install smart bin mostly

Prediction:

Areas who want to install Smart Bin Mostly

- Bahria Town
- Bahria University
- DHA Islamabad
- G8 Islamabad
- G9 Islamabad
- NUST University

7.2.2 Relation Between Age Group and Smart Bin Installation

In this figure we show the result of Relation Between Age Group and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is Age group who want to install smart bin

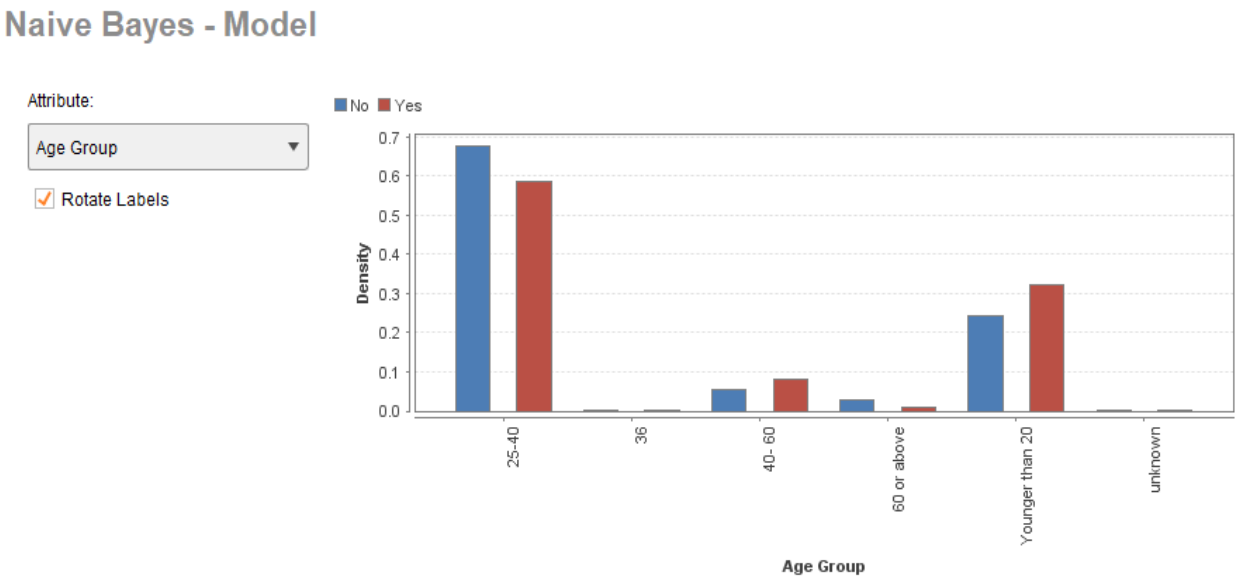

Figure 7. 29: Relation Between Age Group and Smart Bin Installation

Through this model it shows 2 Age group of people like (Younger than 25,25– 40 year age) want to install smart bin mostly

Prediction:

Age Group who want to install Smart Bin Mostly

- Younger than 25

- 25 – 40-year age

7.2.3 Relation Between Gender and Smart Bin Installation

In this figure we show the result of Relation Between Gender and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is which gender is most interested to install smart bin

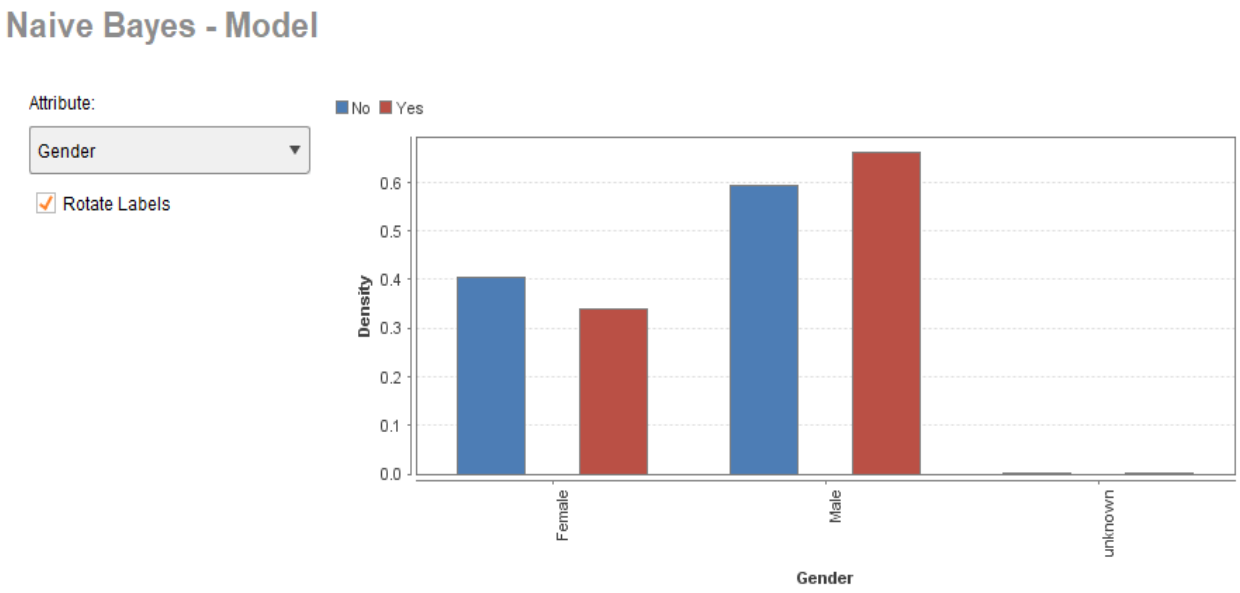

Figure 7. 30: Relation Between Gender and Smart Bin Installation

Through this model it shows Male gender is most interested to install smart bin

Prediction:

Gender who want to install Smart Bin Mostly

- Male

7.2.4 Relation Between Collection Service and Smart Bin Installation

In this figure we show the result of Relation Between Collection Service and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is which collection service is most interested to install smart bin

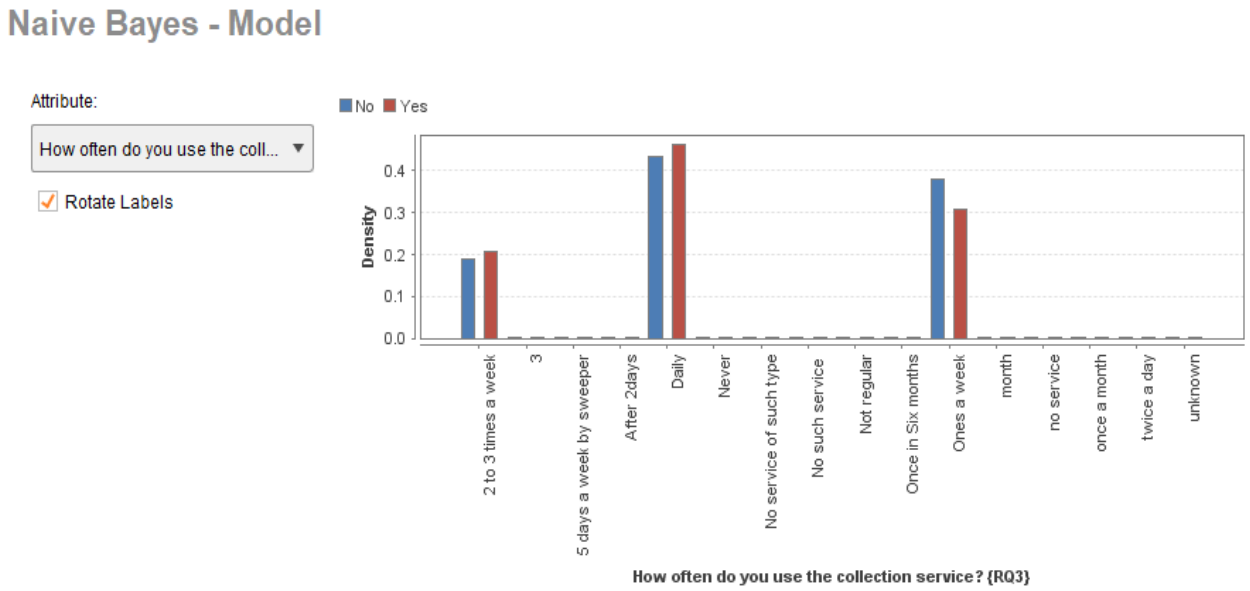

Figure 7. 31: Relation Between Collection Service and Smart Bin Installation

Through this model it shows that those people who use their waste service Daily they are mostly interested to install smart bin

Prediction:

Collection Service who want to install Smart Bin Mostly

- ❖ Daily

7.2.5 Relation Between Large Bin and Smart Bin Installation

In this figure we show the result of Relation Between Large Bin and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is where large bin is situated and they also interested to install smart bin

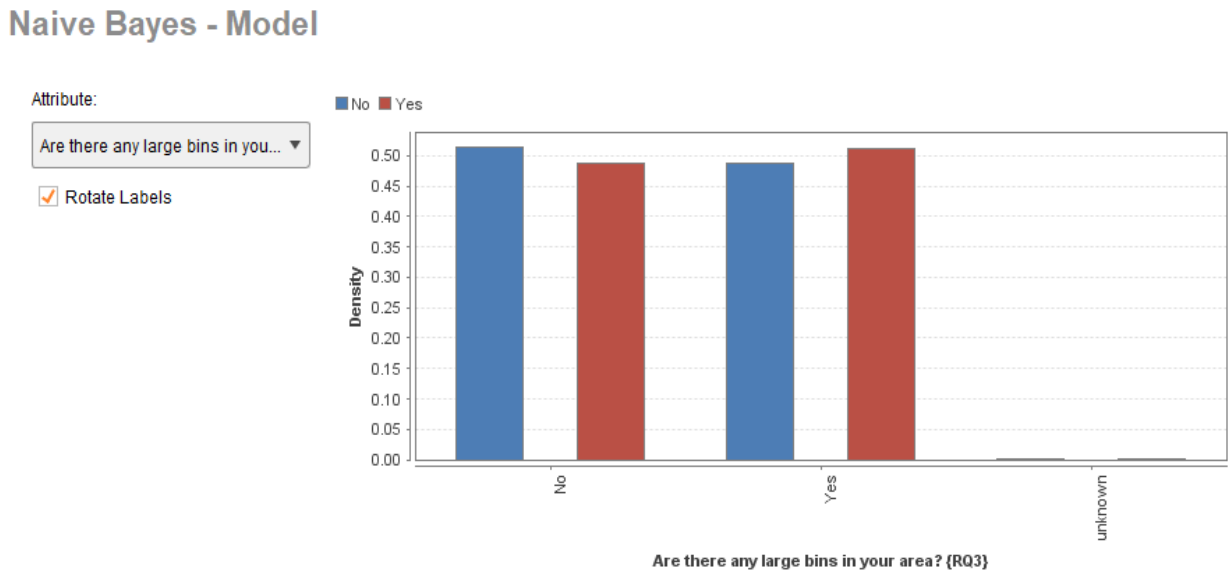

Figure 7. 32: Relation Between Large Bin and Smart Bin Installation

Through this model it shows large bin is situated and they also interested to install smart bin

Prediction:

where large bin is install and want to install Smart Bin Mostly

- Yes

7.2.6 Relation Between Employment and Smart Bin Installation

In this figure we show the result of Relation Between Employment and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is which occupation or employment interested to install smart bin

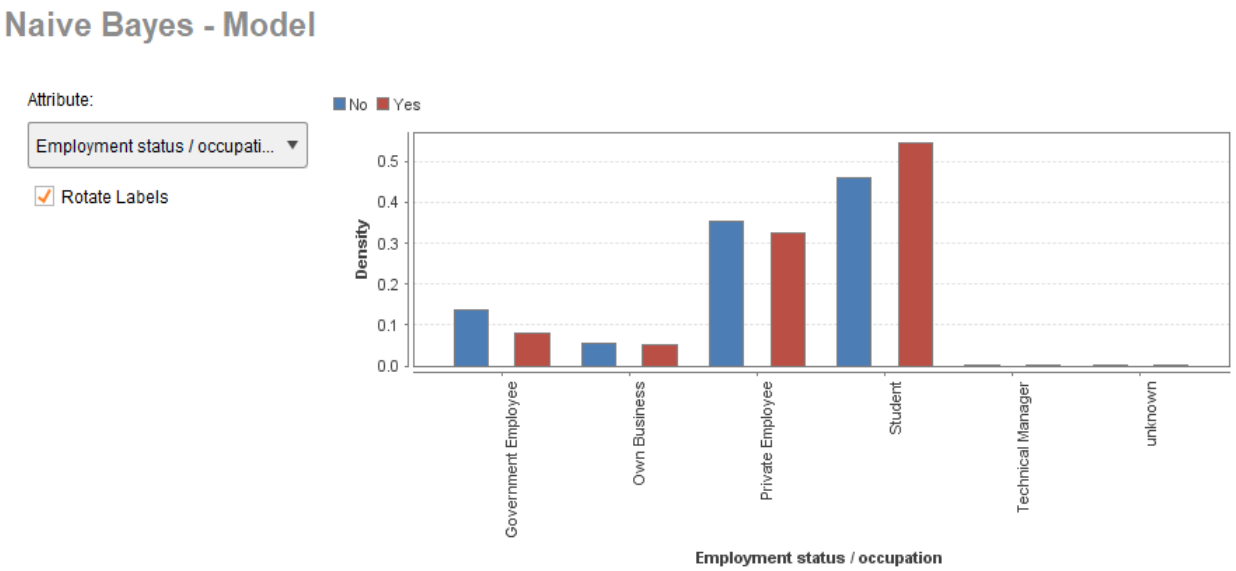

Figure 7. 33: Relation Between Employment and Smart Bin Installation

Through this model it shows student occupation or employment who is mostly interested to install smart bin

Prediction:

Employment Status who want to install Smart Bin Mostly

- ❖ Student

7.2.7 Relation Between Satisfaction current system and Smart Bin Installation

In this figure we show the result of Relation Between Satisfaction current system and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is that people are satisfy through current waste collection method and also interested to install smart bin

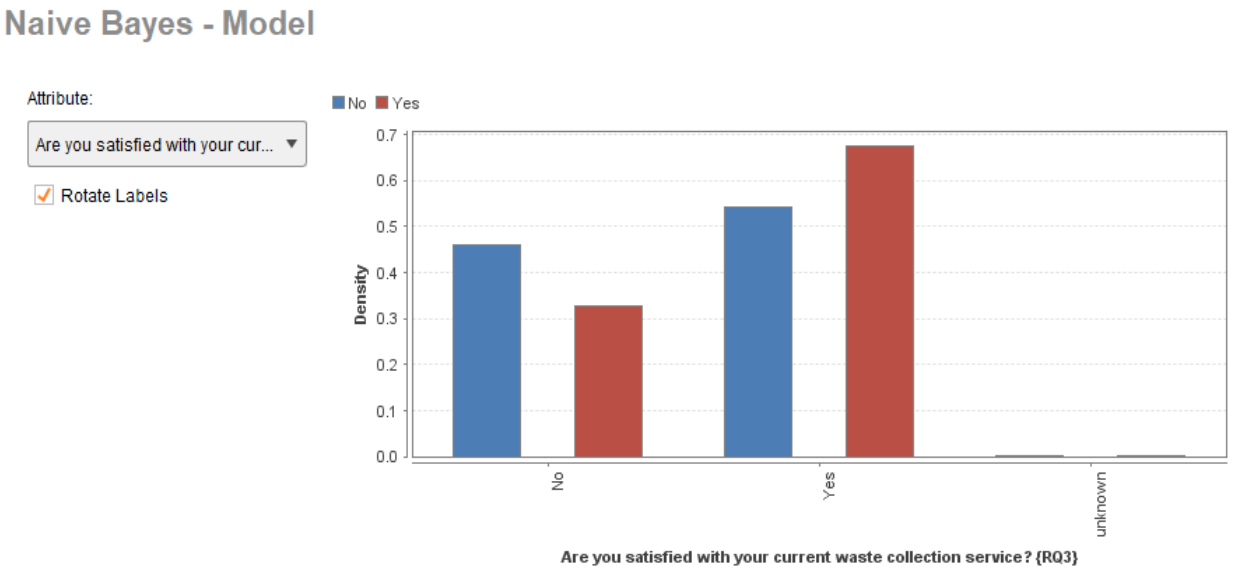

Figure 7. 34: Relation Between Satisfaction current system and Smart Bin Installation

Through this model it shows that people are satisfy through current waste collection method and also interested to install smart bin

Prediction:

Those people who satisfy through current waste system and want to install Smart Bin Mostly

- ❖ Yes

7.2.8 Relation Between Diseases and Smart Bin Installation

In this figure we show the result Relation Between Diseases and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is that people suffered into diseases due to improper waste collection and interested to install smart bin

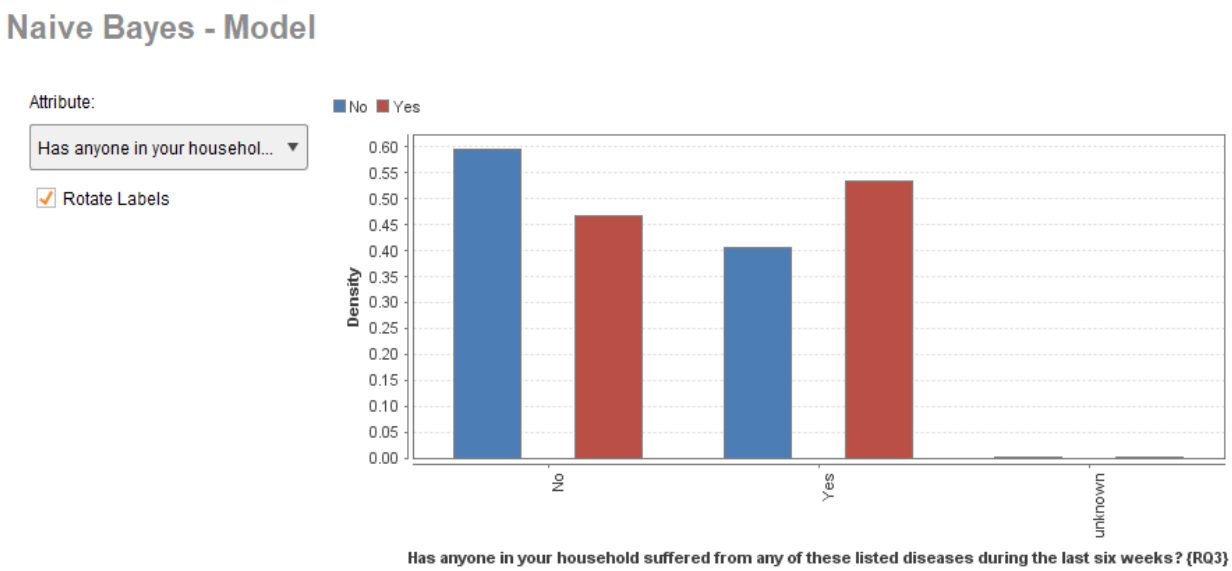

Figure 7. 35: Relation Between Diseases and Smart Bin Installation

Through this model it shows yes people suffered into diseases due to improper waste collection and interested to install smart bin

Prediction:

Those people who suffered from any of diseases during last 6 week and want to install Smart Bin Mostly

- Yes

7.2.9 Relation Between main problem and Smart Bin Installation

In this figure we show the result of Relation Between main problem and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is that what is the main problem of current waste management due to people interested to install smart bin

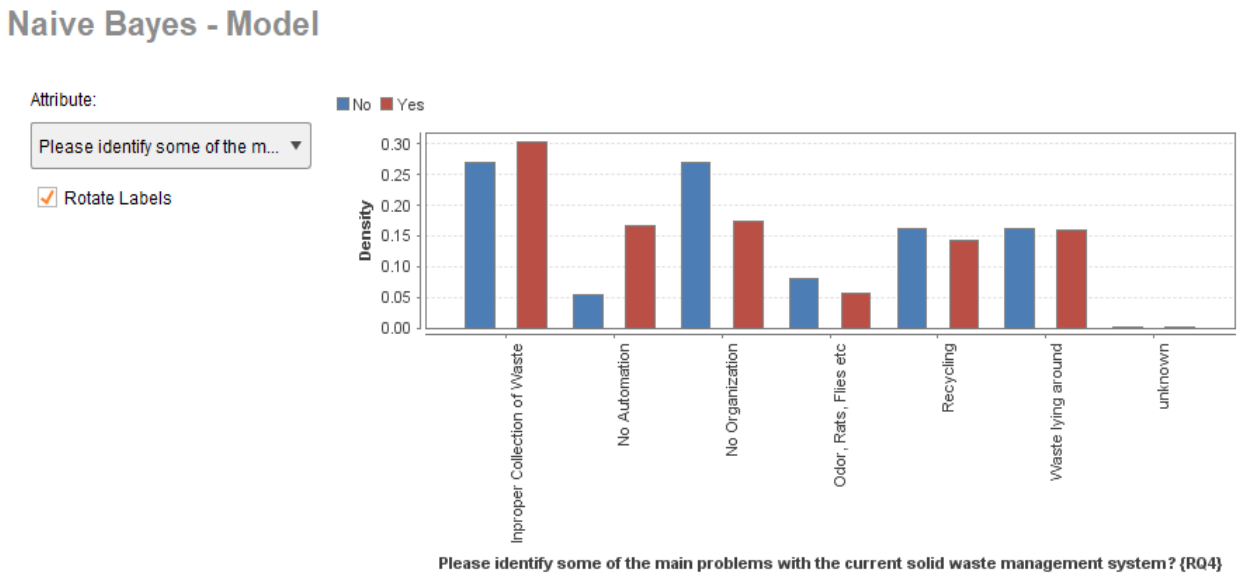

Figure 7. 36: Relation Between main problem and Smart Bin Installation

Through this model it shows that improper waste collection is the main reason of current waste management due to people interested to install smart bin

Prediction:

Main problem of waste management and want to install Smart Bin Mostly

- ❖ Improper Collection of waste

7.2.10 Relation Between Demand of Smart Bin Installation

In this figure we show the result of Relation Between want proper computer system and Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last I performed performance variable than rum my model it give me result my relationship is that if a proper computer system is launch who ease collection system can people interested to install smart waste bin

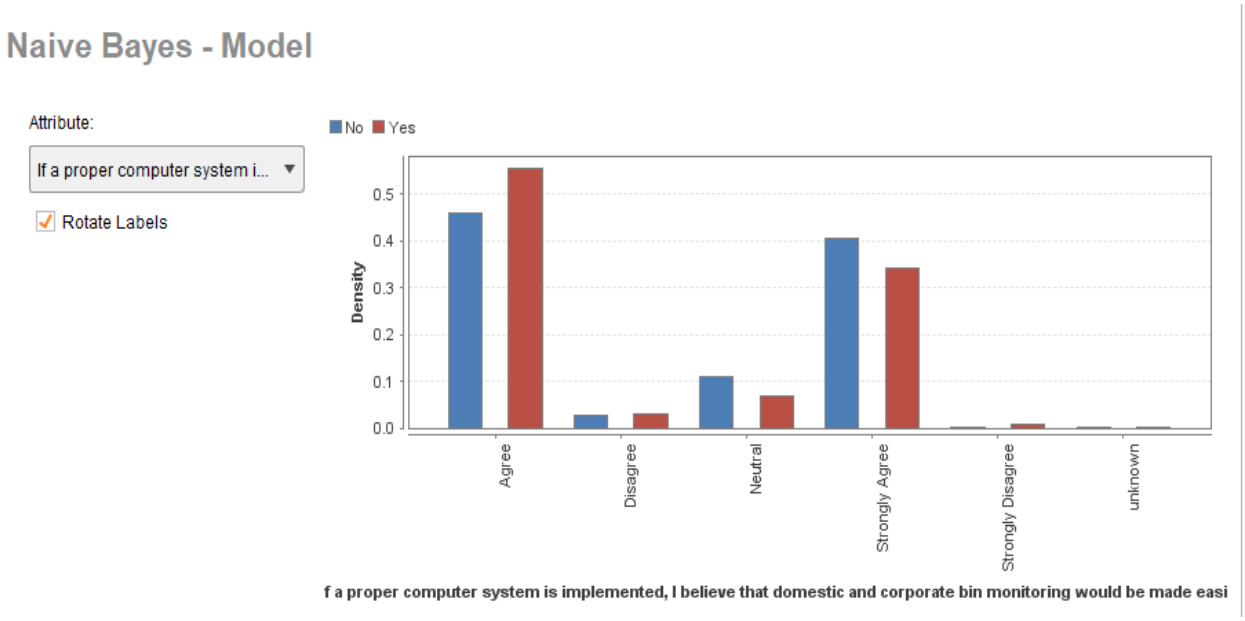

Figure 7. 37: Relation Between Demand of Smart Bin Installation

Through this model it shows that yes if a proper computer system is launch who ease collection system can people interested to install smart waste bin

Prediction:

If a proper computerize system implemented and want to install Smart Bin Mostly

- ❖ Agree

Overall Predictions

In this figure we show the result of Relations of Smart Bin Installation for this result we perform model naïve Bayes model in RapidMiner. 1st of all I input my data which was in excel form format import data and then perform validation parameter after validation I apply naïve Bayes model than perform cross validation and at last, I performed performance variable than rum my model it gives me result my relationship is that

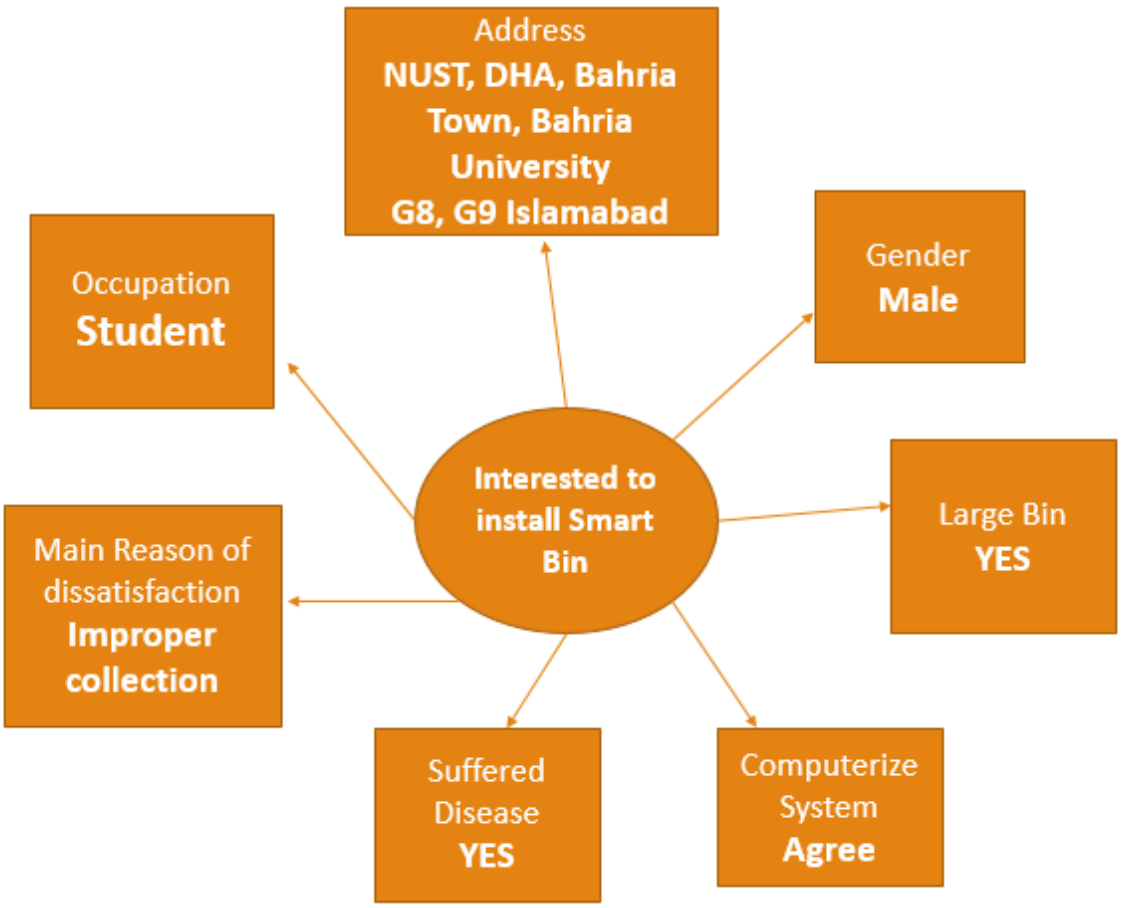

Figure 7. 38: Overall Predictions

if whose people who is educated or student their gender is male, and they live in developed areas they have large bin for waste collection and they also suffer with diseases due to improper waste collection they want to install Smart Bin In their areas

Figure explain that male people of educated areas and student want to install smart bins. Also, who people their areas are in under waste problems they also want to install smart method of waste collection. Also if a computerize system is launch who define their fill level, real time monitoring, proper notification the peoples are interested to install smart bins in their areas

Chapter 8

8.0 Conclusions

This chapter provides the Conclusion, Reconciliation of Research Questions and Future work of the thesis.

8.1 Traditional Waste Management

This survey has been performed for collecting the details of TWM system, problem, waste generation, waste disposal, waste collection, main reasons, satisfaction, dissatisfaction scenario, smart waste management, health issues and many more.

8.1.1 Smart Waste Management

A Smart City is an efficient and sustainable place with intelligent public services. There is not just a single style of Smart City; each one can become more effective and sustainable with different solutions that can be tailored to its specific needs. The cities of the future must be more sustainable, safer, effective, relaxed, and communicating. They will be an urban environment that is always connecting with the residents and capable of managing public services in real time to progress their quality of life, waste collection, through traffic management, irrigation systems, alerting the local authority when an event occurs and allowing the government to stay in touch with the people. Technologies allow us to make more reasonable decisions.

Technology driven initiatives to encourage people and children to throw rubbish in the bin, this will keep them up on good conduct, keep on health, save the environment, make more space for Malls, Restaurants, Parks, Schools, Universities and Homes.

So, the smart waste management system is a step forward to make the manual collection and detection of wastes smart in nature and monitoring waste collection. The developed system by using five subsystems Smart Waste System, Local Station, Smart Monitoring and controlling, Smart Truck System and Smart Monitoring and controlling Interface the Smart waste to monitor the bins filling, include the Centre system get data from Wireless ultrasonic Sensor Networks have been working to specific sensors with RF transmitter use with arduion and, use GSM/GPRS.

Solid waste collection management processes and monitoring. This offer the organization of wastes is effective and time saving process than the presently start technique in which worried urban worker has to see for the filled waste bins manually through different spots in a

region/street for testing regularly whether the waste bin is filled or not and show

waste levels bins, which is difficult and time-consuming development. This smart of waste too decreases the human effort and as a result the cost of the whole process. This system might be implemented at any residence with simplicity and within reasonable quantity of time. The implementation costs for the smart is also affordable. The general method for the discovery and management of waste becomes efficient and intelligent. This planned system would not only purpose for collecting and updating data automatically and timely, but similarly it might analyses and use data intelligently. The planned system would solve a lot of problems connected to solid waste collection, minimizing cost, monitoring and accelerate the management. The system has many advantages than the other system was done before because

The hardware used more developer and using Arduino is open foundation can use free to Get the schematics and programming software and advance them with free code libraries. And used to GSM/GPRS One advantage of using SMS is that it will preserve the shield having to begin a GPRS connection which will usually take longer and may use more power.

Smart waste method offers a higher quality service to the citizen like fill level, optimal level, notification also geo location of fill bin Smart waste method can be easily implemented in the city and Easy-to-use Service because it is use small battery and wireless small device their usage is very easy and easy implement anywhere with low knowledge. Smart waste Bin can be used everywhere when the place has network and signal of mobile

phone with SIM card

8.2 Reconciliation of Research Questions

To address the objective and guide the process of research, four research questions were

put forward. they are revised in the sections and the key finding and conclusions related to each question are presented and discussed below.

RQ1) How waste can be measured in Pakistan?

For this question we review existing Literature on the subject and conduct survey to collect remaining data. We find in Pakistan generates about 30 million tons of solid waste a year through literature review, and we conduct a survey our survey question 10, 29, 30 indicate the measurement of waste their production in percentage. we cover the Rawalpindi and Islamabad 10 different areas and then we measure the waste and waste issues through the survey. Through case study article newspaper, website and other resources of Pakistan waste collection we measure the waste.

Also, we conduct interview to CDA (Capital Development Authority, Islamabad) supervisor in G9 Sector Islamabad (Karachi company) and through this interview we asked the question

of waste generation waste collection, all about waste.

RQ2) Why SWM has not been implemented in Pakistan yet? What hurdles exist before it can be implemented?

For this question we conduct survey to learn difficulty in the adoption of SWM, people's perception and awareness regarding it and identify hurdles being faced for its implementation.

Pakistan is one of underdeveloped country. Due to lack of knowledge and innovation there is no any smart waste collection method implement in Pakistan yet. For measure or SWM we conduct a survey we cover 10 different areas of Islamabad, Rawalpindi areas and our survey questions 11, 12, 14, 25, 31, 32, 35, 40, 41 indicate the hurdles and not implementation of SWM in Pakistan, Basic reason of not implementation is lack of knowledge lack of innovation. Also 1st time cost of implementation of devices is the main reason for not implement yet in Pakistan.

RQ3) Which SWM methodologies exist and which are ideal to be implemented in Pakistan?

For this question we review existing Literature and suggest models that meet our criteria for selection. Pakistan is one of underdeveloped country. Due to lack of knowledge and innovation there is no any smart waste collection method implement in Pakistan yet. In Pakistan there is a traditional waste management is working which is not proper method for collections and there are many issues in the existing method, many health issues spread through waste improper collection and waste generation exceeding limit.

For measure SWM we conduct a survey we cover 10 different areas of Islamabad, Rawalpindi areas and our survey questions 7, 8, 9 , 13, 16, 17, 19, 26, 33 , 34, 36, 37, 39 indicate the SWM methodologies and not implementation of SWM in Pakistan.

We purpose a SWM which is efficient and cover all our requirements. In future we implement this method which fill our requirement like Recycling, IOT (internet of things), Smart Bins, Cost Effective, Citizen Involvement, Real Time Monitoring, RFID, another Wireless Sensor.

Through survey and literature review we know yet there is not any smart waste management method in Pakistan. Outside Pakistan SWM is used and take important rule in environment.

RQ4) How SWM can resolve Pakistan's existing waste management issues?

For this question we review existing Literature and identify problems that can be solved by SWM, that are currently being faced by people and city administrative authorities.

For measure SWM we conduct a survey we cover 10 different areas of Islamabad, Rawalpindi areas and our survey questions 18, 21, 22, 23, 24, 28, 38, 42, 43 indicate the SWM methodologies and not implementation of SWM in Pakistan

In Pakistan there is no any smart waste management the main issues which we find through survey is lack of innovation and lack of knowledge. Outside Pakistan in India, Canada, Australia, Europe and many more countries use SWM methods and we know about their literature that if we launch smart waste management its benefit ease our life through current traditional waste method, in which real time monitoring, fill level, Geo location, notification, and many more benefit that ease our life. SWM devices have one-time cost after that it ease our life. If we compare traditional waste cost with one time cost we find that smart waste method is cost effective.

Through survey and literature review we know main reason is lack of knowledge and lack of innovation. People not know about their benefit and effectiveness.

8.3 Limitation:

Our purposed questionnaire survey covers only select issues as related to the denizens

of cities. (small segment papulation) like its only cover small areas of Islamabad Rawalpindi. Due to small areas where we conduct our survey perception of the individuals who have filled the questionnaire and cannot be generalized This could limit the findings as these cities work under similar type of political, economic, and social environment.

Due to undeveloped country of Pakistan and lack of knowledge about new and smart methods the understanding of the psyche of the people impacted by a scheme of SWM. For launch of the smart waste methods and understanding of people we want to Carrey out such more studies to arrive at better options for the management of solid wastes. Study conducted has been done in metropolitan area.

Smart Bins is expansive on 1st time implementation as compare to traditional method because of installing smart devices, smart bin, wireless sensor, IOT devices, internet, geo location device, mobile application, desktop application.

8.4 Future Work:

After all studies and experiment we will implementation Smart Bin our area to notice the advantages of smart method of collection as compare to traditional method. We will focus on smart waste method for Recycling and reuse our waste for energy generation and agriculture department. In future we implement smart method of collection of waste which segregating different kind of wastes (e.g., solid, liquid etc.) We will work on separation of different kind of waste and Identifying different vehicles for collecting different wastes (e.g., solid, liquid etc.). In future we will work on different kind of waste use for different purpose of generation of energy and so on for example we can use wet waste can be

decomposed and used for making biogas. Application of improvement in another city administration this would likewise decide the part of the structure that should be disconnected from city administrations. Deliberation of structure capacities would make it less demanding to apply structure to different city administrations without requiring numerous program

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