BasuraHunt: Next Level Monitoring Application System for Waste Management Solution

A Capstone Project Documentation

Presented to

The Institute of Information, Communication Technology

PATEROS TECHNOLOGICAL COLLEGE

In Partial Fulfillment

of the Requirements for the Degree

BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY

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June 2024

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Chapter 1 Background

Introduction

Urban areas worldwide face significant challenges in managing waste effectively. Rapid urbanization and population growth have worsened issues with improper waste, disposal, which results in environmental degradation, health risks, and a decline in the quality of life for residents. Despite ongoing efforts by municipal authorities to address this issue.

These concerns are emphasized by the continual occurrence of improper waste and unregulated dumping sites. There is a need for more innovative and proactive solutions. This capstone project presents BasuraHunt as a solution to these challenges. This is a pioneering mobile application specifically designed to enhance waste management practices in Baranggay Pinagbuhatan in Pasig City, particular in Nagpayong Area.

BasuraHunt App utilizes technology to empower its users. Residents should actively participate in maintaining the cleanliness of their neighborhoods. The application allows users to document and report instances of improper waste. disposal using their smartphones, creating a platform that is driven by the community environmental stewardship.

This project operates through a straightforward yet effective process. Users capture photos of illegal throwing or waste issues, geotag the images, and submit reports directly through the app. The app then consolidates these reports into a centralized database, offering local Authorities are provided with real-time data on waste disposal hotspots. This data-driven approach enables municipal authorities

to prioritize and address waste management issues. More efficiently and systematically.

This capstone project aims to demonstrate the significant impact of technology-driven solutions have the potential to significantly impact urban waste management. BasuraHunt App represents a crucial step. The research focused towards creating a sustainable, clean, and healthy environment for all residents in Nagpayong, Baranggay Pinagbuhatan, Pasig City. Through this initiative, this project aims to encourage the community by leveraging innovation and fostering collaboration with BasuraHunt App to achieve an eco-friendly society.

Project Context and It’s Background

In the active area of Nagpayong Barangay Pinagbuhatan, Pasig City, the issue of improper waste disposal has become increasingly prominent. Navigating the streets and neighborhoods reveals litter to be a prevalent problem affecting the community's aesthetics and health. Based on this observation, the researchers started a conversation about how they could use technology to tackle this environmental issue. As a result, the researchers developed "BasuraHunt: Next Level Monitoring Application System for Waste Management Solution," a mobile camera-based application that integrates with a database to report and mitigate improper waste disposal.

During routine commutes and community visits in Nagpayong at Brgy. Pinagbuhatan, the researchers frequently encountered piles of garbage scattered along roadsides, near public parks, and in residential areas. Despite the local government efforts to maintain cleanliness, many residents and visitors still did not adhere to proper waste disposal practices. This situation led to various negative consequences, including clogged drainage systems, unpleasant odors, and potential health hazards.

We conducted informal surveys and held conversations with residents to understand the root causes of this issue. The researchers identified several factors, including a lack of awareness about the importance of proper waste disposal, insufficient public waste bins, and inadequate enforcement of waste management regulations. The residents expressed frustration over the recurring litter problem and highlighted the need for a more effective and proactive solution.

The researchers, inspired by the growing trend of smart cities and the increasing accessibility of mobile technology, brainstormed potential solutions that

could harness these advancements to combat improper disposing in Nagpayong area at Brgy. Pinagbuhatan, Pasig City. The vision was an application that would empower residents to take an active role in maintaining their community's cleanliness. By enabling users to document and report instances of improper waste disposal, the aim was to create a collaborative platform that would foster accountability and prompt action from local authorities.

The idea evolved into “BasuraHunt: Next Level Monitoring Application System for Waste Management Solution,” a comprehensive system that integrates mobile capturing of pictures and videos, a robust database, and IoT capabilities. The application's core functionality allows users to capture photos and videos of violators of littering or improper waste disposal sites, reports, and submit them to the app. Local authorities can access and prioritize these reports in a centralized database to make an informed decision and implement appropriate action.

Project Purpose and Description

BasuraHunt App aims to improve waste management by creating an advanced monitoring application system specifically designed to identify and deal with those who violate trash regulations. BasuraHunt aims to improve environmental sustainability, promote proper garbage disposal, and foster cleaner and healthier communities by using modern technology.

- User registration and profile creation: Using the application, users can register and provide basic facts like name, contact information, and location. Ensuring accountability for reported occurrences and enabling individualized user experiences are the goals of this registration process.

- Incident Reporting: The ability for users to report waste infractions immediately through the application will be the core feature of BasuraHunt. Users can provide information about the occurrence, such as the location, a description, and any photos that they may have taken. The information will be accurately timestamped and geotagged.

- Real-Time Monitoring: The application's real-time map interface will show reported occurrences, enabling users and authorized personnel to see how waste violations are distributed over various areas. This feature will allow the appropriate authorities to respond and intervene promptly.

- Community participation: Through encouraging user cooperation and communication, BasuraHunt will promote community participation. Users will be able to take part in community cleanup initiatives coordinated by the app, provide comments on instances that have been reported, and exchange advice on waste management.

- Enforcement Integration: The program will facilitate communication between waste management and environmental protection departments in local governments and enforcement organizations. A dashboard will be available to authorized people so they may assign tasks for investigation and resolution, examine reported issues, and update users.

- Reporting system: BasuraHunt will produce in-depth analyses and reports on hotspots, trends in waste violations, and metrics related to user engagement. These understandings will guide focused actions and policy choices meant to enhance waste management procedures and lessen their negative effects on the environment.

Objectives of the Study

General Objective

The project “BasuraHunt” mainly aims at developing an application that improves the management and surveillance of wastes in different communities. The app calls upon residents to use it by taking pictures or videos about violations in waste management before reporting them. This will give power to individuals who can ensure their localities are clean and make sure that waste disposal is done according to the rules set out. Overall, BasuraHunt App is committed to environmental cleanliness through community participation as well as real time reporting.

Specific Objectives

This study aims to obtain the following

- To design and develop a BasuraHunt Mobile Application
- Enhance Community Engagement in Waste Management.
- Educate and Inform the Community the proper waste disposal.
- Implement real-time reporting and monitoring for waste violators.
- Establish a Centralized Database of violations and compilation for photos and videos.

Significance of the study

The project BasuraHunt Mobile App shows the importance of proper waste management and promotes sustainable habits and reduces trash pollution. By implementing this innovative technology, the following groups stand to gain significantly:

Residents - By participating in this initiative, residents may gain both immediate and long-lasting advantages, contributing to the development of a lively and environmental-friendly community. Provides a multitude of benefits to residents, such as enhanced unity in society, and improved environmental conditions and public well-being.

Municipal Authorities – Basurahunt can monitor and enhance waste collecting procedures, resulting in improved efficiency, safety, and eco-friendly waste management methods.

Waste Collectors - Utilizing modern technology, the garbage collectors are able to monitor and enhance waste collecting procedures, resulting in improved efficiency, safety, and eco-friendly waste management methods.

Environmental Groups - Environmental groups gain from generating substantial environmental effect, improving credibility and exposure, raising public participation and awareness, giving useful data, aligning with their sustainability goals, and creating chances for innovation.

Future Researchers – future researchers can further knowledge, influence legislation, and help create more sustainable and efficient waste management techniques by making use of these resources.

Scope and Limitations

Scope

This project aims to develop an app for smart waste management as well as monitoring in one Barangay. This application can be downloaded by the residents who will use it to take pictures or videos of non-compliance to waste disposal regulations such as wrong disposal of waste materials in MRFs or improper segregation. It has also been considered whether to report these cases or perhaps link them up with existing waste control systems within Barangay.

Limitation

There are some limitations to the BasuraHunt application, a tool that could be useful in making garbage management more efficient in barangays. Firstly, this app is really only as good as the number of people who use it and so levels of engagement may vary depending on internet access or even community awareness. Secondly, failure by app users to secure follow-up actions on reported acts of non-compliance would greatly hinder its enforcement mechanisms in place for garbage management. It can be also used for false reporting, victim stalking and other privacy related issues thus calling for strict guidelines and safeguards. These shortcomings emphasize the need to overcome these obstacles to implement BasuraHunt effectively and have it serve as an answer towards managing waste products within societies.

Conceptual Framework of the Study

This conceptual framework of the proposed project. An input-process-output (IPO) model, which is a visualization that will act as a guide and set of instructions for the development of the system shown below.

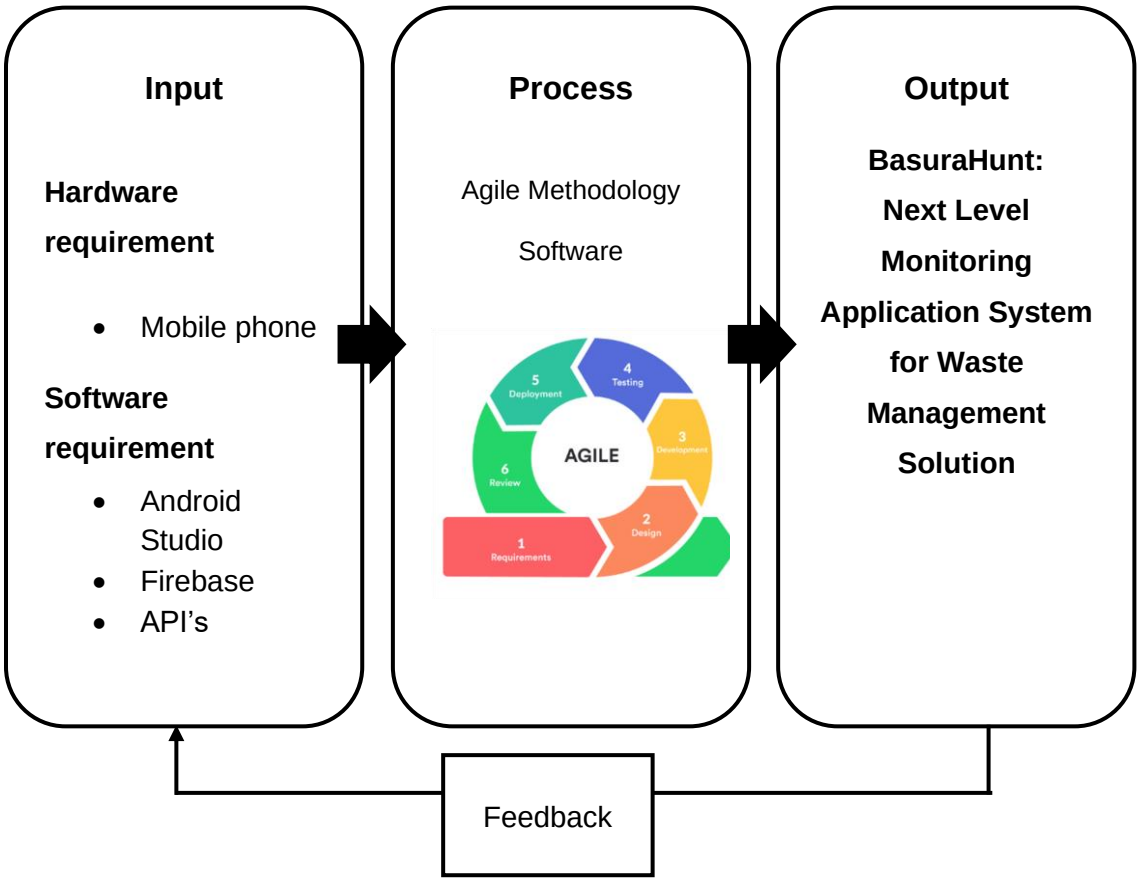

Figure 1. Conceptual Framework

Definition of Terms

Technical Terms

Agile. A methodology defined as a framework for software development success.

Application Programming Interface. It allows BasuraHunt to seamlessly connect and interact with other systems.

BasuraHunt. An app for smart waste management and monitoring that enables users to report their community's violations in waste management.

Cloud computing. provision of computer services via the internet, specifically for the purpose of storing and managing data from the waste management system.

Data analytics. systematic examination and analysis of data sets in order to get meaningful insights and conclusions.

Geo-tagging. Identification of geographical location on various media like photos and videos.

GPS Tracking. utilization of Global Positioning System technology for the purpose of monitoring the current and precise location of waste collection vehicles in real-time.

Mobile Application. A software program specifically developed to operate on portable electronic devices, enabling users to engage with the BasuraHunt system.

The Internet of Things (IoT). refers to a network of interconnected devices that communicate and share data. In the context of BasuraHunt, IoT is utilized for the purpose of enabling smart garbage bins and sensors.

Web Interface. An online portal that enables users to retrieve and control data from the BasuraHunt system.

Wireless communication. facilitating the connectivity of IoT devices inside the BasuraHunt system.

Operational Terms

Collection Schedule. A predetermined timetable that governs the timing of waste collection at various places.

Community Engagement. The process of working with community members to address issues that affect their well-being.

Compliance Monitoring. Ensuring that all waste management activities conform to local rules and environmental requirements.

Feedback Mechanism. An intricate system designed to gather and scrutinize feedback from users and stakeholders with the aim of enhancing the waste management system.

Incident Reporting. Systematic documentation and resolution of any problems or irregularities that arise in the waste management system.

Operational dashboard. A graphical user interface that presents essential performance indicators and metrics pertaining to the waste management system.

Operational Efficiency. capacity to deliver waste management services in a manner that minimizes costs while maintaining high quality standards.

Public Awareness Campaign. Efforts focused on teaching the public about appropriate methods of trash disposal and the advantages of the BasuraHunt system.

Real-time Reporting. Immediate writing & communication of information as it happens

Reporting System. A structured mechanism for recording and communicating incidents, activities or breaches.

Resident Participation. Involving resident in the decision-making processes in governance

Resource allocation. Act of distributing existing resources, such as staff to different jobs within the waste management system.

Service quality Agreement (SLA). a contractual agreement between service providers and clients that specifies the anticipated quality of service, encompassing factors such as response times and performance measures.

Unlawful Dumping. Disposing garbage at sites not approved for dumping.

Urban Cleanliness. absence of dirt, rubbish, pollutants in an urban area.

User Interface (UI). The space where human-machine interactions take place.

Waste segregation. act of categorizing waste into distinct groups to ensure appropriate disposal and recycling.

Chapter 2 Review of Related Literature, Studies and Systems

This chapter presents the relevant literature and studies that the researcher considered in strengthening the importance of the current study. It also presents the synthesis to fully comprehend the capstone project BasuraHunt: Next Level Monitoring Application System for Waste Management Solution

Related Literature

Local Literature

According to Development Asia (2022), the rapid urbanization, its resultant high population density, and increasing commercial activities have led to dramatic growth of the Philippines population. The country's urban areas were estimated to produce over 22,000 tons per day in 2008 and this would increase to about 28,000 tons per day by the year 2025.[1] In 2010 for example Legazpi City the provincial capital of Albay province in the Philippines produced eighty tons of municipal solid waste every single day but this figure rose to a staggering number of one hundred and nine tons daily in just eleven years.[2] Trash Flow Diagram Tool analysis projected that there will be a total of twenty eight thousand nine hundred sixty nine metric tons of municipal solid waste in 2021 with eighteen thousand three hundred forty nine being effectively collected and the remaining ten thousand six hundred twenty being uncollected.[3]

According to IRJIET (2022), one of the major problems faced by metropolitans these days is their inability to properly dispose of wastes; it is

especially pressing for developing countries where rapid population growth has been noted IRJIET (2022). Waste collection is an intricate procedure requiring considerable financial investment and complex logistic planning. Waste collection is a challenging procedure that calls for significant financial investments and complex logistics planning. Interconnecting heterogeneous devices and distributing data among numerous parties are essential for smart waste management. Employing a smart trash management system driven by solar energy and the Internet of Things mechanism that can guarantee appropriate gathering, moving, and real-time residential and industrial garbage disposal remote observation.[4]

According to Charmalyn Cataroja(20219) As the reach of technological modernization expands in the Philippine landscape, solid waste management still prevails to be one of the most basic yet relatively under innovated facet of governance present in every part of the society. Generally, solid waste management systems involve three aspects referred to as Ogdol, Samar and Cataroja J-HERD Vol.3. Issue 2. 2018 44 Collection, Treatment and the Recycling of solid waste. As a pre-defined constraint, the conduct of this study focuses on innovating the aspect of collection of solid waste management in rural areas of the Philippines.

According to IJSR (2023) Municipal Solid Waste Management rose to the top of local governments' lists of most pressing environmental and public health concerns in low - and middle - income countries.(2) Population increase, sustained economic expansion, urbanization, and industrialization contribute to the rising global volume of solid waste due to increased consumption rates (Henry et al., 2006; UNEP, ISWA, 2009; Aleluia et al., 2016). Ineffective and inefficient garbage

collection and management systems are a significant cause for concern in many cities and areas as waste production rises (Jacobsen et al., 2018).[6] On the other hand, smart cities are increasingly concentrating on finding answers to these issues by employing innovative enabling technologies like the Internet of Things, big data, and Artificial Intelligence (Esmaellian et al., 2018). It was predicted that the widespread use of these technologies would alter urban planning and enhance efforts to create a Circular Economy (Ghisellini et al., 2016). With the pressing issues of solid waste collection impacting the environment and increasing the quantity of solid wastes, the study sought to develop innovative solutions for waste collection.

According to the IEEE (2022) In many places, rubbish is piling up in public trash cans. The trash cans are often not picked up by the garbage collector on schedule. It thus releases an unpleasant stench that is harmful to human health. As a result, the ecology deteriorates, the region becomes unsanitary, and the air quality declines. To prevent these distressing situations, maintaining the environment is crucial for a healthy atmosphere. Based on this idea, an ultrasonic sensor concept is designed to determine the volume of garbage in the trash can. The researchers created a low-cost hardware prototype that uses GPS technology to track the location of the trash can and the overall amount of rubbish produced in the community.

Foreign Literature

The World Bank Group (2023) estimated that global solid waste production would reach 2.24 billion tons in 2020, equating to 0.79 kilograms per person per day. The predicted growth in population and urbanization will increase waste generation every year by 73% from 2020 levels, reaching 3.88 billion tons by 2050.

The term waste management is essential in everyone's life. Pollution and the accumulation of enormous volumes of garbage due to the lack of an appropriate waste management system have become one of humanity's most serious problems. (Goutam Mukherjee et al., 2021). Likewise, if trash is not effectively managed, environmental issues will worsen over time and become the most significant obstacle to sustainable development methods (Zhang et al., 2021)

Moreover, waste management is a difficult problem for both developed and developing countries. One of the biggest problems is that trash cans in public areas often overflow long before the next scheduled cleaning. Waste management causes high levels of gases, insects, and houseflies, which can cause serious health problems. With machine learning, the system may enhance waste disposal using the quickest route. The ML-IoT-based design incorporates equipment to determine the weight of the waste, which adjusts to the network environment and contains information regarding waste management. (Umer et. al.,2022)

In the study of Chakraborty et. Al (2021), outdated and obsolete waste management strategies still exist. Overspilled waste and irritating smells cause health issues and environmental problems. The author proposed a Global Positioning System (GPS)-based technology that can track waste storage. By

integrating communication technology like GPS, it can increase awareness about solid waste inspection and management.

Moreover, the research by Pardini et al. (2020), suggested a solution that utilized hardware and software through the Internet of Things (IoT). Sensors could be used to monitor the waste-filling level. This aimed to improve the handling of waste and ways of dealing with it and optimize economic and material resources.

Cong Wang et. al. (2021) propounded the Internet of Things (IoT) devices as a communication maneuver between waste containers and waste management communities to help them monitor general waste through sensors. Having proper waste management is essential for the community. Therefore, IoT integrates into a smart waste management system that can plan a schedule of waste collection, vehicle routing, and monitoring. [11] Also, Akram et al. (2021) concluded that the integration of the Internet of Things (IoT) has an essential function in reducing the negative effects of waste on the environment. It is also determined that battery-powered sensor nodes at bins entail the appropriate selection of IoT-based systems, such as wireless communication technology.

Based on the findings of Bano et al. (2020), systematic waste management is challenging, mostly in highly populated communities. Managing and monitoring trash bins demands time and effort. Therefore, the Smart Bin Mechanism (SBM) with Artificial Intelligence of Things (AIoT) is designed to provide a real-time monitoring solution to prevent overflow of waste and health risks.

In the study of Babayode (2023), the introduced waste disposal system incorporates an Arduino Uno microcontroller to acquire signals from a sensor of the person’s location. After receiving the signal, the microcontroller activates a servomotor to open the trash bin lid. When the person is no longer in the sensor’s

range, the lid closes automatically. An alert and LED indicator are also activated to notify the user when the trashcan reaches its capacity threshold. This offers a chance to manage the trash in the bin. As a result, this design effort can meet goals, such as reducing harm and improving cleanliness with a straightforward and affordable method.

Furthermore, Smart Waste Management (SMW) must incorporate a technical as well as a strategic viewpoint. The three significant SWM The following are examples of strategic goals: (1) waste alleviation; (2) waste collection and transport optimization, and (3) improve waste treatment. (Bastidas et al., 2022)

According to Kaseraka Henrys(2021) There are new Solid Waste Management Collection practices that have come up as innovation to modify the existing one. The consequence caused by badly management of solid waste, it is very dangerous to the world and human health this calls for the need to salvage the situation before it gets out of hand. That conducts us to use best practices to properly manage solid waste collection following the new trend of mobile technology, this research developed a solid waste collection management model with the aim to design a Mobile Application model for solid waste collection management which will help to improve the quality of management in Solid Waste collection and impacting positively the environment by reducing the quantity of Solid waste. Using our model based on mobile technology will reduce the municipality authorities' budgetary expenditure for solid waste service and help the municipality to cover more people in solid waste service. The solid waste companies will have the possibility of monitoring its activities by receiving households request, benefit of route optimization, planning for solid waste collection, and manage the team of garbage collectors. (1)

According to Biological Conservation(2019) This systematic review examines the state of knowledge and trends in the peer-reviewed literature related to the use of smartphone technologies for community and citizen science environmental monitoring. We organize our findings in relation to data collection and data handling, the process of developing smartphone applications, and the ways that outcomes are reported. While the literature is nascent and technological advances are continually opening new opportunities, it is notable that there is limited scholarship that explicitly connects the monitoring function of smartphones to tangible conservation action (e.g., only 10 percent of the papers analysed data collected by smartphones, let alone making connections to required actions or policy).

According to Smart Cities(2021) One of the most significant issues associated with smart city applications is solid waste management, which has a negative impact on our society's health and the environment. The traditional waste management process begins with waste created by city residents and disposed of in garbage bins at the source. Municipal department trucks collect garbage and move it to recycling centers on a fixed schedule. Municipalities and waste management companies fail to keep up with outdoor containers, making it impossible to determine when to clean them or when they are full. This work proposes an IoT-enabled solid waste management system for smart cities to overcome the limitations of the traditional waste management systems. The proposed architecture consists of two types of end sensor nodes: PBLMU (Public Bin Level Monitoring Unit) and HBLMU (Home Bin Level Monitoring Unit), which are used to track bins in public and residential areas, respectively. The PBLMUs and HBLMUs measure the unfilled level of the trash bin and its location data, process it, and transmit it to a central monitoring station for storage and analysis. An intelligent

Graphical User Interface (GUI) enables the waste collection authority to view and evaluate the unfilled status of each trash bin.(3)

According to MUET(2019) it is the need of time to seek an organized and well-structured mechanism to cope with this problem. Owing to this, world is moving towards smart systems to have the most efficient framework in dealing with the everyday garbage as it comprises of major chunk of waste material of cities and contributes heavily in environmental problems. Resultantly, smart cities with smart waste management systems can be the step in right direction. Smart cities are combination of several Internet of Things (IoT) systems that make human lives more comfortable and secured in every aspect. One of the applications of IoT is the effective management of garbage, which would ensure healthy environment for life on this green planet, with greater efficiency.(4)

Related Studies

Local Studies

According to Smith et. al. (2018), there has been a lot of focus on automated waste segregation systems employing Arduino microcontrollers and sensors in their design. By sorting out recyclable materials without any human intervention, such systems provide an answer to inefficiencies related with waste management. [16] In addition, research by Jones and Brown (2019) indicates that smart compression technologies must be integrated into waste segregating systems for storage optimization as well as efficient trash disposal methods.[17] One can also find out from the studies by Lee and Kim (2020) the significance of these platforms

in terms of environmental preservation which includes reducing landfill waste and enhancing recycling programs. [18] Further, Endaya et al., (2020), explains how combining stepper motors, linear actuators, and ultrasonic sensors requires a multidisciplinary approach to solve solid waste problems. [19]

According to Flores et. al. (2023), Smart trash bin development investigates the desire of finding effective measures in waste management. It is a study involving capacitive and inductive proximity sensors to locate and segregate non-metallic and metal recyclable waste materials like tin cans and plastic bottles. This study also recognizes that it can observe other forms of waste such as paper, wood, and plastics, but it confines itself to just these objects. With automatic lid opening and closing mechanisms incorporated; users have an improved experience with reduced physical contact with potentially contaminated surfaces in line with health standards. Also, integration of GSM communication enabled autonomous trash level detection through ultrasonic sensing facilitates remote control/monitoring by making garbage collection/retrieval processes easier. [20]

The issue of limited access to advanced waste management technologies in the Philippines was addressed by Y. Mortos et al. (2024). The study revealed existing problems in waste segregation methods and proposed a solution through development of an automated trash bin system. The focus of this research is to make waste sorting easier and contribute towards sustainable waste management practices. [21] Moreover, Lynlei L. Pintor and Josel Godezano (2019), although the Ecological Solid Waste Management Act was passed in 2000, managing wastes has become a huge problem in the Philippines. Diverse studies have been carried out on various aspects of solid waste management but there is scarce literature about sustainable circular economy-oriented waste technology systems. For ten years between 2009 and 2019, Pintor and Godezano studied scientific,

technological and innovative approaches used in managing garbage completely. As it can be seen from this, all these steps were not enough because the government did not pay enough attention for this area either way indicating that there still exists a long path to make country attain circular economy due to lack of political will on their part, etc. [22]

According to Lynlei L. Pintor and Josel Godezano (2019), although the Ecological Solid Waste Management Act was passed in 2000, managing wastes has become a huge problem in the Philippines. Diverse studies have been carried out on various aspects of solid waste management but there is scarce literature about sustainable circular economy-oriented waste technology systems. For ten years between 2009 and 2019, Pintor and Godezano studied scientific, technological, and innovative approaches used in managing garbage completely. As it can be seen from this, all these steps were not enough because the government did not pay enough attention for this area either way indicating that there still exists a long path to make country attain circular economy due to lack of political will on their part.[23]

According to Charlyn Hibaya-Pendang (2024), digital solutions have been implemented, specifically Smart Waste Management System and Staff Tracker Application in Legazpi City, Philippines to help improve Solid Waste Management practices in the city. This study therefore emphasizes the need for efficient waste collection and transport systems especially in highly urbanizing areas such as Legazpi City where conventional methods of waste management result into environmental pollution and leakage of marine plastics. The research points out the problems that are associated with the existing waste management systems that include; inefficiency in truck routing, increased operational costs and environmental degradation. The research therefore demonstrates how this digital

application helps solve these challenges through real-time monitoring, data analytics as well as other strategic optimizations including advanced technology integration hence reducing fuel costs, operational time, and waste leakage.[24]

According to Sidhu et al. (2021), plastic generated from homes is a priority worldwide because of the increased use of plastics in different sectors and the announcement made by United Nations on plastic pollution as a planetary emergency. Consequently, several nations have banned single-use plastics while producers are also campaigning against its use. However, traditional garbage collection mechanisms with set timetables are still in place even though there is acknowledgment about need for more effective collection modalities. Research has been done in the areas of digitalization of maps for rubbish bins and using sensors that weigh garbage to determine the level of garbage collected at any given time; however, difficulties remain, especially in developing countries such as lack of enough money to remove waste and poor collection services.[25]

According to Pamintuan et al. (2024), the topic of waste management has become global where population growth is increasing at an exponential rate with a corresponding increase in waste production. The study underscores the importance of waste management in addressing environmental risks that come with increasing volumes of filth due to this paper’s compilation. In connection to technology, the authors emphasize on technology intervention through IoT and machine learning approaches to automatic waste segregation. Their work points out urgent need for innovative ways to mitigate the negative effects of unsanctioned garbage disposal in areas such as Philippines, which is experiencing much more severe environmental consequences than other parts of the world are currently facing. The study emphasizes forward looking concepts in respect to

waste management using sensors and image recognition technologies which take cue from increasing use of IoT in different sectors for sustainable development.[26]

According to Samonte, Baloloy, and Datinguinoo (2021), the idea of using Internet-of-Things (IoT) technology for solid waste management has become increasingly popular in recent years. Their research sheds light on solid waste management as a pressing urban environmental concern calling for inventive solutions. The arrival of IoT means everyday objects such as trash cans can be made capable with sensors and connectivity to the internet thus allowing real-time monitoring and management of refuse. Integrating microcontrollers like Raspberry Pi and Arduino UNO with ultrasonic and color sensors gives an interesting way forward to automate waste collection and segregation processes.[27]

According to Camarillo et. al. (2021), despite this formal framework for managing waste, in the Philippines, the country's people have not taken part in its operations. This legislation is founded on practices like separation of waste at source, proper disposal, and diversion of waste. [28] Furthermore, Coracero et. al. (2021), highlight valorization as the answer to natural resource depletion by stating that "solid waste is a resource that can be recovered" (RA 9003, ZWRMP 2005).[29] Torres (2023) points out that the management of solid waste through public participation within their community is important. [30]

Foreign Studies

Internet of Things (IoT) technology and advanced analytics combined with waste management systems can greatly increase efficiency and sustainability according to Kuzhin et al. (2024). [31] Other than that, Gupta et. al.'s (2019) and

Singh et. al.’s (2020) research have also highlighted some of the advantages that can be derived from applying IoT and analytics in waste management. For example, their studies show that bin fill levels can be monitored in real time using IoT sensors which then helps optimize collection routes and schedules based on this information.

According to a study by Hasan (2023). The proposed framework integrates sensor networks, data analysis, communication infrastructure, and intelligent garbage bins into a platform. Through data-driven decision-making processes this pioneering strategy seeks to optimize waste collection routes monitor fill levels, in time, and support recycling initiatives. The research delves into the environmental impacts of the system highlights challenges that may arise and provides recommendations for successful implementation. By merging advancements with waste management systems this initiative represents a step, towards creating smarter and more environmentally friendly cities.

Moreover, Morais, (2022) studies developed optimization-tools to optimize waste collection by defining smart waste collection routes that consider the fill levels of the bins and their locations to maximize the amount of waste collected while minimizing the total distance traveled, considering different planning horizons (short and medium term).

Furthermore, a solution methodology is developed to address the decision on which bins, from the whole set of waste bins, should receive a sensor, considering both the expensive investment value of the sensor and the economic gain provided by the early knowledge of information about the bin fill levels. In this research, solution methods are developed to solve real large-scale smart waste collection routing problems, and the proposed approaches are validated using real case studies.

Additionally, Silva et al. (2022) believe that Wireless Sensor Networks (WSNs) can be used for monitoring waste levels in Municipal Solid Waste Management Systems (MSWMS), which is a good way to improve the efficiency of garbage collection in cities. They show us how important it is to use information and communication technologies when dealing with rapidly growing urban populations. One thing that municipalities can do is to strategically place sensors inside bins for gathering data about rubbish amounts at any given moment thus helping them select the most effective collection routes while cutting down on time as well as fuel consumption.

Based on the study of Vishnu et. al (2022), IoT-based systems are superior to other design approaches and the preferred communication protocol for automating systems for handling solid waste in urban areas. In addition, the most pressing unsolved problems in the field of cutting-edge solid waste management systems are highlighted, as are potential future research avenues. [36]

In Jasim et al. (2021) A smart waste system based on the Internet of Things (IoT) technique has been proposed using an ESP-32 Wi-Fi microcontroller. This system can be adopted to avoid the accumulation of waste in the streets that distorts the face of civilization and to reduce the burden on workers and limit the workforce. The system is based on multiple sensors in the garbage baskets, as they measure the waste level using an ultrasonic sensor, the moisture percent, and the temperature degree using a DHT-22 sensor. The sensor data is processed by the ESP32 microcontroller and displayed on both the LCD screen using the I2C protocol and mobile applications using the IoT cloud. System baskets automatically open their covers when the person approaches with a distance less than or equal to 30 cm to throw garbage. Any approved waste basket is automatically discharged through an underground dump system using a conveyor

belt if the basket is full of 80% garbage and/or the basket moisture reaches 40%.

In 2022, a published journal article discussed a proposed digital control system for municipal solid waste management using a mobile application in South Africa. The authors concluded that digitalization would help achieve efficiency enhancement in waste collection. The use of mobile application would aid in identifying areas with low accessibility.(1) Adeniran (2022) cited an earlier study that identified barriers including the lack of awareness campaigns that inform communities regarding the best waste management practices, and lack of accessibility in buyback centers to encourage continuous recycling activities. The conclusion was that harnessing tools of digitalization would encourage every resident to report on environmental issues and irregularities, therefore, enhancing efficiency and fostering increased community participation in waste management. The WasteWays application has the potential to efficiently provide information and service relevant to the users' needs in waste management and junkshop transactions. Secondly, this research provided a platform designed for the purpose of communicating waste management related information between different users.(2)

According to Kurniawan et al. (2022) in their published article on transformation of solid waste management in China, they discussed that future lies in digitalizing waste recycling. In addition, digitalization provides solutions that strengthens waste management practices by generating real-time data regarding the location and condition of waste which increases the traceability and accessibility to products and services. The authors concluded that fostering technological innovation promotes efficient waste minimization and longevity of products.

In research by Henrys (2021), a solid waste collection management model was developed with the aim of designing a mobile application model for solid waste collection. The author stated that upon the research, not all solid waste collection management activities are covered by some existing system models, thus, the development of their proposed model with the utilization of mobile technology. As a result, the study recommended the use of mobile technology to help with the improvement of solid waste collection management process by the usage of a model that includes solid waste collection on-demand and collection route optimization. Their study explored the concept of how digital changes affect how people deal with waste in year 2021, by Nkwo et al. In this research they noted that user-friendly interfaces make waste management more convenient. In which this allows the users to engage easily while cutting down on face-to-face interactions. To briefly discuss, this marks an explain immense move towards a more efficient and eco-friendly habits in the digital space.

Synthesis

This chapter provides an extensive review of both local and foreign literature and studies related to smart waste management systems. The literature and studies explained and supported the importance of the process and development of a self-moving trash bin as an innovative smart waste management system.

The local and foreign related studies conducted discuss waste management problems, innovation, solutions, and technological applications needs to support in developing smart waste management solutions. Those studies mentioned above emphasize the importance of selecting the applicable technologies with the Information and Communications Technology (ICT), the Internet of Things (IoT), and multimedia technologies. Technology is at the core of providing smart waste management solutions and enabling more sustainable practices. Additionally, the paper presents frameworks and design of smart waste management system for trash bin using hardware such as Arduino, sensors and IoT technology.

In conclusion, The Internet of Things is a powerful tool in making solutions to some problems in our society. Therefore, smart waste management innovation is essential in developing IoT-based projects to attain cleanliness and lessen the existing waste management obstacles and promote sustainable and healthy environment for all.

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Chapter 3 Design and Methodology

Methodology

The study process for the development of the BasuraHunt application in Nagpayong Area of Barangay Pinagbuhatan, Pasig City consists of an initial exploratory phase, followed by a qualitative research strategy that emphasizes phenomenological inquiry. This technique seeks to gain a thorough understanding of waste management systems by examining the actual experiences, perspectives, and actions of people, stakeholders, and community leaders. The research methodology incorporates a variety of approaches, including semi-structured interviews, focus group discussions, and field observations, to obtain a comprehensive understanding of garbage disposal procedures. The qualitative data is interpreted using thematic and narrative analytic methodologies to gain a comprehensive picture of the social, cultural, and environmental aspects of trash management in Pateros.

The BasuraHunt project in selected beneficiary utilizes a phenomenological qualitative research approach. This method centers on comprehending the subjective perceptions and significance that individuals assign to waste management activities. Phenomenology enables a more thorough investigation of the underlying motivations, attitudes, and perceptions related to trash disposal practices by examining the lived experiences of inhabitants and stakeholders. The qualitative data is analyzed using thematic and narrative analysis approaches to identify reoccurring themes and narratives. This analysis helps to gain a deeper understanding of the struggles of trash management in the community.

Requirement Analysis

The City of Pasig one of the prominent city among here Metro Manila and active on environment conservation, one the Barangay in the said city experiencing problems in waste problem. Barangay Pinagbuhatan particular in Nagpayong Area experienced a lot of problems in waste management in their communities. Undisciplined residents is the main problem and result to unwanted trash problems. Therefore, this project BasuraHunt app was introduced to provide solutions related to the waste disposal issues existing. By this system, it will make an impact to calibrate the problem in littering, disposing and handling.

Sampling Technique

For a fair and efficient waste management monitoring system for BasuraHunt, the researchers make use of a stratified random sampling method. In other words, the researchers will split the population into different groups based on such factors as their location, the nature of the rule that was broken, how often it is done and how severe it was. Within each group, we shall randomly choose a few reports for checking by the waste management team. This way, it ensures that they are looking at reports from all around and about different types of rule-breaking hence not concentrating too much on one region or type of problem. When reported in this fashion, time can be managed as well as resources by the waste management team to give more attention to those areas or problems which are truly critical. This will help BasuraHunt be more equitable in its operations and also become more sustainable since it enables corresponding local government units (LGUs) to enhance their solid waste management programs.

Current Technical Situation

"BasuraHunt" present technical situation comprises developing a comprehensive app designed for smart waste management and monitoring within Barangays. The application allows users to be actively involved in ensuring clean environment by reporting photos or videos of errant acts of waste management. Through its user-friendly interface, people can conveniently take photographs and upload them to expose violations such as improper disposal of waste or non-adherence to materials recovery facility (MRF) segregation rules. It is a hub for the community where neighbors may report those who violate garbage control policies. On top of that, it has two separate login sections; one for users and another for administrators (waste management teams). While users are allowed to file reports, administrators are given responsibility to review them and take necessary action based on the information presented. Therefore, this dual system ensures proper inspection and implementation of garbage laws leading to cleaner and sustainable surrounding at local level.

Requirement Documentation

BASURAHUNT is a sophisticated monitoring system created to detect and monitor individuals who violate waste management regulations. The system

utilizes diverse technologies to identify, document, and communicate instances of non-compliance with waste management standards, equipping authorities with effective means to enforce the rules. This paper aims to describe the prerequisites for the BASURAHUNT system, guaranteeing that all parties involved possess a lucid comprehension of the system's capabilities, characteristics, and limitations. This document encompasses the functional and non-functional requirements, system architecture, user interfaces, and other crucial components required for the development and deployment of BASURAHUNT App.

Project In – Scope

Development of a Monitoring Application:

- **Mobile Application:** Develop a user-friendly mobile application for real-time tracking and reporting of waste management activities.
- **Web Portal:** Create a comprehensive web portal for administration and monitoring by waste management authorities.

Data Collection and Analysis

- **Data Storage:** Establish a secure database for storing collected data.
- **Analytics Dashboard:** Develop an analytics dashboard to visualize data, identify trends, and generate reports.

User Authentication and Role Management:

- **User Roles:** Create different user roles (e.g., admin, waste collector, citizen) with varying access levels**.**

- **Authentication:** Implement secure user authentication methods.

Incident Reporting

- **Reporting System:** Enable users to report incidents such as overflowing bins, illegal dumping, or missed collections.
- **Notification System:** Implement notifications and alerts for residence and administrators.

Community Engagement:

Feedback Mechanism: Provide a platform for citizens to give feedback and suggestions.

Project Out – Scope

- **Physical Infrastructure Development**: pertains to the process of building or modifying physical structures, such as surveillance towers or trash disposal facilities. However, this type of tangible infrastructure creation or modification is not included in the current scope.
- **Legal enforcement:** The execution of legal measures against individuals who violate laws, such as imposing monetary sanctions, penalties, or initiating legal procedures, is not within the purview of this project.
- **Third-Party Integration**: the project exclude integrating with any external systems or services beyond what has been specifically mentioned, such as law enforcement databases or environmental regulation platforms.

Design of Software, Systems, Product and/or Processes

BASURAHUNT App signifies a higher level of monitoring software designed to track and identify individuals who violate waste management regulations. The system utilizes innovative technology and employs a holistic approach to waste management, providing exceptional capacities to identify, address, and avoid waste infractions. By utilizing BASURAHUNT App, authorities could introduce a new age characterized by cleanliness, sustainability, and environmental preservation inside their communities.

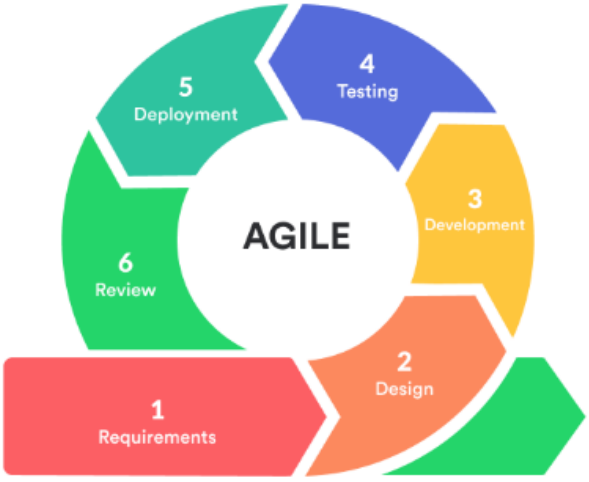

Figure 2. From “ResearchGate”, Agile Methodology

The Scrum Agile technique is a widely used framework in software development, renowned for its iterative and incremental approach. The BasuraHunt project will employ Scrum to efficiently oversee the development process that monitors waste management violations. The project began with a planning phase that will develop the product backlog, detailing all the features and needs for the application. The project stakeholders will prioritize this backlog, giving priority to the most critical features. The development team, comprised of

developers, testers, and a Scrum Master, would engage in brief, predetermined periods of work known as sprints, usually lasting between two and four weeks. Each sprint begins with a sprint planning meeting, where the team selects the most crucial items from the backlog to concentrate on for that specific sprint. We conduct regular stand-up meetings to keep all team members informed about our progress and potential obstacles. After each sprint, researchers hold a sprint review meeting to present the finished work to stakeholders, gather feedback, and strategize for the next sprint. The iterative process enables ongoing improvement and adaptation, guaranteeing that the BasuraHunt application grows in response to changing requirements and user feedback. Moreover, the Scrum structure promotes openness, cooperation, and adaptability, rendering it very suitable for intricate projects such as the BasuraHunt system.

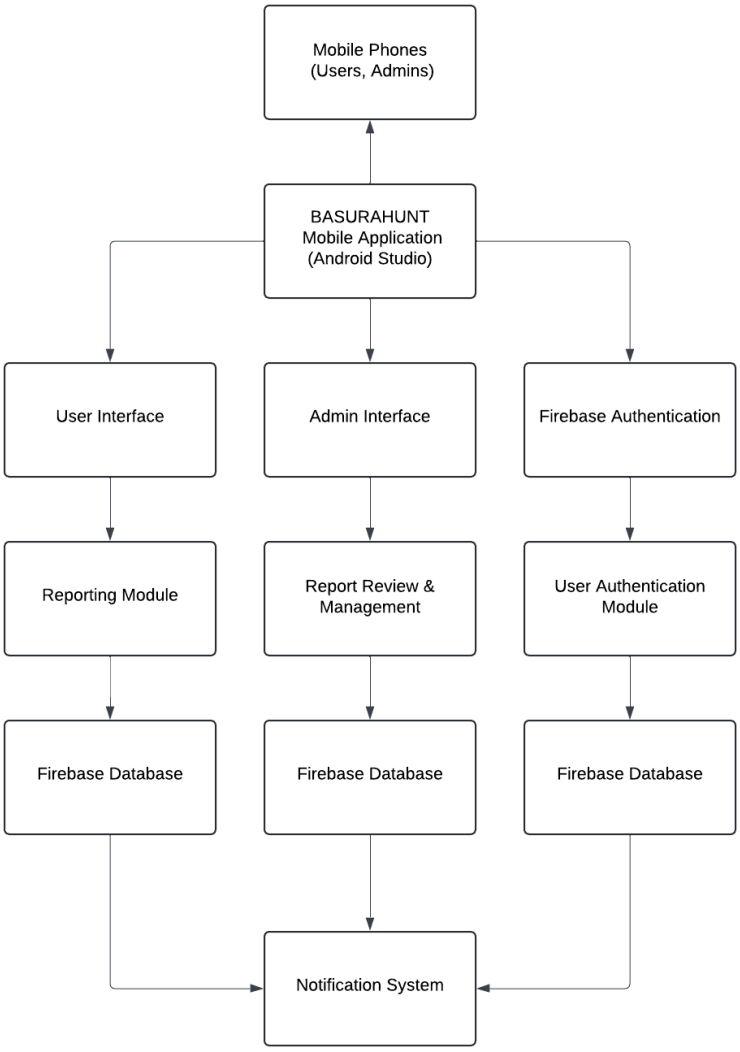

Figure 3. Block Diagram of BasuraHunt App

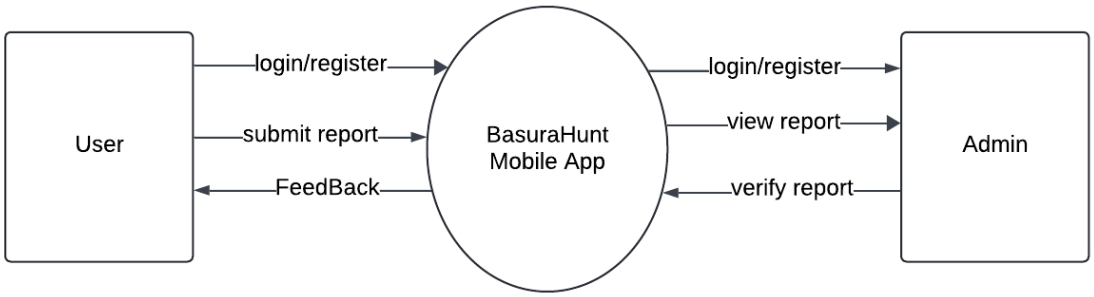

Figure 4. Context Diagram/Data Flow Diagram (Level 0)

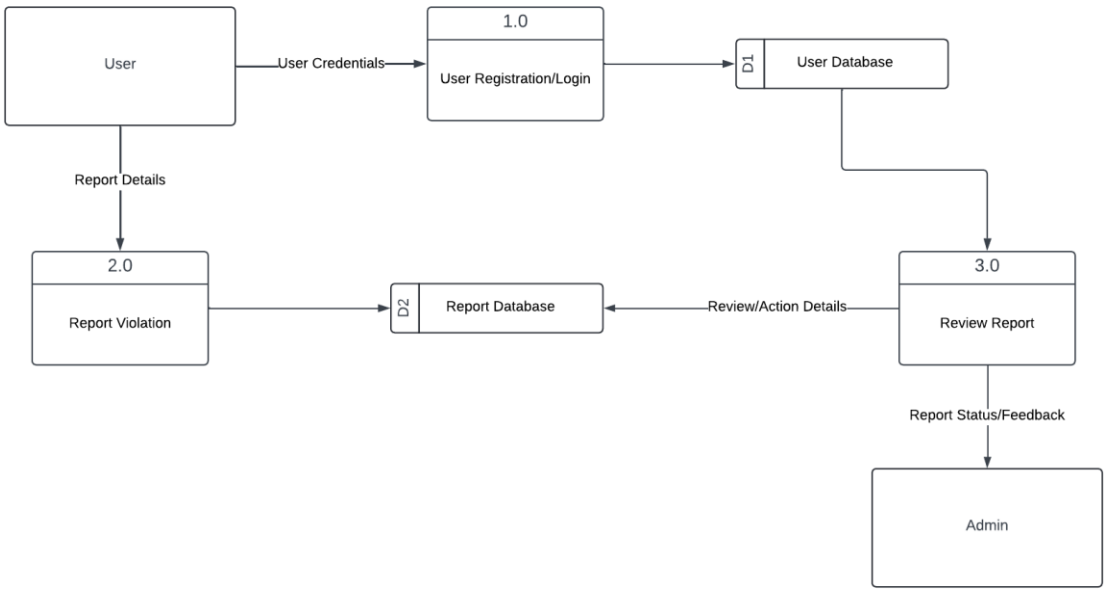

Figure 5. Data Flow Diagram Level 1

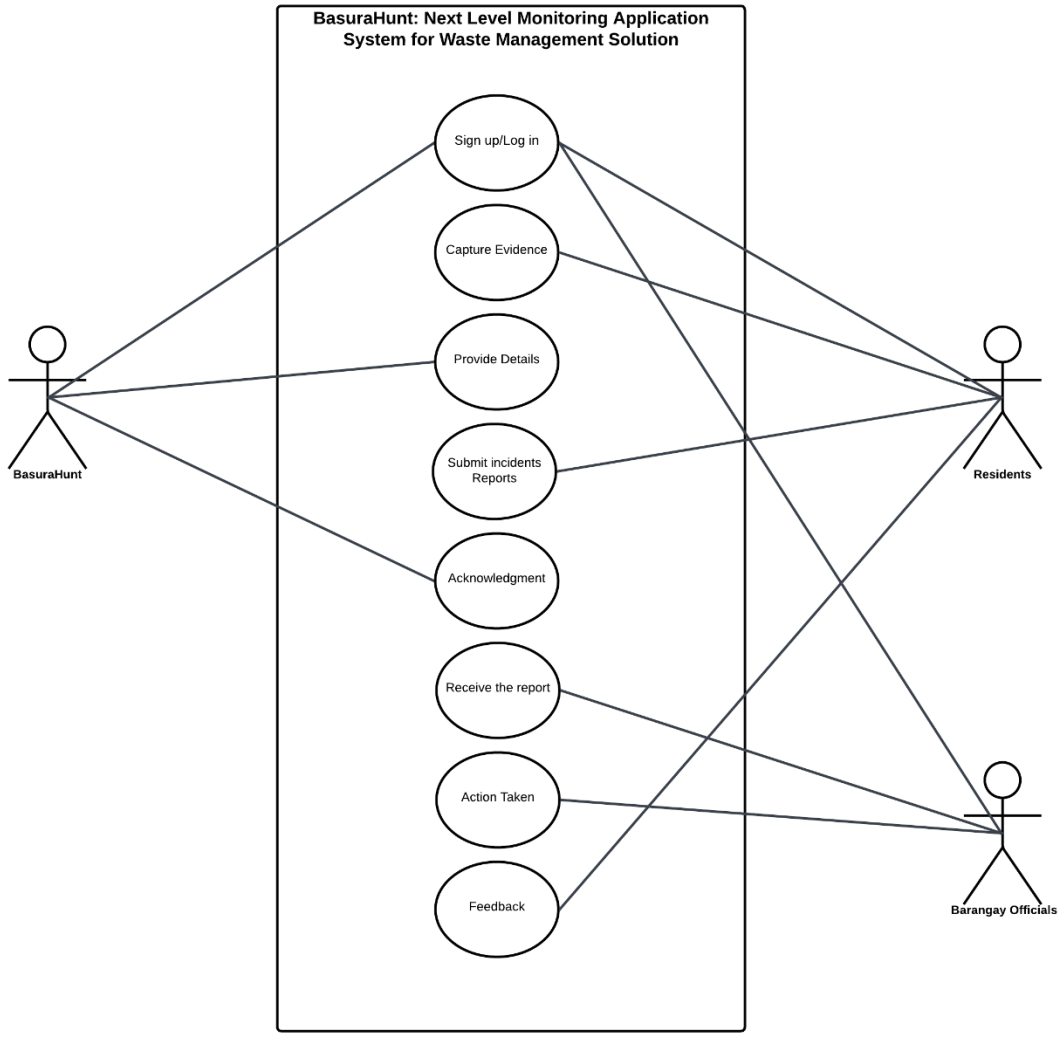

Figure 6. Use Case Diagram

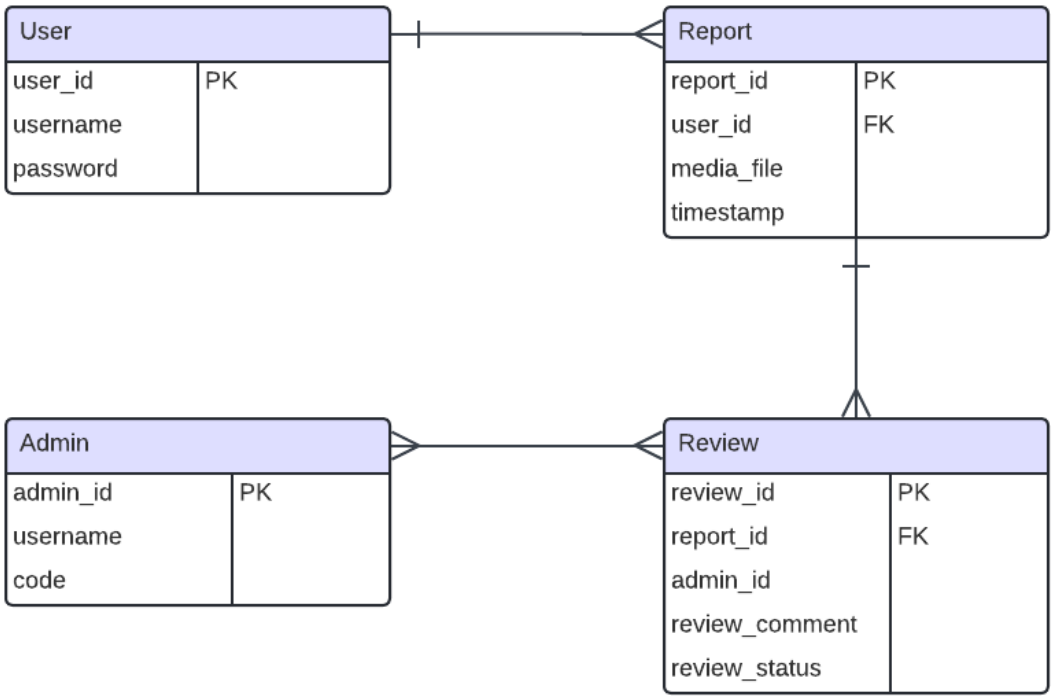

Figure 7. Entity Relationship Diagram

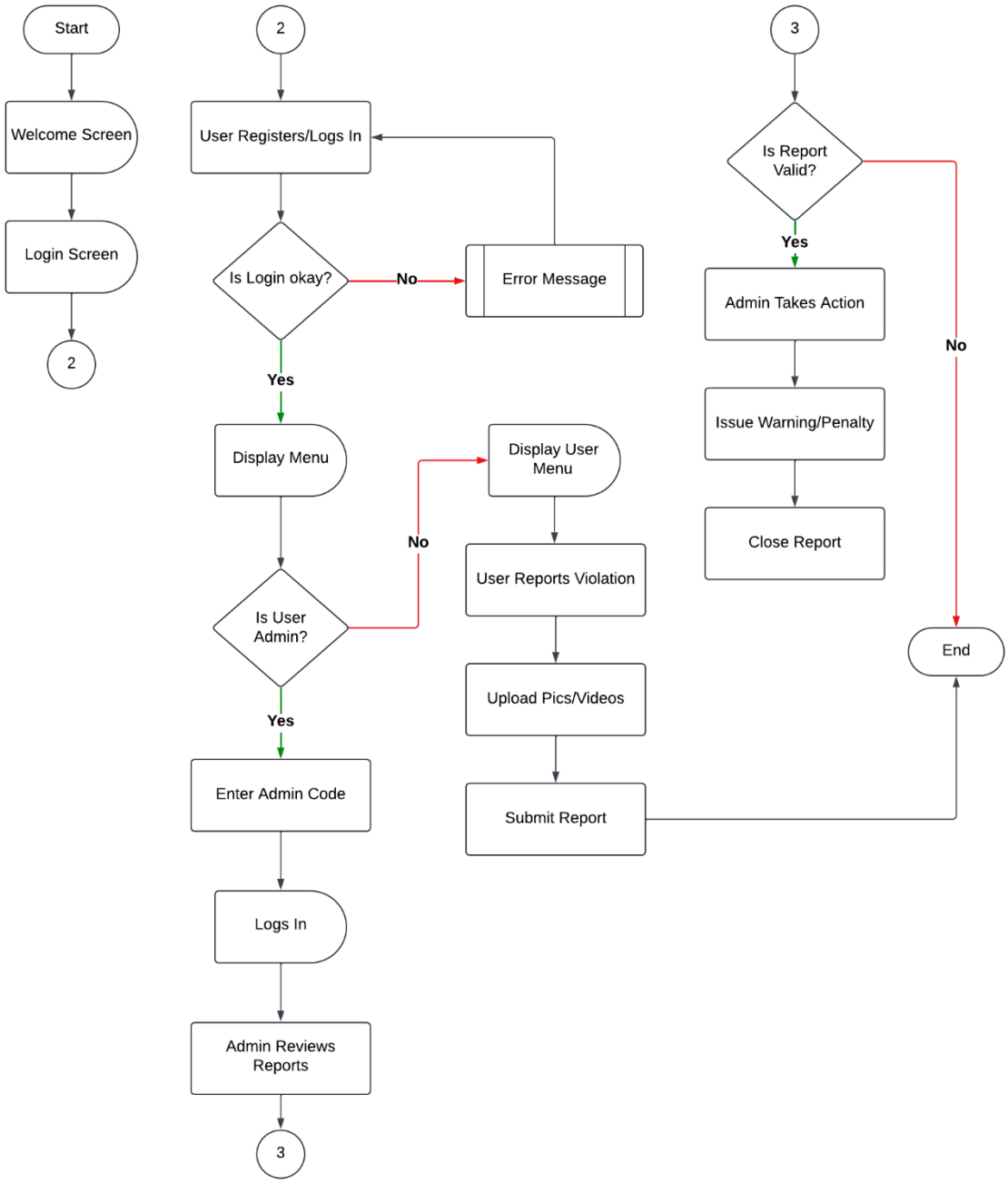

Figure 8. Flowchart

Development and Testing

BasuraHunt App offers a new way of managing waste by applying technology to enable communities enforce regulations on waste management and the use of this can mobilize them to participate actively in keeping their place clean and in order. Inappropriate dumping or non-compliance with segregation guidelines, for instance, is easily captured through photo or video evidence. This approach allows for quick reporting while enhancing accountability among residents who work collectively towards a cleaner environment.

The system integrates both user and admin aspects to facilitate efficient management and review of recorded incidents. When it comes to documenting and filing reports, users log into the application whereas the administrator or waste management department would visit another portal for reviewing such cases as well as taking necessary measures. This two-tiered authentication helps monitor and resolve garbage disposal problems more effectively. BasuraHunt thus positions itself at the forefront of revolutionary solutions in garbage collection that bring about social consciousness towards one’s local environment.

Data Analysis Plan

After gathering data, the statistical tools that will be used in the analysis of data are the weighted arithmetic mean, standard deviation, analysis of variance, and the person product-moment coefficient of correlation. The weighted arithmetic mean will be used to determine the average responses for item of the five (5) options in each item in the questionnaire namely, 5 (Strongly Agree / Very Good / Very Willing / Very High), 4 (Agree / Good / Willing / High), 3 (Undecided / Fair), 2 (Disagree / Hesitant / Low / Poor), and 1 (Strongly Disagree / Very Hesitant / Very Low / Very Poor). The Likert scale can be generated by means of the respondents' replication on the survey.

Implementation Plan

The implementation plan describes how the information system will be deployed, installed and transitioned into an operational system. The plan contains an overview of the system, a brief description of the major tasks involved in the implementation, the overall resources needed to support the implementation effort (such as hardware, software, facilities, materials and personnel), and any site-specific implementation requirement.

Table 3-1. Implementation Plan

STRATEGY	ACTIVITIES	PERSON INVOLVED	DURATION
Title Proposal	Letters for the Administrator	Proponents and Administrator	1 day
System's installations	Installation of the system and required hardware and software	Proponents and Administrator	5 Hours
Information Distribution	Flyers	Administrator and Students	1 day
	Posters	Administrator and Students	
	Manuals	Administrator and Students	
3 Day Training	Hands on Training and Lectures	Administrator, Officers, and Students	3 Days

Milestone Schedule

This table shows the outline of key phases, activities, resources, and timelines to achieve the project objectives. This serves as the roadmap for the researchers to guide them through the development process to attain and address all necessary components in the entire development.

Table 2. Chapter 1 Milestone Schedule

Milestone Scheduling	March 2024						Assigned	Priority	Status
Task	4	5-10	11	13-19	21-27	28-31			
Group Meeting (Project Title)							PROPONENTS	URGENT	COMPLETE
Project Title Proposal							PROPONENTS	HIGH	COMPLETE
Final Title Proposal							PROPONENTS	HIGH	COMPLETE
Chapter 1									
Introduction							SIBULO	NORMAL	COMPLETE
Project Context and It's Background							SIBULO	NORMAL	COMPLETE
Project Purpose and Description							ALL MEMBERS	NORMAL	COMPLETE
Significance of the study							ORTEGA	NORMAL	COMPLETE
Objectives of the study							ORENDAIN	NORMAL	COMPLETE
Scope and Limitations,							FABOL	NORMAL	COMPLETE
Conceptual Framework							ALL MEMBERS	NORMAL	COMPLETE
Definition of Terms							ALL MEMBERS	NORMAL	COMPLETE

Table 2. Chapter 2 Milestone Schedule

Chapter 2																		
Local Literature																	ORENDAIN & SIBULO	NORMAL	COMPLETE
Foreign Literature																	ORENDAIN & SIBULO	NORMAL	COMPLETE
Local Studies																	ORENDAIN & ORTEGA	NORMAL	COMPLETE
Foreign Studies																	FABOL & ORTEGA	NORMAL	COMPLETE
Synthesis																	SIBULO	NORMAL	COMPLETE

Table 2. Chapter 3 Milestone Schedule

Chapter 3	May 2024				June 2024			Assigned	Priority	Status
	1-8	9-18	19-24	25-31	Week 1					
Requirement Analysis								ORENDAIN	NORMAL	COMPLETE
Sampling Technique								ORENDAIN	NORMAL	COMPLETE
Current Technical Situation								FABOL	NORMAL	COMPLETE
Project In/Out– Scope								FABOL	NORMAL	COMPLETE
Design of Software, Systems								PROPONENTS	NORMAL	COMPLETE
Product and/or Processes								PROPONENTS	NORMAL	COMPLETE
Development and Testing								PROPONENTS	NORMAL	COMPLETE
Data Analysis Plan								PROPONENTS	NORMAL	COMPLETE
Implementation Plan								PROPONENTS	NORMAL	COMPLETE
Final Submission of Paper								PROPONENTS	HIGH	COMPLETE
Initial Defense								PROPONENTS	URGENT	
Final Revision								PROPONENTS	URGENT	

Chapter 4 Results and Discussion

This section presents the comprehensive discussion on the developed/used algorithm.

Discusses the interpretation or findings of the study from the data collected.

Chapter 5 Summary, Conclusions, and Recommendations

Summary of Findings

Provide a rather concise summary of the research work.

Conclusions

The conclusions are direct statements that would prove the achievement of the specific objectives. The conclusions should have one-to-one correspondence to the specific objectives, i.e. if you have 4 specific objectives (a to d) then you should have 4 conclusions (1 to 4).

Recommendations

References

Use APA formatting for all references (in the body and in the listing here).

Appendices

<Appendix A:> <Title>

Place your appendices here. Please be sure that these have been referenced in the body of document.