**CHAPTER ONE**

**INTRODUCTION**

* 1. **Background Information.**

It is prudent to have a proper system that enables the collection, storage and analysis of data derived from crowd-sourced web applications. This project aims to develop a web application that integrates Geographic Information Systems(GIS) technology to allow for reporting of sewer incidents, map the same, and further enable analysis of the spatial distribution of such incidents. This information can be used to identify hot-spots of sewer incidents, understand the underlying causes of such incidents, and inform the development of mitigation strategies. The web application will also provide real-time updates and improve the efficiency response and management.

Globally, faulty sewer systems have become one of the greatest causes of pollution, especially in urban areas. However, smart cities all over the world have majorly incorporated smart wastewater networks into their systems which use sensors, automatism and technological processes that provide substantial improvement in their sewer systems. According to Fira Barcelona, the use of sensors, data analysis and state-of-the-art infrastructure, places such as the counties Jefferson and Louisville, and the city of Cincinnati in the United States have improved their sewer systems, applying real-time control combined with a weather forecast. These combined tools predict the collapse of sewer infrastructure and can be used to prevent wastewater overflows.

In Kenya, especially in urban areas, faulty sewer systems are a common problem. The causes of the problem are complex and include a lack of investment in the waste water infrastructure, poor maintenance and repair practices, and rapid urbanization that puts additional strain on the system. Moreover, the rapid increase in population growth, increased urbanization processes and rural-urban migration has created an enormous pressure on the existing sewerage services(Asoka et al., 2013). In Nairobi, most of its areas lack sewage systems, in the areas that do have a system such as Kawangware, issues such as non-functional sewers, accidental and or deliberate breakages of manhole covers, sewer pipe bursts, blockages of sewer lines, sewer chokes, sewage outflows and open sewage still reign supreme.

The Nairobi City Water and Sewerage Company(NCWSC) is the authority in charge of providing and managing clean water and sewerage services in Nairobi. However, the authority has been using conventional methods for allowing residents to air their complaints and inputs related to faulty sewer incidences, such as social media platforms like Facebook and Twitter, and through their email addresses and telephone number. This has proved to be an unreliable mode of feedback collection since most residents claim that there has been little to no follow-ups and responsiveness to their complaints and reports.

**1.2 Statement of the Problem**

The old and poor infrastructural conditions and the lack of proper maintenance practices of the sewer systems have been the cause of sewer outbursts, overflows, chokes, bursts and other related sewer incidents along the streets and residential areas. In the event that these incidents occur, the residents do file complaints to the NCWSC and the county government for mitigation and fixing of these problems. However, it has been noticed that there is slow, little or no responsiveness of the NCWSC to reported incidences such as sewer bursts and chokes. Most of the residents also lack a proper systemic structure that enables them to report these incidences to the necessary authority and the assurance that their problems will be fixed timely.

Owing to the fact that the sewer chokes and bursts are not responded to and repaired timely, Kawangware has experienced challenges that intensify environmental degradation, pollution, poor sanitary conditions and a strain on the existing sanitary facilities such as treated water pipes. There has also been rampant cases of bad odour caused by the open sewers, breeding sites of mosquitoes, spreading of waterborne diseases, damage of infrastructure and traffic congestion, flooding, and ultimately disruption of normal life.

To solve this problem, a smart solution is needed, which will offer the residents of the Nairobi a reporting communication system in the form of a web application which could be an effective way to improve the reporting of sewer incidents. This type of system could allow users to report incidents through a user-friendly interface and provide real-time updates on the status of incidents. Its key features will include;

* Incident Reporting: Users could report sewer incidents through a simple online form, providing details such as the location of the incident, type of incident, and any other relevant information
* Real-Time Status Updates: The web application should provide real-time updates on the status of incidents, allowing users to track the progress of the response and resolution of incidents.
* Interactive Map: The web application should include an interactive map that displays the location of reported incidents and provides information on the type and status of each incident.
* Analysis and Reporting: The web application could provide analysis and reporting capabilities, allowing administrators to generate reports and track trends in sewer incidents over time.

By incorporating these and other features, a reporting communication system in the form of a web application could provide an effective means of improving the reporting and response to sewer incidents, while also increasing transparency and accountability in the waste water management system.

**1.3 Objectives**

**1.3.1 Main Objectives**

The main aim of this project is to develop a web-based Geo-enabled application for reporting sewer incidences in Kawangware.

**1.3.2 Specific Objectives**

* To collect data and information about the system
* To design a comprehensive conceptual model of the system
* To develop the physical implementation of the system (Develop the system components) and Integration
* To test and validate the system
* To deploy and maintain the system

**1.4 Methodology**

1. Collect user requirements of the system to meet the needs of the users, including residents, sewer service providers, and local authorities. The user requirements will be identified through user research, surveys, and user testing.

2. The conceptual models will be created using UML diagrams.

3. To develop the physical implementation of the system, the following methods will be used;

* Software Development: The software development process involves coding, testing, and debugging the software components of the system. This includes developing the user interface, incident management system, reporting and analysis dashboard.
* Database Design: The database design process involves creating the database schema and defining the relationships between the data entities. This includes designing the Geospatial database and the user management system database.
* User Acceptance Testing: The user acceptance testing process involves testing the system with a group of representative users to ensure that it meets their needs and is easy to use. This includes testing the user interface, incident reporting, and data visualization features.

1. To integrate the system components, the following methods can be used: 1. Application Programming Interfaces (API ): API can be used to connect the different system components and allow them to communicate with each other. For example, an API can be used to connect the incident management system with the Geospatial database, allowing users to view the location of reported incidents on a map.
2. Continuous Integration (CI): CI can be used to automatically integrate the different system components as changes are made to the system. This can help to ensure that the system remains stable and functional over time.
3. To test and validate the system, the following methods can be used:

* Unit Testing: Unit testing involves testing each component of the system in isolation to ensure that it performs as expected. This includes testing the incident reporting system, the Geospatial database, and the authentication and authorization system.
* Integration Testing: Integration testing involves testing the system as a whole to ensure that the different components work together correctly. This includes testing the integration of the incident management system with the Geospatial database, the user management system, and the reporting and analysis dashboard.
* User Acceptance Testing: User acceptance testing involves testing the system with a group of representative users to ensure that it meets their needs and is easy to use. This includes testing the user interface, incident reporting, and data visualization features.
* Performance Testing: Performance testing involves testing the system under different levels of load to ensure that it performs well and responds quickly. This includes testing the system with a large number of simulated incidents and users.
* Regression Testing: Regression testing involves testing the system after changes have been made to ensure that the changes have not introduced new bugs or problems. This includes testing the system after new features have been added or after bugs have been fixed.

1. To deploy and maintain the system, the following methods will be used:

* Continuous Deployment: Continuous deployment involves automating the deployment process to ensure that new changes to the system are deployed quickly and reliably. This includes using tools such as GitLab to automate the deployment process.
* Monitoring: Monitoring the system involves using tools to monitor the system's performance and identify issues as they arise. This includes monitoring the system's uptime, response time, and resource utilization.
* Scaling: Scaling the system involves adding more resources, such as servers or databases, to ensure that the system can handle increased demand.
* Backup and Recovery: Backup and recovery involve creating and maintaining backups of the system's data and configuration to ensure that the system can be restored in case of a failure. This includes using tools such Google Cloud Storage to store backups.
* User Support: User support involves providing users with assistance and support when they encounter issues or have questions about using the system. This includes providing user guides, and FAQs to support users.

The resources needed for this project include; software such as Kobo Collect, UML diagrams, Visual Studio Code, Command Prompt, Chrome Web Browser, PostgreSQL, GitHub. Frameworks to be used include Bootstrap for Front-end Development, Django for Back-end Development

Geo-enabled Web Application for Reporting Sewer Incidences

User Interface

Incident Management

Sysem

Geospatial

Database

Reported Cases Data

Incident Dashboard

Report Incident Form

Reporting and Analysis Dashboard

**1.5 Justification for the Study**

The users of the web application will include; Municipal or city officials, Maintenance and Repair Crews, Environmental Health and Safety officials, Residents and Business Owners, and Contractors. The web application is intended to be user-friendly, and accessible to all users regardless of their technical expertise.

The benefits of the web application will include;

* Improved Communication: The web application will provide a centralized platform for users to report incidents and communicate with city officials. This can help to improve the efficiency and effectiveness of communication, reducing the time and resources required to report and resolve incidents.
* Increased Transparency: The web application will provide real-time updates on the status of repairs and investigations, allowing residents and business owners to track the progress of the response to incidents. This can help to increase transparency and accountability, building trust in the city's management of the sewer system.
* Improved Data Management: The web application will provide a centralized repository of incident data, allowing city officials to analyze and track trends over time. This can help to inform decision-making and resource allocation, improving the overall management and maintenance of the sewer system.
* Enhanced Safety and Health: By providing a platform for residents and business owners to report incidents, the web application can help to ensure that issues are addressed in a timely and effective manner, reducing the risk of health and safety hazards.
* Streamlined Processes: By automating many of the manual processes involved in reporting and tracking incidents, the web application can help to streamline and simplify the response process, reducing the time and resources required to resolve incidents.

**1.6 Scope and Limitation of work**

The specific objectives of this project is to evaluate user experience and also assess the effectiveness of the web application in reporting and tracking sewer incidents. The methods to be used to conduct the study include carrying out user needs assessment using user surveys, interviews and questionnaires, use of UML diagrams, design and development, test and validate the system, deploy and maintain the system. The geographic area being studied is Kawangware area, Nairobi, Kenya. User groups involved in the study are residents, business owners, city officials, the NCWSC

The study will not be including existing sewer systems data, since its focus is to implement crowd sourcing capabilities in the web application. This is owing to the fact that not all areas in Kawangware have sewer network coverage. It is therefore impractical to use existing data since it may be incomplete or may not represent the whole area. The web application aims to incorporate data collection capabilities that will provide a platform for further analysis to be done.

**1.7 Organization of your Project**

This project includes the following elements:

* Chapter One: Background, Statement of the Problem, Objectives, Methodology, Justification for the Study, Scope and Limitation of work, Organization of your Project
* Chapter Two: Definitions, The History of Sewer Systems, Sewer Systems in Kenya

**CHAPTER THREE**

**METHODOLOGY**

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.0 DEFINITIONS**

Sewage refers to the waste material and water that is carried away from homes, businesses, and industrial sites through a network of underground pipes and channels. Sewage typically contains a variety of organic and inorganic materials, including human and animal waste, food waste, oil, chemicals, and debris. A sewage system, also known as a wastewater system, is a network of pipes, pumps, and other infrastructure that collects and transports sewage from homes, businesses, and other sources to a treatment plant or disposal site. Sewage systems are essential for maintaining public health and protecting the environment, as they prevent raw sewage from contaminating water sources and spreading disease.

**2.1 THE HISTORY OF SEWER SYSTEMS**

The history of sewer systems dates back thousands of years. In ancient civilizations such as the Indus Valley, Mesopotamia, and Egypt, early forms of sanitation systems were used to dispose of human waste and prevent the spread of disease. These early systems used channels, drains, and pit toilets to collect and remove sewage from populated areas. In the western world, the development of modern sewer systems can be traced back to the ancient Roman Empire. In Rome, a network of aqueducts and sewers was built to supply water to the city and carry away wastewater. The Cloaca Maxima, a massive sewer system constructed in the 6th century BC, is still in use today and considered one of the greatest engineering feats of the ancient world.

During the Middle Ages, the use of primitive sanitation systems and the lack of proper waste management led to outbreaks of disease, such as the bubonic plague. It wasn't until the 19th century that significant progress was made in the development of modern sewer systems. In the early 1800s, cities such as Paris, London, and New York began constructing extensive sewer networks to improve public health and sanitation. In the late 19th and early 20th centuries, improvements in technology led to the development of centralized wastewater treatment facilities, which used a combination of physical, biological, and chemical processes to remove contaminants from sewage. Today, sewer systems continue to be an essential component of modern urban infrastructure, as they help to protect public health and the environment by safely disposing of sewage and preventing the spread of disease.

The development of smart sewer systems is a relatively recent development that began in the late 20th century. A smart sewer system is an advanced wastewater management system that uses sensors, data analytic, and other technologies to optimize performance and reduce costs. The first modern smart sewer system was developed in 1998 in Kitchener, Ontario, Canada. This system, known as the Smart Sewer System (S3), uses advanced sensors and data analytic to optimize the performance of the sewer system and reduce the frequency and impact of sewer overflows. The system uses real-time data to predict sewer overflow events and automatically adjusts the flow rate in the system to prevent overflows from occurring.

Since then, the development of smart sewer systems has continued to grow. Today, many cities around the world are implementing smart sewer systems to improve wastewater management, reduce the frequency of overflows, and save costs. These systems can provide real-time data on sewer conditions, detect leaks and blockages, optimize flow rates, and prioritize maintenance and repairs. The use of smart sewer systems is expected to continue to grow in the coming years, as advances in technology and data analytic make it easier and more cost-effective to implement these systems. As the world faces increasing pressure on water resources, climate change, and urbanization, smart sewer systems will play an important role in improving the sustainability and efficiency of wastewater management.

**2.2 SEWER SYSTEM IN KENYA**

The origin of sewer systems in Kenya can be traced back to the colonial era, when the British constructed the first major sewer system in Nairobi in the early 20th century. This system was designed to serve the European population and was not extended to the African areas of the city. After Kenya gained independence in 1963, the government initiated a series of programs to expand access to sanitation services, including the provision of sewer systems. In the 1970s and 1980s, the government constructed large-scale sewer systems in Nairobi and other major urban centers, with the goal of improving public health and sanitation.

The main providers of sewer systems in Kenya are the water companies, which are tasked with the provision of water and sanitation services in their respective areas of operation. These companies are overseen by the Water Services Regulatory Board (WASREB), which is responsible for regulating the provision of water and sanitation services in the country. One of the main challenges facing the provision of sewer systems in Kenya is inadequate infrastructure and resources. Many existing sewer systems are outdated and in need of repair or upgrading, and there is a lack of investment in new sewer infrastructure. In addition, there is limited capacity for wastewater treatment, which can lead to the discharge of untreated wastewater into water bodies and the environment.

To address these challenges, the government of Kenya has launched various initiatives to improve the provision of sewer systems in the country. These initiatives include the Kenya Informal Settlements Improvement Project (KISIP), which aims to improve the sanitation and living conditions in informal settlements, and the Kenya Urban Support Programme (KUSP), which seeks to improve the delivery of basic services, including water and sanitation, in urban areas. Overall, while the provision of sewer systems in Kenya is still limited, there are efforts underway to expand coverage and improve the sustainability and efficiency of wastewater management in the country.

The sewer system in Nairobi has been a long-standing problem due to various factors, including:

* Aging Infrastructure: Much of the sewer system in Nairobi was built during the colonial era and has not been upgraded or maintained adequately. This has led to frequent sewer overflows, blockages, and leaks.
* Rapid Urbanization: The rapid growth of Nairobi's population has put a strain on the existing sewer system. Many residents live in informal settlements where access to sanitation facilities is limited, and this has resulted in increased pollution of water sources and the environment.
* Poor Maintenance: The maintenance of the sewer system in Nairobi has been inadequate, leading to the accumulation of solid waste and debris that cause blockages and overflows.
* Illegal Connections: Many residents in Nairobi have made illegal connections to the sewer system, leading to overload and blockages that cause sewage spills and overflows.

The sewer system problem in Nairobi has resulted in severe environmental pollution, health hazards, and inconvenience to residents. Sewage spills and overflows have caused waterborne diseases, contaminated water sources, and environmental degradation. To address these problems, there is a need for investment in upgrading the existing sewer infrastructure, improving maintenance, and enforcing regulations to prevent illegal connections. Additionally, increasing public awareness on the importance of proper waste disposal and sanitation practices can help to reduce the pollution of water sources and the environment. The development of a web application for reporting sewer incidents can also be a useful tool in improving the management of the sewer system and addressing sewer-related issues in a timely and efficient manner.