Chapter 1

THE PROBLEM AND ITS BACKGROUND

This chapter presents the introduction, background of the study, statement of the problem, scope and delimitation of the study and significance of the study.

Introduction

The field of disaster risk reduction and management is undergoing a revolutionary shift in an era characterized by rapid technical breakthroughs and the ever-increasing influence of digital solutions. Traditional methods of communicating crucial information, which frequently rely on lectures, printed materials, and traditional warning systems, have long formed the foundation of DRRM techniques. Modern ways, however, are gaining significance in a society increasingly defined by real-time networking and new solutions. Within this changing setting, we begin an exploration of a ground-breaking effort, the AGAPAY AI Enhanced Reporting for Disaster Risk Reduction Management with Real-Time Alerts, designed to transform disaster management in the unique context of Caloocan City, Philippines.

Caloocan City, located in a historically prone zone to a wide spectrum of natural catastrophes, is grappling with the critical need for adequate disaster resilience. Conventional tactics, similar to conventional approaches mentioned in prior studies, have gained trust and acceptance. However, in order to keep up with the dynamism of the modern world, AGAPAY emerges as a change agent, powered by the convergence of technology, community participation, and real-time data. AGAPAY intends to reshape how information flows in disaster management, mimicking the shift from old methods of instruction to new online instructional approaches. It is a tribute to the power of innovation in the face of adversity, providing a dynamic platform where information is exchanged, contextualized, and acted on with unprecedented rapidity. As we traverse the terrain of tradition and innovation in the context of disaster resilience, stakeholders of the Caloocan City Disaster Risk Reduction and Management Department (CCDRRMD) aim to highlight the motivations behind these choices and decipher the implications they hold for disaster risk reduction, community empowerment, and the evolving role of technology. The AGAPAY project, at the crossroads of tradition and innovation, aims to bridge the gap between established wisdom and technological promises, ultimately charting a new course for disaster management in Caloocan City's specific landscape.

In crisis circumstances, consider technical accessibility and the urgency of information distribution. In the midst of these complicated dynamics, our research seeks to explain the complex elements that influence CCDRRMD stakeholders' selection of current disaster risk reduction and management systems.

Background of the Study

Natural or human disasters pose an ever-present hazard to populations around the world. The ability to respond to severe emergencies quickly and efficiently is a crucial component of modern emergency management. This study sets out on a quest to create and deploy an innovative Disaster Risk Reduction and Management System called "AGAPAY”. Disaster Risk Reduction and Management System are at the forefront of modern disaster management, serving as the first line of defense against calamities destructive forces. They play a critical role in saving lives and limiting damage by providing real-time information, early warnings, and important assistance to both authorities and citizens.

The city confronts challenges because it is in an area prone to a wide range of natural disasters such as floods, earthquakes, and typhoons. According to Calder and Kirby's (2020) recent study, the landscape of catastrophe risk reduction is always changing, emphasizing the importance of context-specific and adaptive solutions.

In this study, we present a brief summary of the disaster management concerns and discuss the current condition of the disaster risk reduction management system in Caloocan City. A mixed-methods research strategy was used for the study, which included qualitative interviews, quantitative surveys, and data analysis. This paper seeks to contribute to the literature on disaster management by providing insights on the effectiveness and feasibility of sophisticated Disaster Risk Reduction and Management Systems in a localized context.

The development of this system has traditionally focused on natural hazards where there is a relatively high degree of certainty of a rapid or sudden-onset event that may endanger lives and property. Warning systems have also traditionally been developed in parallel with response mechanisms and scenarios for emergency response organizations. Thus, disaster management has historically focused on disaster preparedness and response. With enhanced technology for real-time data collection and capability for modeling and dissemination of information, disaster risk reduction systems are becoming increasingly sophisticated and complex. They are able to provide more accurate and detailed information, and disseminate more broadly to the population. In turn, advances in computer simulation and modeling have made it possible to include information about the underlying hazards, as well as about the exposure and vulnerability of populations so that warning information can truly inform response.

Environmental, technological, biological, and natural hazards operate on many different time scales. Monitoring and warning systems need to consider this in time for developing and disseminating information to the public so that appropriate and timely action can be taken.

Statement of the Problem:

The client for this research is the Caloocan City Disaster Risk Reduction and Management Department (CCDRRMD). The Caloocan City DRRMD is a local government office responsible for disaster risk reduction and management within the city. It focuses on ensuring the safety and preparedness of the residents and businesses in the face of various disaster events in Caloocan City. The office is headed by Mr. Julius Baylon, who oversees disaster management initiatives and operations. Caloocan City is located in the National Capital Region of the Philippines and faces various environmental risks, including flooding, landslides, vehicular accidents, and fire incidents.

This research delves into the "AGAPAY: Disaster Risk Reduction Management System with real-time alerts" within the context of the Caloocan

City Disaster Risk Reduction and Management Department. The study aims to address the following key concerns:

According to Mr. Julius Baylon, responsible for disaster management initiatives and operations at the Caloocan City Disaster Risk Reduction and Management Department (CCDRRMD), has identified pressing challenges in the current disaster response procedures. The primary concerns include the need to enhance real-time data analysis and decision-making capabilities during disaster events. The current processes often face delays in data interpretation and decision-making, which can impact the efficiency of disaster response.

Additionally, there is a demand for a more streamlined and efficient system for disseminating disaster alerts and coordinating emergency responses. The existing alert systems may not be synchronized, leading to confusion and potential delays in response efforts.

To address these problems, the integration of artificial intelligence (AI) into AGAPAY has been proposed as a plausible solution. This innovative approach aims to improve the effectiveness of disaster management in Caloocan City, ensuring timely responses and accurate information dissemination. The AI component will play a pivotal role in enhancing real-time data analysis, providing insights for quick decision-making, and automating personalized alert notifications for residents and authorities.

Records from the Caloocan City DRRMD show that one of the agency's top concerns right now is the potential for system overload during significant disaster events or emergencies. During these critical situations, there could be a surge in users attempting to access AGAPAY simultaneously, leading to potential system overload. This, in turn, may result in slow response times, decreased system reliability, and a hindrance to effective disaster response efforts.

To address this problem effectively, the AGAPAY system will be designed with scalability. Such an approach ensures the system remains responsive during times of heightened user activity. Furthermore, consistent performance and performance monitoring are imperative to identify and proactively address potential issues, ensuring AGAPAY operates reliably even during peak usage.

Based on Caloocan City DRRMD system logs and data, a critical issue arises from the frequency of monitoring and response to real-time alerts. Additionally, our client faces the challenge of ensuring timely and efficient responses to disaster events, a minor problem intricately linked to the main issue. It is imperative to address these concerns as they directly impact the effectiveness of disaster management in Caloocan City.

To address the critical problem regarding the frequency of monitoring and response to real-time alerts, AGAPAY An enhancement focused on real-time monitoring and alert response capabilities will be implemented, incorporating our features. Furthermore, a user-friendly interface will be implemented for response teams, allowing them to swiftly access and respond to alerts generated by AGAPAY.

To address the minor problem of timely and efficient responses to disaster events, the system will incorporate a GIS integration feature. This feature enables response teams to pinpoint incident locations accurately and aids in planning the most efficient response routes.

Based on the interview with Mr. Julius Baylon from CCDRRMD and the development team, another significant challenge in disaster management is the efficient spread of critical information. Ensuring that residents receive timely updates, severe weather warnings, evacuation notices, and information on ongoing disasters is crucial for their safety.

To address this challenge, our solution involves the development of a notification system that will deliver real-time alerts. These alerts will include important information such as severe weather warnings, including system alerts. This feature will significantly enhance the effectiveness of disaster management in Caloocan City, ensuring that vital information reaches residents promptly.

General Objectives

The main objective of this study is to create AGAPAY: AI Enhanced Reporting for Disaster Risk Reduction Management system for use by the Caloocan City Disaster Risk Reduction and Management Department (CCDRRMD).

The Caloocan City DRRM Department problems are addressed by our capstone project, AGAPAY which offers a workable and realistic solution. AGAPAY streamlines risk reduction and disaster management by utilizing technology and user-friendly features. It makes reliable and easily accessible disaster information available to the CCDRRMD and the people of Caloocan City, enhancing their ability to plan for emergencies and respond to them more quickly while also improving their economic stability. With an emphasis on bringing real advantages to Caloocan City, our initiative considers the unique problems of disaster-prone locations. It is an easy-to-use and efficient tool for increasing citywide efforts to reduce disaster risk.

Specific Objectives

- To create a user authentication and authorization module, incorporating secure methods such as Gmail account connection, two-factor authentication. This module will ensure secure access control for Caloocan City residents using the system.
    - This specific objective is crucial to safeguard sensitive disaster-related information and limit system access to authorized users, enhancing overall system security.
- To develop a user-friendly front-end interface using React.js, enabling residents to easily upload videos and reports, and access real-time alerts. This interface will integrate the WebRTC API for camera access, allowing seamless video uploads.
    - This objective prioritizes user experience, ensuring that residents can efficiently contribute disaster-related content, including videos, and access vital information with ease.
- To establish a php and mysql back-end with RESTful APIs, dedicated to video verification, report management, and data storage.
    - This objective forms the backbone of the system, facilitating efficient data handling and processing, crucial for disaster management.

- To integrate AI technology, specifically Google Cloud Video API, for automatic video verification, enhancing the accuracy of disaster reports.
    - Integrating AI technology aims to reduce manual verification efforts while ensuring the reliability of user-contributed content.
- To integrate a weather forecasting API, specifically the OpenWeatherMap Weather API, to enhance real-time weather data availability for disaster preparedness.
    - Weather data integration is essential to equip users with timely information from the OpenWeatherMap Weather API for informed decision-making during disaster events.
- To leverage locating capabilities, for responders' location and coordination, optimizing disaster response efforts.
    - Ensures efficient resource allocation and coordination during disaster events, minimizing response time.
- To create a guide and scenarios for the users to know what to do in case a disaster occurs.
    - It ensures users have clear, actionable steps to follow during emergencies, enhancing safety and minimizing confusion.

Significance of the Study

The researchers believe that a comprehensive study of the "AGAPAY: The Development of AI-Enhanced Reporting for Disaster Risk Reduction Management System with Real-Time Alerts for Caloocan City" is essential for advancing disaster risk reduction and management. The research results will be beneficial for the following:

People At Risk. The findings of this research hold direct significance for the students of Caloocan City. Understanding the effectiveness of the "AGAPAY" in enhancing disaster preparedness and response will empower students with the knowledge and tools to protect their lives, homes, and communities during disasters. By embracing AGAPAY, students can become active participants in building a safer and more resilient city.

To the Parents. This study is a valuable resource for parents, providing information about the AGAPAY and its role in disaster risk reduction and management. Parents can better support their children's use of AGAPAY by recognizing its effectiveness in improving catastrophe preparedness and response. This information enables parents to actively participate in disaster resilience talks and to reaffirm the need for preparedness within their families.

To the Teachers and School Administrators. The study provides valuable insights to teachers and school administrators, helping them understand the effectiveness of the "AGAPAY" Disaster Alert System. This understanding can lead to the development of more effective disaster resilience education programs, ultimately improving students' preparedness and academic performance.

To the Government Agencies. This study is a valuable resource for government entities in charge of disaster risk reduction and management. It gives insights into the effectiveness of modern alert systems, directing policy and resource allocation decisions to improve community catastrophe resilience.

To the Local Communities. The study has the potential to increase local community understanding of the necessity of disaster preparedness and communication confidence. Communities may actively participate in disaster resilience efforts by knowing the benefits of AGAPAY, establishing a culture of preparedness and safety.

To the Future Researchers. This study serves as a valuable reference and source of knowledge. It enlarges their understanding of disaster risk reduction and management, and it can guide further research and experimentation in the field, contributing to the continuous improvement of disaster resilience strategies.

Scope of the Study

This research focuses on the implementation and impact assessment of the "AGAPAY: The Development of AI Enhanced Reporting for Disaster Risk Reduction Management with Real-Time Alerts for Caloocan City". The study encompasses the following scope:

Front End Scope

- Responsive Design: Ensure that the interface is responsive and can be accessed on various devices, including desktops, tablets, and smartphones.
- Real-time Alerts: Develop a notification system that delivers real-time alerts, including severe weather warnings, evacuation notices, and updates on ongoing disasters.
- User Authentication: Develop secure access controls for Caloocan City residents using Gmail account connections and phone number OTP verification.
- The research will include an exploration of the use of SMS for alerting and communication purposes within the AGAPAY System.

- The study will primarily focus on the functionalities related to alerts, information dissemination, and communication with emergency professionals within the System.

Back End Scope

- Set up a database system to store various types of data, including disaster records, and user information.
- Define user roles and permissions to control access to different system functionalities and data.
- Implement secure user authentication, including two-factor authentication options.
- Use APIs and reporting tools to allow authorized users to extract and analyze data for decision-making and reporting purposes. (AI Video Verification).

Limitations

- The research's limitation lies in its specific focus on disaster scenarios, including floods, landslides, fires, and vehicular accidents. While these are critical events, the exclusion of pandemic or virus-related emergencies is a limitation. This omission is due to the distinct response mechanisms required for health-related crises, which fall outside the scope of this project.

  - This limitation means that the AGAPAY System, while valuable for various disaster scenarios, may not address the complexities of health emergencies, potentially leaving a critical gap in the city's disaster response capabilities.
- Another limitation of this research is its geographical scope, which encompasses only three districts within Caloocan City.
  - This narrower focus restricts the generalizability of findings to the entire city and may not fully represent the diverse disaster-related challenges faced in other areas.
- The AGAPAY System, though versatile, is subject to limitations in responding to certain types of disasters. The exclusion of pandemic or virus-related emergencies from the research stems from the unique nature of healthcare responses required during such crises.
  - This study primarily concentrates on disasters with distinct response dynamics and does not encompass health-related emergencies due to their specialized nature.

Definition of Terms

For better understanding, the following words and phrases were conceptually defined:

1. **Progressive Web App (PWA)** type of web application that leverages modern web technologies to provide a more app-like experience to users. PWAs are designed to work on any platform or device with a standard-compliant browser and have several key characteristics and advantages.
2. **Geographic Information System (GIS)** A Geographic Information System (GIS) is a technology that captures, stores, analyzes, and displays geographic data. It is often used in disaster management to map and analyze disaster-prone areas, response resources, and evacuation routes.
3. **React. js framework** is an open-source JavaScript framework and library developed by Facebook. It's used for building interactive user interfaces and web applications quickly and efficiently with significantly less code than you would with vanilla JavaScript.
4. **PHP** - short for Hypertext PreProcessor is the most widely used open source and general purpose server side scripting language used mainly in web development to create dynamic websites and applications.

5. **End User License Agreement (EULA)** is an agreement or contract between the user of software and the licensor that provides the software. EULAs usually outline the ways in which software can be used, copyright information, liability information, etc.

6. **Application Programming Interface (API)** In the context of APIs, the word Application refers to any software with a distinct function. Interface can be thought of as a contract of service between two applications. This contract defines how the two communicate with each other using requests and responses.

Chapter 2

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter reviews relevant literature and studies, emphasizing disaster risk reduction and the role of technology in bolstering disaster resilience in Caloocan City. It explores existing knowledge, theoretical frameworks, and technological applications related to the "AGAPAY" Disaster Alert System, providing a foundation for this research. Key terms are defined to enhance comprehension.

Foreign Literature

Disaster Risk Reduction is at the core of the mission of the World Meteorological Organization (WMO). WMO, through its scientific and technical programs, its network of Global Meteorological Centers and Regional Specialized Meteorological and Climate Centers, provide scientific and technical services. This includes observing, detecting, monitoring, predicting and early warning of a wide range of weather–, climate- and water-related hazards. Through a coordinated approach, and working with its partners, WMO addresses the information needs and requirements of the disaster risk management community in an effective and timely fashion. Every year, disasters related to meteorological, hydrological and climate hazards cause significant loss of life, and set back economic and social

To minimize vulnerabilities for foreign residents, conventional disaster preparedness strategies rely on the institutional environment, infrastructure safety and available information. However, little attention has been given to the role that perception of risk plays in minimizing vulnerabilities, despite the literature suggesting an important link between risk perception and disaster preparedness (Oliver-Smith 1999, Boret 2020). This research aims to fill this gap by investigating the disaster risk perceptions of foreign residents.

The relevance of this study is that risk awareness during a crisis can increase resilience and reduces reliance on external help. A case study is used to illustrate this. During the flooding in Kyushu, Japan in 2020, the deployment of relief personnel, normally in charge of coordinating and providing relief operations was reduced, delayed or did not occur at all due to the COVID-19 pandemic. As a result, individuals and households had to rely on their own knowledge and local resources (Kamino 2020).

During the various catastrophic events of recent years, the use of social media to communicate timely information in crisis periods has become a common practice, allowing affected population to quickly publish a considerable amount of disaster information which can help managers making correct and quick decisions. In this paper, we propose a new real-time alert model for the management of natural or anthropogenic disasters. This model is based on a semi-supervised inductive technique to use unlabeled multi-source data, which are often abundant during a crisis event, with less data previously labeled than previous event. We use two sets of real-world crisis data from Facebook and Twitter manually tagged to launch streaming retrieval of relevant content: it is used for evaluating our proposed approach. Preliminary results are satisfactory. (Zair Bouzidi, Mourad Amad and Abdelmalek Boudries, 2020)

Local Literature

Philippines is an archipelago state, consisting of some 7,100 islands and islets, and covering a land area of approximately 300,000 km2. The country comprises three groups or large islands: (1) the Luzon group in the north and west, consisting of Luzon, Mindoro, and Palawan, (2) the Visaya group in the centre, consisting of Bohol, Cebu, Leyte, Masbate, Negros, Panay and Samar, and (3) Mindanao in the South. Manila and nearby Quezon City, the country's most-populous cities, are part of the National Capital Region (NRC or Metro Manila), located on the largest island Luzon (Cullinane, 2019). The islands and groups are divided into four main classes of administrative divisions, which consist of 17 autonomous regions, 81 provinces, 1,489 municipalities, and the smallest political units, 42,044 Barangays as of 2018 (PSA, 2018).The Philippines is governed by a presidential form, in which power is divided among three juridical branches; executive, legislative and judicial, which seek democracy and balance by carrying their equally weighted duties to uphold law, rights and representation of the interests of the people (GoP, 2019).

In terms of disaster risk, Philippines ranked third among all of the countries with the highest risks worldwide according to the World Risk Report 2018, with index value of 25.14% (World Economic Forum, 2018). At least 60% of the country's total land area is exposed to multiple hazards, and 74% of the population is susceptible to their impact (GFDRR, 2017). This is largely due to the location and geographical context as the risk involving coastal hazards such as typhoons, storm surges and rising sea levels is high. Also, as the islands are located within the "Ring of Fire" between the Eurasian and Pacific tectonic plates, earthquakes and volcanoes are posing serious risks to the safety of the populace. Flooding, landslides, droughts and tsunamis further contribute to the exposure to natural hazards (CFE-DM, 2018). Of these, hydro-meteorological events including typhoons and floods, accounted for over 80% of the natural disasters in the country during the last half-century (Jha, 2018).

Tropical storms Urduja and Vinta battered the Philippines in December 2017. Despite advances in disaster risk reduction efforts of the country, the twin December storms caused numerous deaths in the Visayas and Mindanao regions. Analysis of these events shows that alerts raised during the Pre-Disaster Risk

Assessment (PDRA) for both storms were largely ineffective because they were too broad and general calling for forced evacuations in too many provinces. Repeated multiple and general warnings that usually do not end up in floods or landslides, desensitize people and result in the cry-wolf effect where communities do not respond with urgency when needed. It was unlike the previous execution of PDRA from 2014 to early 2017 by the National Disaster Risk Reduction and Management Council (NDRRMC), which averted mass loss of lives in many severely impacted areas because of hazard-specific, area-focused and time-bound warnings. PDRA must reinstate specific calls, where mayors of communities are informed by phone hours in advance of imminent danger to prompt and ensure immediate action. Mainstreaming Climate Change Adaptation and Disaster Risk Reduction information using probabilistic (multi-scenario) hazard maps is also necessary for an effective early warning system to elicit appropriate response from the community. The paper aims to discuss these issues. (Mahar Lagmay, 2018)

It was found out that the numerous casualties were due to inadequate warning issued during the approach of the tropical cyclones. During an impending hazard, warnings must be accurate, reliable, understandable and timely. Despite the availability of maps that identified safe zones for different communities, warnings raised during the PDRA for both tropical cyclones were deemed too general, calling for evacuations of whole provinces. As such, not all communities were evacuated in a timely manner because of failure in the key elements of an effective early warning system. (Bernard Alan Racoma 2019)

Foreign Studies

The fact that foreigners are disproportionately affected in disasters, in combination with an expected increase in Japan's foreign resident population, requires an urgent assessment of their vulnerability (Nagy 2009). To minimise vulnerabilities for foreign residents, conventional disaster preparedness strategies rely on the institutional environment, infrastructure safety and available information. However, little attention has been given to the role that perception of risk plays in minimising vulnerabilities, despite the literature suggesting an important link between risk perception and disaster preparedness (Oliver-Smith 1999, Boret 2020). This research aims to fill this gap by investigating the disaster risk perceptions of foreign residents.

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Research on communication during disaster events for foreign residents often focuses on linguistic barriers and pays less attention to other social and cultural aspects such as disaster risk perceptions of foreign populations (Uekusa 2019). This study investigated the social and cultural factors affecting disaster risk perceptions of foreign nationals and how these factors could be included in future communication strategies.

To understand individual perceptions of disaster risks, different cultural backgrounds and other social factors must be acknowledged. Social factors, such as age, gender and social class, are important aspects of social vulnerability (Jayarathne & Babu 2017; Hamidazada, Cruz & Yokomatsu 2019). However, these aspects have only been considered as vulnerabilities after a disaster, not as factors that can influence the perception of risks before a disaster. An example is the post-disaster study by Davidson and co-authors (2013) that investigated the effects of social and economic factors on disaster vulnerabilities among Latino and African communities in the US. The study showed that the socio-economic conditions of immigrant communities made them more vulnerable and more exposed to negative mental health outcomes compared to local residents.

In the policy-making arena, disaster risk communication is an important part of Disaster Risk Reduction (DRR). The Sendai framework [17] acknowledges the need for participation of citizens and non-professionals when dealing with multiple hazards. With the advent of the Information Age and new forms of social media, such participatory schemes and platforms, have become more interactive and dynamic. For qualitative research, the internet can be approached as a medium for communication, as a network of computers and as a context of social construction. Web-based access to data, model results to support participatory early warning and monitoring of flood risks on catchment scale have created new challenges for emergency response organisations and public entities responsible for flood risk communication. In Europe, the Joint Research Centre [2] has highlighted new emerging challenges related to risk communication, noting that key challenges are not so much about new tools and innovations, but rather about embedding social mechanisms in communication practice [2].

Web-based access to data and model simulations as part of early warning and monitoring systems (EWMS) and risk communication play a crucial role in both the survival and recovery of populations affected by disasters. Various tools can empower the local community to act in response to an early warning and support the adaptive capacity of local responding institutions [2]. Increasing public participation in disaster risk reduction and dealing with multiple flood hazards are promising, because these imply that focus is on risk, on how people understand and perceive the risk, how they spread information and how they are engaged in protective actions [2].

Early-warning and monitoring systems (EWMS) are defined as [8]: "The set of capacities needed to generate and disseminate timely and meaningful information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss". While classical EWMS focus on risk knowledge and monitoring and warning services, participatory EWMS (pEWMS), according to Basher [1], make up the public part of EWMS. Basher's elements of pEWMS can be summarized as [1]: (i) risk knowledge; (ii) monitoring and warning services; (iii) dissemination and communication; and (iv) response capability. Transitioning EWMS towards pEWMS is about adding network-based, public participation to one or all of the four elements in order to provide more accurate warnings, more comprehensive damage evaluations and improved public risk perception and hazard awareness.

Traditionally, scientists and engineers have provided relevant parties in municipalities with reports or information on flood risks. Recently, however, web-based access to data and model simulations, as well as interactive tools have become available to support decision-making in flood risk management.

In this way, problems such as the consequences of measures pertaining to infrastructure or to the establishment of water retention can be analysed on a catchment level, and the results can be presented in intuitive ways, making it easier to understand for stakeholders with varying expertise and skills. Flexible solutions that can adapt to unknown, unexpected or changing conditions can be used.

This means that stakeholders and local communities can be more engaged in the risk knowledge production, and that authorities and stakeholders at different administrative levels, and across upstream and downstream community borders can interact in the risk knowledge communication. Risk knowledge refers to the level of comprehension of each of the relevant risk components, including hazards and vulnerabilities. Examples of participatory elements include participatory mapping activities related to flooding [9], [10], infrastructure vulnerability [11] and climate change impact and risk [12].

Flood risk communication covers a range of activities [18], [20]. It can be activities that stimulate interests in environmental health issues related to flooding, activities that increase public knowledge about groundwater, storm-surge, consequences of subglacial volcanic eruptions, or influence the attitude and behaviour of people in emergency responses or crisis situations during flooding events. Additionally, flood risk communication can help the decision-making process or assist in conflict resolution [18]. Risk communication can be defined as [19] "any purposeful exchange of information about health or environmental risks between interested parties". As highlighted by Kellens et al. [18], risk communication has evolved gradually from exclusive communication between experts into an inclusive engagement of risk managers and the public, instead of the previous expert-to-expert, linear communication, without public participation.

This paper aims to identify strengths, weaknesses, opportunities, and threats of web-based access to data and model simulations and to add insight into participatory forms of early warnings and monitoring to reduce disaster risks. It also proposes a framework to reformulate the classic view of Early Warning and Monitoring Systems towards a participatory one. Hans Jørgen Henriksen a 1, Matthew J. Roberts b, Peter van der Keur a, Atte Harjanne c, David Egilson b, Leonardo Alfonso 2018.

Local Studies

The Philippines is one of the most disaster-prone countries in the world. Located along the Pacific ring of fire, the Philippines is highly susceptible to seismic and volcanic risks. The country is also subject to the world record of typhoons every year. Climate change and pandemics are exacerbating those risks.

Over the past decade, the World Bank has been supporting the Government of the Philippines in building the country's resilience to climate change, natural disasters, and pandemics through development policy financing, investment operations, technical assistance, analytical work, knowledge-sharing, and policy dialogue. (Worldbank, 2023)

The Department of Science and Technology-Philippine Institute of Volcanology and Seismology (DOST-PHIVOLCS) developed the GeoRiskPH, a web-based platform that serves as the government's central source of information for accurate and efficient hazards and risk assessment. It promotes the use of science-based risks and hazards information for planning and prioritization of investments in public infrastructure projects. The GeoRiskPH-Informed Local Disaster Risk Reduction and Management Plan (LDRRMP) Coaching Sessions implemented by the OCD, DOST-PHIVOLCS, and the WB facilitates efficient integration of science-based risks and hazards assessment in local DRM plans. A total of 450 technical staff from 150 provinces and cities were trained to use the GeoRiskPH platform for their DRM plans. (Worldbank, 2023)

The Ready to Rebuild: Disaster Rehabilitation and Recovery Program is a joint program of the National Disaster Risk Reduction and Management Council (NDRRMC), Office of Civil Defense (OCD), and the World Bank (WB). Ready to Rebuild enhances the capacity of national and local governments to recover better and faster from natural disasters and climate risks even before it happens. This covers pre-disaster and post-disaster activities such as gathering baseline data, formulating a recovery plan, financing, facilitating emergency procurement and implementation, crafting a communications strategy, and developing M&E mechanisms. A total of 325 local governments have participated, translating to 1,805 Mayors, DRM officers, and technical staff trained to prepare baseline data, risk-informed recovery plans, and risk financing strategies prior to disasters. Robielos, R.A.C.; Lin, C.J.; Senoro, D.B.; Ney, F.P. Development of Vulnerability Assessment Framework for Disaster Risk Reduction at Three Levels of Geopolitical Units in the Philippines. Sustainability 2020, 12, 8815.

The Tsunami alert system is an Android-based application that requires installation and is designed and developed for Abuyog residents. This system will deliver a real-time tsunami alert message and push notification to the registered netizen. It will also recommend a map of higher ground safe from the Tsunami. The Municipal Disaster Risk Reduction and Management Office (MDRRMO) spent a lot of time alarming the Abuyog Residents, aware of the possible incoming

Tsunami. They started activities for the residents to prepare for how to survive before and during the disaster. This study aimed to develop a system that improves and provides efficiency for the residents of Abuyog and to support the preparations of the Municipal Disaster Risk Reduction and Management Office of Abuyog. Moreover, the project conducted was beneficial to the citizen of Abuyog that helped facilitate the dissemination of information to all netizens registered in the system. In this study, an Iterative Method was used to develop the system based on the client's perspective. The system was tested and revised until clients were satisfied with the result. And this system was evaluated by fifty (50) and exceeds end-users which concluded that the system is highly accepted with an average of 4.89 out of 5 as the highest for measuring the system's quality and performance proving that this has a great potential for disaster risk management. (2022 Fifth International Conference on Vocational Education and Electrical Engineering (ICVEE)) Rommel V. Traya (2022)

Conceptual Framework

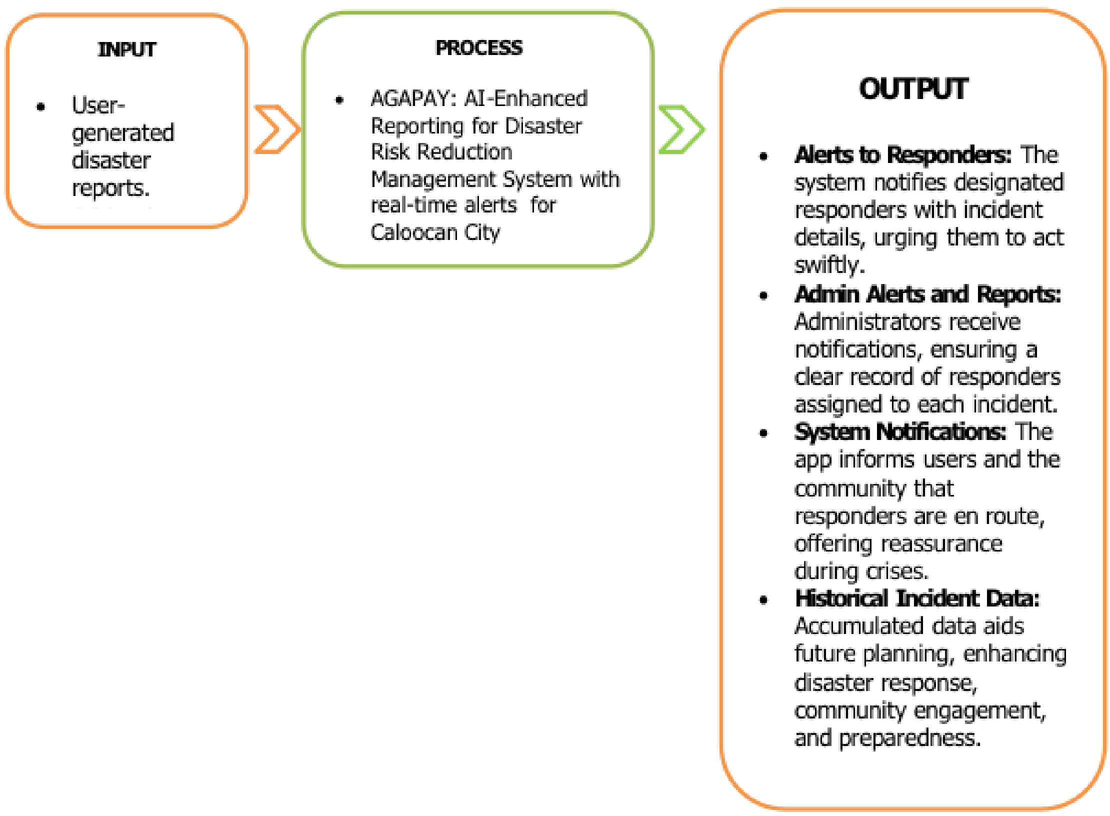

Figure 1.1 Conceptual Framework Diagram for AGAPAY: The Development of AI-Enhanced Reporting for Disaster Risk Reduction Management System with real-time alerts fo Caloocan City

Theoretical Framework

In the domain of Disaster Risk Reduction Management (DRRM), vital for areas susceptible to disasters such as Caloocan City, Philippines, this investigation establishes an encompassing theoretical framework that amalgamates essential insights derived from seminal research in disaster risk management. Given the struggle of Caloocan City with intricate challenges stemming from urbanization, an aging population, depopulation, and vulnerability to various disasters, it becomes imperative to attain a deep understanding of decision-making procedures, nuances of urban planning, and the harmonization of policy and action within the DRRM context. This framework, influenced by three seminal research papers, incorporates the examination conducted by Horita et al. (2018) into the intricacies of decision-making in disaster risk monitoring and early warning systems, with a focus on the dimensions and pillars shaping decision-making. Furthermore, it integrates Karashima et al.'s (2014) exploration of the intersection between land use policy, depopulation, and disaster vulnerability, shedding light on the amalgamation of land use policy and disaster mitigation, taking into account future demographic trends and urban configurations.

In addition to these components, Ogra et al.'s (2021) insights into bridging the gap between policy formulation and its practical implementation in DRRM, with an emphasis on fostering local understanding, community involvement, and a shift in the comprehension of disaster risk, offer invaluable guidance for achieving synergy between policy and effective action in the specific context of Caloocan City. This framework not only serves as the foundation for this study but also provides a structured approach to enhance disaster resilience and preparedness in Caloocan City by addressing crucial gaps and constraints in existing theories, ultimately paving the way for the development of practical, context-tailored strategies in the field of DRRM.

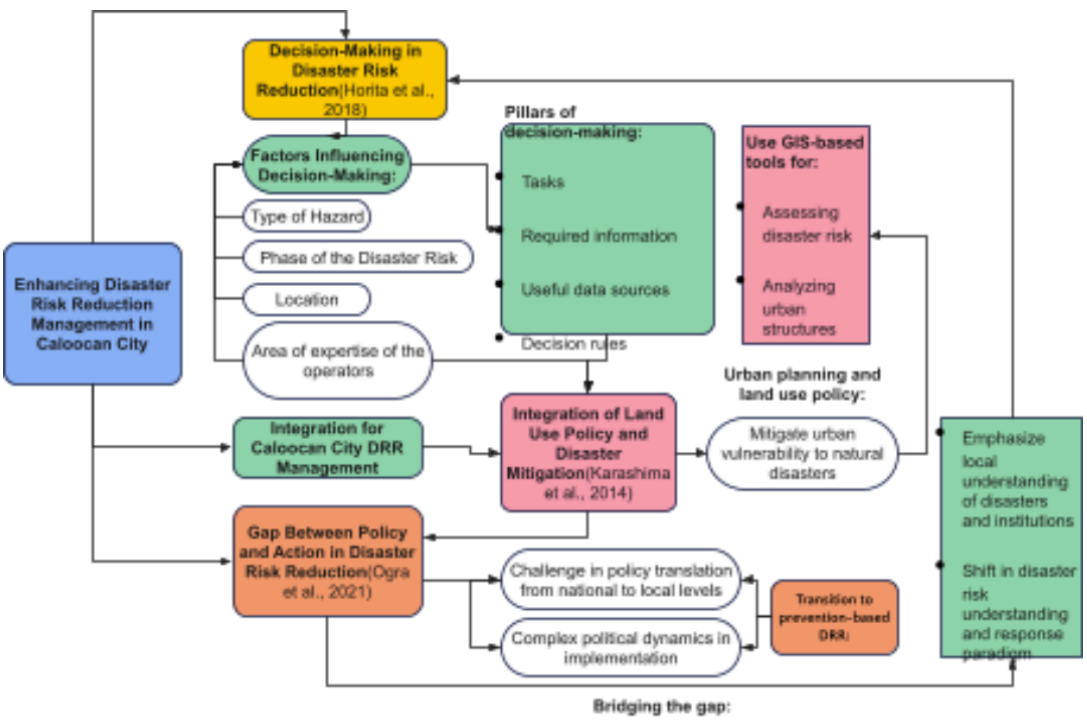

Figure 1.2 Theoretical Framework Model Diagram: Disaster Risk Reduction Management in Caloocan City

Chapter 3

TECHNICAL BACKGROUND

Geographical Information System (GIS):

- Purpose: For mapping and visualizing disaster-prone areas and incidents.
- Implementation: Integrate GIS capabilities to display real-time maps, overlay risk assessments, and provide location-based information.

Database Management System:

- Purpose: To store and manage data related to incidents, locations, and user information.
- Implementation: Implement a database system to organize and retrieve data efficiently.

Incident Reporting:

- Purpose: To enable users to report incidents easily real-time.
- Implementation: Develop a user-friendly incident reporting module and upload the real-time video or photo of the incident.

Emergency Alert System:

- Purpose: To send real-time notifications to users based on their location and the type of disaster.
- Implementation: Implement a notification system that integrates with location data and delivers alerts.

Weather Data Integration:

- Purpose: To provide real-time weather updates and risk assessments.
- Implementation: Integrate with reliable weather APIs to fetch and display current weather conditions, forecasts, and risk maps.

Mobile Optimization:

- Purpose: To ensure accessibility on mobile devices, considering the popularity of smartphones.
- Implementation: Optimize the system for mobile use that they can use for real-time reporting.

Data Security Measures:

- Purpose: To protect user data and ensure compliance with privacy regulations.
- Implementation: secure data storage, and adherence to data protection standards. Providing the terms and conditions to the users.

Analytics and Reporting:

- Purpose: To analyze system usage and incident patterns.
- Implementation: Integrate an API for monitoring system performance, that validates whether the report information is accurate or legitimate.

Chapter 4

Methodology, Results, and Discussion

This chapter includes the analysis and interpretation of the findings drawn out from this study. It is necessary to analyze the collected data to answer the research questions and evaluate the software in different aspects such as functional suitability, performance efficiency, compatibility, usability, reliability, security, and maintainability. A quantitative survey was used to collect the data from the participants.

Requirements Analysis

The AGAPAY disaster management system was developed with input from the community of Caloocan City, and its seamless alignment with their requirements and expectations was made possible in large part by the Requirements Analysis process. This section describes the methodical approach used to determine, record, and evaluate key characteristics and functions that are vital to the community.

1. User Requirements:
    - CCDRRMD Personnel: Ability to access and utilize the system for efficient disaster response coordination, real-time data monitoring, and decision-making.

2. Community Members of Caloocan City: Easy access to disaster information, reporting mechanisms, and communication channels for timely response and preparedness.

2. Functional Requirements:

   - Real-time Data Integration: Capability to collect, analyze, and visualize real-time data related to weather patterns, disaster incidents, and community metrics.

3. Alerting Mechanisms: Automated alert generation and dissemination to relevant stakeholders based on predefined thresholds and triggers.

4. User-friendly Interface: Intuitive interface design for easy navigation and use by CCDRRMD personnel and community members.

5. Reporting and Feedback: User-friendly reporting tools for community members to submit incident reports, feedback, and suggestions.

6. Data Security: Implementation of security measures to safeguard sensitive information and ensure compliance with data protection regulations.

3. Non-functional Requirements:

   - Ability to accommodate increasing data volume and user traffic as the system usage grows over time.
   - High system availability and uptime to ensure continuous access to critical disaster information and resources.

- Fast response times and minimal latency for data retrieval, analysis, and communication.
- Compatibility with a range of devices and internet connections to ensure accessibility for all users, including those with limited resources or disabilities.
- Intuitive design and user-friendly features to facilitate adoption and utilization by CCDRRMD personnel and community members with varying levels of technical proficiency.

4. **Technical Requirements:**
   - Development and deployment of software applications for data collection, analysis, visualization, and communication.
   - Technological Stack: Selection of appropriate technologies, frameworks, and programming languages for system development, taking into account scalability, performance, and security considerations.

Requirements Analysis Process

The requirements that were gathered were carefully categorized, prioritized, and validated in accordance with AGAPAY's primary goals.

- **Emergency Hotlines:** Immediate access to emergency contact information for swift response.
- **Emergency Alert Notifications:** Real-time alerts to keep users informed about ongoing situations nearby on their locations.
- **GIS Mapping:** Facilitating coordinated and optimized emergency response efforts.

Results

A total of 30 respondents participated in answering the questionnaire conducted after the software demonstration which was a mix of 1st year and 4th year students under the Computer Studies Department.

Data gathered through the questionnaire was subjected to frequency count, mean identification, and verbal interpretation. The responses of each participant for their demographic profile were added together to find the highest frequency occurrence and presented in percentage after quantification. Likewise, a formula was used to find the mean value of gathered data in terms of software evaluation.

Table 1. Frequency Distribution of the Demographic Profile of the Respondents

Variable		Frequency (F)	Percentage (%)
COURSE	BSCS	11	36.7%
	BSEMC	3	10%
	BSIS	5	16.6%
	BSIT	11	36.7%
	TOTAL:	**30**	**100%**
YEAR	1st Year	11	36.7%
	2nd Year	6	20%
	3rd Year	10	33.3%
	4th Year	3	10%
	TOTAL:	**30**	**100%**

The table shows that the respondents' courses vary from BSCS, BSEMC, BSIT and BSIS. A total of 11 (36.7%) students' respondents were from BSIT. While the another 11 (36.7%) respondents are from BSCS, the BSIS has 5 (16.6%) respondents and the BSEMC has 3 (10%) respondents. The 1st year students dominate the respondents' number with a total of 11 (36.7%), followed by 3rd year students with 10

(33.3%) students, next is the 2nd year with 6 (20%) students, and last is 4th year that has equal students of 3 (10%).

Evaluation of the AGAPAY as a product of the study, "The Development of AI-Enhanced Reporting for Disaster Risk Reduction Management System with real-time alerts for Caloocan City" in terms of:

Table 2.1 Functional Suitability

Indicators	Weighted Mean	Descriptive Equivalent
1. Does the software meet the functional requirements specified for its intended use?	3.70	Strongly Agree
2. How would you rate the accuracy of the software's calculations or processing?	3.74	Strongly Agree
3. Does the software support interoperability with other systems or software components?	3.74	Strongly Agree
4. Is the software compliant with relevant industry standards or regulations?	3.83	Strongly Agree
General Weighted Mean	**3.75**	**Strongly Agree**

Table 2.1 shows the rating of functional suitability of the AGAPAY system. With the highest mean of 3.83, interpreted as Strongly Agree that the AGAPAY is compliant with relevant industry standards or regulations. Followed by the accuracy of the software's calculation or processing and this software can support the interoperability

with other systems that has a same weighted mean of 3.74. Respondents also Agree the software meet the functional requirements specified for its intended use with the mean of 3.70. The total weighted mean of table 2.1 is 3.75 and is interpreted as “Strongly Agree”.

Table 2.2 Performance Efficiency

Indicators	Weighted Mean	Descriptive Equivalent
1. How would you rate the speed and responsiveness of the software during normal usage?	3.74	Strongly Agree
2. Does the software perform efficiently under various workload conditions?	3.70	Strongly Agree
3. How does the software handle peak load situations or scalability requirements?	3.67	Strongly Agree
4. Is the software's resource utilization optimized, such as CPU, memory, and network bandwidth?	3.80	Strongly Agree
General Weighted Mean	**3.72**	**Strongly Agree**

Table 2.2 reflects the performance efficiency of the software. According to the respondents, they are Strongly Agree that the software's resource utilization is optimized, such as CPU, memory, and network bandwidth with the mean of 3.80. The respondents rate the speed and responsiveness of the software during normal usage has a mean of 3.74 which is also interpreted as Strongly Agree. They also Agree that the software performs efficiently under various workload conditions with the mean of 3.70

and 3.67 for the software to handle peak load situations or scalability requirements. The overall average weighted mean of table 2.2 is 3.72 with verbal interpretation of “Strongly Agree”.

Table 2.3 Compatibility

Indicators	Weighted Mean	Descriptive Equivalent
1. Does the software coexist with other software applications or systems without conflicts?	3.70	Strongly Agree
2. How well does the software integrate with third-party tools, plugins, or APIs?	3.67	Strongly Agree
3. Is the software compatible with different operating systems, browsers, or devices?	3.70	Strongly Agree
4. Does the software support backward compatibility with older versions or legacy systems?	3.67	Strongly Agree
General Weighted Mean	**3.68**	**Strongly Agree**

Table 2.3 includes the Compatibility aspect of the software. Leading with the same mean of 3.40 and interpreted as Strongly Agree that the software ithe software coexist with other software applications or systems without conflicts and the software compatible with different operating systems, browsers, or devices. It is followed by the same mean of 3.67 that software integrate with third-party tools, plugins, or APIs and the

software support backward compatibility with older versions or legacy systems. Overall, 3.68 average weighted mean Strongly Agree with the compatibility of the AGAPAY system,

Table 2.4 Usability

Indicators	Weighted Mean	Descriptive Equivalent
1. Is the user interface intuitive and easy to navigate for users with varying levels of experience?	3.73	Strongly Agree
2. How quickly can new users learn to perform basic tasks using the software?	3.70	Strongly Agree
3. Does the software provide adequate guidance or assistance to users when needed?	3.76	Strongly Agree
4. Are user interactions and workflows designed to minimize errors and confusion?	3.73	Strongly Agree
General Weighted Mean	**3.73**	**Strongly Agree**

In table 2.4, the Usability aspect of the software is reflected with the mean of 3.76 as the highest, indicating the software provide adequate guidance or assistance to users when needed. It is then followed by user interface intuitive and easy to navigate for users with varying levels of experience and user interactions and workflows designed to minimize errors and confusion with the same mean of 374 and still interpreted as Strongly Agree. They also Strongly Agree that new users can quickly learn to perform basic tasks using the software. With the total average weighted mean of 3.73, the table shows the respondents Strongly Agree on the software's usability.

Table 2.5 Reliability

Indicators	Weighted Mean	Descriptive Equivalent
1. Has the software demonstrated stability and maturity in its performance over time?	3.73	Strongly Agree
2. How does the software handle errors, exceptions, or unexpected inputs?	3.63	Strongly Agree
3. Is the software resilient to failures or crashes, with mechanisms for recovery?	3.60	Strongly Agree
4. What measures are in place to ensure data integrity and consistency?	3.60	Strongly Agree
General Weighted Mean	**3.64**	**Strongly Agree**

Table 2.5 is about the software's reliability. Respondents Strongly Agree that the software demonstrated stability and maturity in its performance over time, with the highest mean of 3.73 and that the software handle errors, exceptions, or unexpected inputs with the mean of 3.63. Also strongly agreeing tsoftware resilient to failures or crashes, with mechanisms for recovery andmeasures are in place to ensure data integrity and consistency with has a same mean of 3.60. Overall, the general weighted mean of 3.64, respondents strongly agreeing with AGAPAY's reliability.

Table 2.6 Security

Indicators	Weighted Mean	Descriptive Equivalent
1. How does the software protect sensitive user data, such as authentication credentials or personal information?	3.86	Strongly Agree
2. Are there mechanisms in place to prevent unauthorized access, such as encryption or access controls?	3.67	Strongly Agree
3. Does the software comply with security best practices and standards relevant to its domain?	3.63	Strongly Agree
4. How does the software handle security vulnerabilities or incidents, such as patching and incident response procedures?	3.60	Strongly Agree
General Weighted Mean	**3.69**	**Strongly Agree**

Table 2.6 focuses on AGAPAY's software security. There are four items the respondents Agree to: the software protects sensitive user data, such as authentication credentials or personal information which has the highest mean of 3.86 and followed by 3.67, mechanisms in place to prevent unauthorized access, such as encryption or access controls. Next is that the software comply with security best practices and standards relevant to its domain with the mean of 3.63 and lastly, a mean of 3.60 indicating that the software handle security vulnerabilities or incidents, such as patching and incident response procedures. In all, the table tallies a total average weighted mean of 3.69 with the verbal interpretation of Strongly Agree.

Table 2.7 Maintainability

Indicators	Weighted Mean	Descriptive Equivalent
1. Is the software's codebase well-organized, documented, and maintainable?	3.67	Strongly Agree
2. How easily can developers understand and modify the software to accommodate changes or updates?	3.63	Strongly Agree
3. Does the software support version control, automated testing, and continuous integration/continuous deployment (CI/CD) practices?	3.70	Strongly Agree
4. Are there tools or processes in place to facilitate debugging, profiling, and performance optimization?	3.70	Strongly Agree
General Weighted Mean	**3.68**	**Strongly Agree**

In table 2.7, the maintainability of the software has been focused. Sharing the highest mean of 3.70, respondents Agree that the software's csupport version control, automated testing, and continuous integration/continuous deployment (CI/CD) practices and tools or processes in place to facilitate debugging, profiling, and performance optimization. Followed by the mean of 3.67, respondents are strongly agreeing that the software's codebase well-organized, documented, and maintainable. While, can easily developers understand and modify the software to accommodate changes or updates has a lowest mean of 3.63. Overall, table 2.7 has a total average weighted mean of 3.68, indicating the verbal interpretation of Strongly Agree.

Table 2.8 Summary of weighted mean and description of the seven (7) Indicators for the “AGAPAY: The Development of AI-Enhanced Reporting for Disaster Risk Reduction Management System with real-time alerts for Caloocan City”

Indicators	**Weighted Mean**	**Descriptive Equivalent**
System Functional Suitability	3.75	Strongly Agree
System Performance Efficiency	3.72	Strongly Agree
System Compatibility	3.68	Strongly Agree
System Usability	3.73	Strongly Agree
System Reliability	3.64	Strongly Agree
System Security	3.69	Strongly Agree
System Maintainability	3.68	Strongly Agree
General Weighted Mean	**3.70**	**Strongly Agree**

Tables 2.8 illustrate the results of the ISO Survey Questionnaire. It shows the summary of the weighted mean of the seven (7) Indicators. As gleaned in the table, the weighted mean of the respondents ranged from 3.64 to 3.75. The weighted mean of 3.75 is registered as the highest on the Functional Suitability, followed by 3.73 on the Usability, 3.72 the on the Performance Effieciency, 3.69 on the System Security, and on the System Compatibility and System Maintanability has the same weighted mean of 3.68, and the lowest 3.64 on the System Reliability. Overall, the general weighted mean of system evaluation is equal to 3.70 presented as "Strongly Agree".

Chapter 5

RECOMMENDATIONS

1. **Conduct a Comprehensive Needs Assessment:** Begin by conducting a thorough needs assessment to understand the specific requirements and challenges of the community or region you are serving. Identify the types of disasters most likely to occur, existing vulnerabilities, and the resources available for response and recovery.
2. **Engage Stakeholders:** Involve key stakeholders, including local government agencies, emergency responders, community leaders, and the public. Collaborate with relevant organizations and ensure that the system aligns with the needs and expectations of all stakeholders.
3. **Define Clear Objectives and Scope:** Clearly define the objectives and scope of the system. Determine whether the focus is on incident reporting, resource allocation, community engagement, or a combination of these elements.
4. **Utilize GIS:** Leverage Geographic Information System (GIS) technologies to map disaster-prone areas and the location of critical facilities. GIS can enhance decision-making and resource allocation during emergencies.

5. **Incident Reporting and Response Coordination:** Include a user-friendly incident reporting module that allows the public to report emergencies easily. Implement features for real-time coordination between responders and authorities to ensure a swift and organized response.
6. **Communication and Public Awareness:** Establish effective communication channels for disseminating information before, during, and after disasters. Educate the public on disaster preparedness, evacuation procedures, and the role of the disaster risk reduction management system. Use multiple communication platforms, including social media.
7. **Integrate Weather Monitoring and Forecasting:** Integrate real-time weather monitoring and forecasting data into the system. Provide users with accurate and up-to-date information on weather conditions, enabling better preparedness and response.
8. **Ensure Mobile Accessibility:** Design the system to be accessible on mobile devices, considering that many people rely on smartphones for information. Develop a mobile app or optimize the system for mobile browsers to reach a wider audience.

9. **Security and Privacy Measures:** Implement robust security measures to protect sensitive data and ensure privacy. Adhere to data protection standards and regulations to maintain the confidentiality of user information.
10. **Scalability and Flexibility:** Design the system to be scalable to accommodate growth in users and adaptable to evolving technologies and disaster scenarios.