DESIGN AND IMPLEMENTATION OF A SHELTER LOCATION-ALLOCATION SYSTEM IN CALUMPIT, BULACAN

An Undergraduate Thesis Presented to
the Faculty of the College of Science
of the Bulacan State University
City of Malolos, Bulacan

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Mathematics with
Specialization in Computer Science

by

BRYAN JETT T. CALULO
LOVELY ANGELINE OL. CUNANAN
ELIJAH IÑIGO C. FABIAN

under the supervision of
DR. VALENTINE BLEZ L. LAMPAYAN, PhD

May 2025

APPROVAL SHEET

In partial fulfillment of the requirements for the degree Bachelor of Science in Mathematics with specialization in Computer Science, this thesis entitled **"Design and Implementation of a Shelter Location-Allocation System in Calumpit, Bulacan"** has been prepared and submitted by Bryan Jett T. Calulo, Lovely Angeline OL. Cunanan, Elijah Iñigo C. Fabian, and who are hereby recommended for oral examination.

DR. VALENTINE BLEZ L. LAMPAYAN
Adviser

The document is approved in partial fulfillment of the requirements for the degree Bachelor of Science in Mathematics with specialization in Computer Science by the Committee on Oral Examination.

DR. JAYSON VICTORIANO
Chairperson

AARHUS M. DELA CRUZ
Member

ARCEL F. GALVEZ
Member

The document is accepted and approved in partial fulfillment of the requirements for the degree Bachelor of Science in Mathematics with specialization in Computer Science by the Committee on Oral Examination.

THELMA V. PAGTALUNAN, PhD
Dean, College of Science

May 2025

ACKNOWLEDGMENT

The researchers would like to express their deepest gratitude to God Almighty for granting them strength, wisdom, and perseverance to complete this study.

The researchers extend their heartfelt appreciation to their thesis adviser, Dr. Valentine Blez Lampayan, for her unwavering support, guidance, and valuable insights throughout the development of this thesis. Her expertise and encouragement have played an important role in refining the study. A special thanks to Professor Marrick Neri for sharing his insights and expertise during the researchers' visit to the University of the Philippines Diliman. His knowledge and recommendations have significantly contributed to the improvement of the thesis. The researchers are also deeply grateful to Leah Manongas, whose work served as a reference for the models used in this study. Her thesis provided a strong foundation that helped the researchers in the shelter location allocation process.

Special thanks to the creator of bulsuthsis.cls, and its accompanying files thesis.tex and thesis-structure.tex, Mr. Harris R. Dela Cruz. With these, the authors were able to typeset conveniently and efficiently an elegant and beautiful thesis.

The researchers are also deeply grateful to the IT Experts, MDRRMO, and MSWDO Staff of Calumpit who took the time to evaluate our system and provide valuable feedback. Their insights have helped us identify areas for improvement and refine our work.

Furthermore, the researchers extend their appreciation to their friends and one of the researcher's significant other for their continuous support, understanding, and patience as well as their encouragement which have been helpful in keeping their mental well-being and became our source of motivation throughout this journey.

Lastly, the researchers would like to express their utmost gratitude to their families, whose love and support have been their greatest strength. Their belief in the researchers and their encouragement throughout this academic journey have been invaluable.

This research would not have been possible without the support and contributions of everyone mentioned. Thank you all for being part of this journey.

Bryan Jett T. Calulo

Lovely Angeline OL. Cunanan

Elijah Iñigo C. Fabian

DEDICATION

This thesis is dedicated to our fellow Filipinos,
for their safety and well being.

- The authors

ABSTRACT

The Philippines, being highly vulnerable to disasters such as typhoons and floods, ranks first in the World Risk Index. Among the municipalities of Bulacan, Calumpit is particularly prone to severe flooding. Furthermore, current evacuation system faces challenges such as overcrowding and inefficient resource use. While mathematical models can optimize shelter allocation, they are often inaccessible to decision-makers without mathematical expertise. To address this, a data-driven decision support system was developed. Shelter Location-Allocation System identifies suitable shelters and assigns communities in an optimal manner. The system integrates Bilevel No Transfer (BNT) model, considering distance, cost, capacity, and shelter hierarchy, and applies a genetic algorithm to determine the best allocation strategy. All parameters and data are fully customizable, allowing decision-makers to tailor the system to their needs. The system was evaluated by end-users and IT experts, receiving high acceptability scores, with mean ratings greater than 9.0 across all criteria. These results indicate the system's quality in supporting data-driven disaster response planning, offering a scalable solution for improving evacuation strategies in flood-prone areas.

TABLE OF CONTENTS

TITLE PAGE		**i**
APPROVAL SHEET		**ii**
ACKNOWLEDGMENT		**iii**
DEDICATION		**v**
ABSTRACT		**vi**
LIST OF TABLES		**ix**
LIST OF FIGURES		**xi**
LIST OF APPENDICES		**xii**
CHAPTER		
I	**THE PROBLEM AND ITS BACKGROUND**	**1**
	Background of the Study	1
	Statement of the Problem	4
	Significance of the Study	5
	Scope and Delimitations	6
II	**THEORETICAL FRAMEWORK**	**8**
	Related Theories	8
	Review of Related Literature	9
	Synthesis of the Review	13
	Conceptual Framework	13
III	**RESEARCH METHODOLOGY**	**15**
	Research Design	15
	Model Adoption	17
	Process of Developing the System	24
	System Preliminaries	34
	System Evaluation	37
	Ethical Considerations	43

IV PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA **45**

The Developed System 45

Generated Shelter Location-Allocation Report 52

System Evaluation 53

V SUMMARY, CONCLUSION AND RECOMMENDATIONS **64**

Summary of Findings 64

Conclusion 66

Recommendations 67

REFERENCES **69**

APPENDICES **73**

CURRICULUM VITAE **104**

LIST OF TABLES

Table	Title	Page
1	List of tools and technologies used in the development process	32
2	List of libraries installed in Python	33
3	Variables, Descriptions, and Sources for Community and Shelter Data	36
4	Sources of Appended Shelter Data	36
5	Mean Score Interval and its Verbal Interpretation	43
6	Model Parameters	52
7	Generated Shelter Location-Allocation for Calumpit	58
8	Result Details	58
9	Perceived Usefulness Evaluation	59
10	Perceived Ease of Use Evaluation	59
11	Attitude Towards Using Evaluation	59
12	Behavioral Intention to Use Evaluation	60
13	Functional Suitability Evaluation	60
14	Performance Efficiency Evaluation	60
15	Compatibility Evaluation	61
16	Interaction Capability Evaluation	61
17	Reliability Evaluation	62
18	Security Evaluation	62
19	Maintainability Evaluation	63
20	Flexibility Evaluation	63

LIST OF FIGURES

Figure	Title	Page
1	IPO Model	14
2	A chromosome with 3 communities and 2 shelters	22
3	Selection process where probability is based on their fitness value.	23
4	Crossover process where parents generate a new offspring	24
5	Mutation process where a value is randomly altered	24
6	A representation of an Agile approach	25
7	The Gantt Chart	26
8	System Architecture	29
9	The ERD Schema	30
10	Overview of System Mock-up	31
11	10-point numerical rating scale	42
12	Dashboard	46
13	Community Management	46
14	Shelter Management	47
15	Model Parameter Settings	48
16	Progress Dialog	49
17	Report Dialog	49
18	Solve Settings	50
19	Input Password Popup	51
20	Community to Shelter Straight Path	53
21	Community to Shelter Route Path	53
A.1	Genetic Algorithm	75
A.2	Genetic Algorithm - Selection	76
A.3	Genetic Algorithm - Crossover	77
A.4	Genetic Algorithm - Mutation	78
A.5	Data Modification Feature	79
A.6	Model Modification Feature	80

A.7 Data Simulation Feature 81
A.8 Shelter Tagging Feature 82
A.9 Report Protection Feature 83
B.10 Genetic Algorithm 85
B.11 Genetic Algorithm - Selection 86
B.12 Genetic Algorithm - Crossover 86
B.13 Genetic Algorithm - Mutation 86
B.14 Objective Value 87
B.15 Maximum Distance Constraint 87
B.16 Capacity Constraint 88
B.17 Maximum Shelter Constraint 88
B.18 Maximum Level 2 Shelter Constraint 88

LIST OF APPENDICES

Appendix	Title	Page
A	System Flow Chart	74
B	Relevant Codes	84
C	Letters	89
D	Questionnaires	98

CHAPTER I

THE PROBLEM AND ITS BACKGROUND

Addressing the shelter issues in Bulacan is the focus of this research. This chapter highlights the background and significance of the study. Additionally, the key points and objectives of the study will be discussed along with the study's scope and limitations.

Background of the Study

The Philippines experiences typhoons, earthquakes, and volcanic eruptions each year, leaving people vulnerable and displaced because the country is situated within the Pacific Ring of Fire and directly in the path of the typhoon belt in the Pacific Ocean. Bulacan itself has faced severe impacts from typhoons, including Typhoon Ondoy in 2009 which affected over 250, 000 families and claimed nearly 100 lives (Mananghaya, 2009). For instance, typhoon Haiyan, also known as Super Typhoon Yolanda, devastated the nation in 2013 and displaced over 4 million people, exposing severe shortcomings in the Philippine shelter allocation systems (Iuchi et al., 2019), highlighting the urgent need for efficient and responsive disaster management strategies. Despite ongoing efforts, the country continues to face significant challenges in shelter allocation, like overcrowding, resource distribution inefficiencies, and poor accessibility.

Overcrowding remains a persistent issue, with many shelters operating beyond their intended capacity, leading to unsafe and unsanitary conditions. Accessibility problems further worsen the situation, as shelters are often located at distances difficult for affected individuals, particularly those in rural or remote areas, to reach due to poor infrastructure. Additionally, the inefficient distribution of resources like food, water, and medical supplies results in shortages and uneven support across shelters. Compounding these issues such as disaster preparedness team do not use data-driven decision-making increasing the likelihood of making incorrect decisions highlights the data and planning gaps that hinder effective decision-making and timely shelter assignments. This emphasizes the need on developing innovative approaches to improve shelter allocation in disaster preparedness.

The concept of shelter allocation has been a critical aspect of disaster management throughout history, when communities would seek refuge in caves or fortified structures during emergencies. However, formalized shelter allocation strategies emerged in the 20th century with the rise of civil defense measures during World War II, where air raid shelters were established in urban areas. These air raid shelters were used to ensure the safety of the population of Europe because of the civil casualties and weakening of their social and military morale, as seen in London, Berlin, and Paris (Flebus, 1941; Shakibamaesh, 2015). Post-war, shelter allocation evolved in response to natural disasters, and humanitarian organizations developed temporary shelters for displaced populations. Later, in 1970 in Bangladesh, the inadequacy of early efforts became evident during the Bhola cyclone, which led to numerous deaths. A study showed that people lacked access to information about the cyclone warning and that appropriate shelters were rare, resulting in a devastating 300,000 fatalities, with some estimates being even higher and an estimated 4.8 million people were affected by the cyclone due to the lack of effective shelter allocation. (Miyaji et al., 2020)

Shelter allocation refers to the process of assigning displaced communities to available shelters during disasters (Yin et al., 2023). While shelter location-allocation, focuses on determining shelter would be constructed, and then be used for displaced population (Zhao et al., 2019). These process is crucial to disaster prevention and mitigation, ensuring the safety and well-being of affected populations by providing secure, accessible, and adequate temporary shelters. Effective shelter allocation involves considerations such as shelter capacity, proximity to disaster sites, and the specific needs of vulnerable communities.

Over the years, strategies have evolved from reactive measures to a more systematic approach incorporating modern technologies and methodologies, highlighting the increasing importance of structured and efficient shelter allocation. However, these challenges, particularly in developing countries like the Philippines, where limited infrastructure hinders its effective implementation.

This study proposes a data-driven solution ensuring an effective and feasible implementation of shelter allocation. This would be by developing a decision support system using a genetic algorithm (GA), a computational method inspired by natural selection and evolution, to address the inefficiencies in shelter allocation. GA optimize solutions by mimicking the process of evolution such as selection, crossover, and mutation, to identify best outcome. Mathew (2012) discussed that these algorithms represent potential solutions to a given problem using a basic chromosome-like data structure and employ recombination operators to maintain essential information, making it ideal to solve wide variety of problems. In shelter allocation, GA can optimize the assignment process by simultaneously considering factors such as shelter capacity, location, and accessibility. This approach aims to minimize overcrowding, improve resource distribution, and enhance overall efficiency in managing shelters during disasters.

Given the Philippines' frequent exposure to natural disasters, implementing a shelter allocation system is essential. Calumpit, Bulacan was chosen for its high vulnerability to flooding since it has been a catch basin of floodwaters from their neighboring areas. Despite the multitude of studies formulating models to address the shelter location-allocation problem, there remains a lack of system integration. This gap makes it difficult for decision-makers, particularly those unfamiliar with the mathematical models proposed in various studies, to apply them effectively in their decisions. This study is dedicated to developing a programmed system that uses genetic algorithm to address the challenges experienced in the Philippines, focusing on Calumpit, Bulacan. The proposed shelter location-allocation system has the potential to significantly improve disaster response efficiency, and enhance safety for displaced individuals.The insights gained from this study could be applied to other municipalities facing similar challenges, contributing to the national effort to strengthen disaster resilience.

Statement of the Problem

This study aims to address the shelter allocation problem for the municipality of Calumpit, particularly during disaster situations such as storm surges and flash floods. The primary challenge is how to develop a decision support system integrating a model that solves location-allocation problem to ensure that victims are allocated to shelters in an optimal manner. Specifically, the paper aims to solve the following questions:

1. How can the proposed system be developed featuring the following functionalities:
   (a) Data Modification,
   (b) Model Modification,
   (c) Data Simulation,
   (d) Shelter Tagging, and
   (e) Report Protection?
2. What is the optimal shelter location-allocation plan for the municipality of Calumpit?
3. How acceptable is the proposed system based on the criteria defined in Technology Acceptance Model?
   (a) Perceived usefulness,
   (b) Perceived ease of use,
   (c) Attitude towards using, and
   (d) Behavioral intention?
4. How well does the proposed system meet the ISO / IEC 25010 requirements?

(a) Functional Suitability,

(b) Performance Efficiency,

(c) Compatibility,

(d) Interaction Capability,

(e) Reliability,

(f) Security,

(g) Maintainability, and

(h) Flexibility?

Significance of the Study

The research seeks to improve disaster preparedness by providing a program and a model that facilitates more efficient decision-making and optimizes shelter placements regarding accessibility, cost-efficiency, and community proximity.The proposed solution has the potential to significantly reduce the risks associated with natural disasters in that area and enhance the overall management of shelter allocation and emergency resources.

The resulting shelter location-allocation from this project will primarily benefit the citizens of disaster-prone areas in Calumpit. This leads to faster evacuation times for use in the welfare of its citizens. The resulting optimization of shelter locations also extends to the efficient use of financial and logistical resources, minimizing the costs required in the maintenance and operation of shelters, thus allowing reallocation of previously spent resources into other areas.

By providing insights into optimized shelter locations and evacuee distribution, this project seeks to benefit the following parties:

Local Government. The local government of the target municipality is a beneficiary of this project due to being responsible for disaster management and response within their jurisdiction. The administration of the affected municipalities' LGU would achieve a system that will assist in the evacuation and protection of citizens and thus may divert their attention elsewhere into other areas.

Communities. The local communities within Calumpit that are directly affected by disasters, especially floods, are important beneficiaries of this project. The community would achieve faster response times, shelters that are located in optimal positions that take into account their homes and workplaces, and more systematic procedures in evacuation.

Future researchers. Future researchers are a beneficiary due to this project being open to the public and thus, researchers and developers may derive their own thesis projects that are similar for use in different areas of the Philippines.

Scope and Delimitations

This thesis will be limited only on identifying and assigning evacuation shelters, referred to as shelter location-allocation. This is geographically limited on Calumpit due to being the most affected municipality in Bulacan on typhoons. However, this study can be applied to other disaster-prone areas with some adjustments, which will not be covered in this thesis. Moreover, the system will use Bilevel No Transfer model through Genetic Algorithm only.

The thesis will utilize real-world information from Calumpit, including existing shelter locations and geographic layouts, as well as cost estimates for shelter maintenance and other operations. This data will be acquired by the researchers with the help of the local government units of Calumpit.

In technical aspect, the proposed system is limited to the Windows operating system (OS) due to its accessibility and familiarity among the general population. Additionally, Windows provides a stable environment and robust support for applications, further justifying its selection as the target OS for the proposed system.

The project is limited to a 10-month period wherein all stages of the thesis and consequent testing must be completed. Updates on data, and project maintenance beyond this period will not be covered by the researchers.

CHAPTER II
THEORETICAL FRAMEWORK

Over the years, different types of models have been developed for shelter location-allocation to support evacuation efforts, each with distinct objectives and often integrated with programming. This chapter delves into key theories in modeling and system integration that inform the development of effective shelter location-allocation systems. Moreover, comprehensive review of related literature is conducted, analyzing and synthesizing existing studies to highlight their relevance, explore the current models, and identify areas where system features are lacking.

Related Theories

The development of shelter location-allocation system draws on key theories which feature the optimization of shelter location-allocation, development, and assessment of the system.

Operations Research

Mathematical modeling is an approach to represent a real-life problem and solving them using mathematical techniques such as the operations research. This theory addresses the optimization of objectives, crucial in shelter location-allocation where factors like distance and cost must be balanced. The problem is modeled to find the optimal locations while minimizing travel distances and associated costs, making it ideal for a multi-objective optimization.

Theory of Evolution

Inspired by Charles Darwin's theory of evolution, evolutionary algorithms such as genetic algorithms simulate natural selection within code to solve complex optimization problems effectively. This approach is widely used due to its robustness and adaptability, hence it will be applied to solve the multi-objective model for shelter location-allocation.

Decision Theory

Decision theory is a study of having a rational choice by using models and tools. This involves creating a system that serves as a decision support tool for decision-makers, such as the DRRMO, in allocation of shelters. It features user-defined parameters for model customization and provides functionality for creating, reading, updating, and deleting data.

Technology Acceptance Model (TAM)

TAM was developed by Fred Davis in 1989 and is widely used to assess the acceptability of a digital product. This model is primarily based on two fundamental determinants: users' perceived usefulness and perceived ease of use. This model will be used to assess acceptability of the proposed system with the cooperation of potential end users.

Software Product Assessment Framework (ISO 25010)

ISO 25010 provides standards for assessing software quality, covering aspects such as functionality, usability, reliability, and efficiency. This framework will guide evaluation of the proposed system, ensuring it meets high-quality standards.

Review of Related Literature

This section compiles related literature that will strengthen the foundation of our research. This includes an overview of Bulacan's vulnerability to natural disasters, as well as a review of existing shelter location-allocation models featuring various types and objectives. Additionally, it highlights the gap in system integration, highlighting the need for a comprehensive decision support system for effective disaster response.

Bulacan is vulnerable in disasters

One of the most devastating typhoons to hit the Philippines was Typhoon Ondoy. According to Managhaya's report, it claimed nearly 100 lives and affected around 250,000 families. Large parts of Luzon suffered significant damage, including Bulacan, resulting in heavy flooding. (Mananghaya, 2009)

According to a report by Reyes-Estrope covering Typhoon Fabian in 2021 (Reyes-Estrope, 2021), heavy rainfall caused by the southwest monsoon and Typhoon Fabian resulted in flooding across 35 villages in Bulacan, including Calumpit. The water level of the Angat Dam rose to 185.72 meters above sea level during this event. Moreover, Gozum's report on Typhoon Egay in 2023 (Gozum, 2023) emphasizes the hardships faced by flood victims in Bulacan. The province was declared under a state of calamity due to Typhoon Egay, which affected over 200,000 families and forced many residents to evacuate.

Existing shelter location-allocation models

The allocation of different resources during each evacuation phase is critical, however, this is often delayed, either due to extenuating circumstances or simply lack of a system. Therefore, optimization is a must. In this section, the paper will introduce different models with varying solving techniques to solve each of their own objectives.

In disaster management, the organization of effective evacuation is important. Wang and Xu (2022) address the challenge of determining optimal shelter locations and evacuation routes, integrating methods such as the normal distribution, analytic hierarchy process (AHP), and ordered weighted aggregation operator (OWA); These approaches that have assigned subjective scores and initial weights to critical attributes significantly advances shelter location models for disaster response.

Different studies also features levels of shelters which introduces a hierarchy of shelters, each with different needs that they fulfill and with various requirements to be assigned a level. Therefore the levels of each shelter must be taken into account, and this segment of system requires the use of hierarchical optimization.

Ma et al. (2019) show the importance of site selection models in disaster scenarios, particularly highlighting the application of bilevel programming, a hierarchical optimization method first introduced by H.v. Stackelberg in 1934.

The methods used are applied to different complex location problems, such as the p-median and p-center problems, which are crucial for the distribution of resources during emergencies.

Building on the hierarchical approach, Zhao et al. (2019) applied a hierarchical model for shelter location and evacuee allocation, distinguishing between emergency shelters (EMS) and long-term shelters (LTS). Combined with an optimization algorithm, their model facilitates the selection of EMS locations from a pool of candidates, ensuring the initial allocation of evacuees. Over time, evacuees transitioned from EMS to LTS in a structured and efficient manner, highlighting the practical advantages of hierarchical models in emergency management.

In a different study created by Ma et al. (2019), the paper exposes various models to best represent a shelter location-allocation problem, Single-Objective, Multi-Objective, and Hierarchical models. These were compared for the objectives that were maximized and minimized, and then introduced different algorithms that may be used to solve them.

Locally, according to a published thesis in University of the Philippines(UP) Diliman, there exists 4 shelter location-allocation models; BNST, BST, BNT, and WORK models that are solved using binary genetic algorithms. These answer the optimization of allocation in shelters based on the cost, distance, workplace, and the hierarchy of shelter. This study was applied to the area of Talisay in Batangas using simulated data for shelter information.

A study similar to the thesis has been published locally, however this study answers the optimization of COVID-19 vaccination site allocations(Cabanilla et al., 2021). This study features assigning and identifying shelters to be a vaccination sites considering its distance across all barangay.

Optimization Technique by Genetic Algorithm

Since the optimization of shelter location-allocation requires multiple iterations to test and figure out what is truly optimal, one method of solving this is through the use of genetic algorithms.

Genetic algorithm, a powerful optimization technique inspired by the process of natural selection, is particularly well-suited for tackling complex problems like shelter location allocation. Multi-Objective Genetic Programming (MOGP) emphasizes the importance of semantic diversity and that methods like Pivot Similarity Semantic-based Distance outperform traditional approaches by enhancing solution quality and diversity, according to a study by Galvan and Stapleton (2020).

Numerous published studies and theses highlights allocation models and solved by genetic algorithm. From UP Diliman, Manongas (n.d.) solved their model using Binary Genetic Algorithm. Additionally, a study made by Maghawry et al. (2020) which proposes a Hybrid Genetic Algorithm (HGA) in optimizing multi-objective problems. Yin et al. (2023) exposed formulation of shelter allocation models, and solved by using Improved Quantum Genetic Algorithm (IQGA).

Lack of System Integration

The referenced articles each exposed models with various objectives. However, none offer a fully implemented system for practical use by disaster-response teams. This gap highlights the need for a comprehensive decision support system that integrates these models and enables real-time decision-making and adaptability in disaster situations. While the following articles propose a system, they remain incomplete and require further development.

In the study of Lomer et al. (2023), the researchers are claiming that the group has created a system, which features risk-based decision that affects the output. The paper, however, did not show the system structure nor the system itself. Moreover, they did not show any acceptability measures.

The paper of Cavdur and Sebatli (2019) proposes the use of a decision support tool for the allocation of temporary disaster-response facilities while under the effects of demand uncertainty. The study also develops a database for storing disaster and shelter details to support disaster operations. This system closely aligns with this thesis, as it addresses shelter allocation and provides decision-making assistance for disaster-response teams. However, the study lacks any measures for evaluating system acceptability and has room for improvement, as the system design is also outdated.

Synthesis of the Review

Overtime, the researchers have reviewed and analyzed multiple academic literature and studies that relate to the thesis. These range from literature and studies that cover different areas using differing allocation techniques as well as other formulae and algorithms that may be used in the thesis. However, a large amount of this literature and studies lack a system or other feature that is partly required for the usability of end-user. By studying these collected pieces of literature, the researchers aim to create a programmed system with enough improvements from the previous studies presented. Moreover, this thesis will base the models from the published paper from UP Diliman by Manongas (n.d.), with improved algorithm.

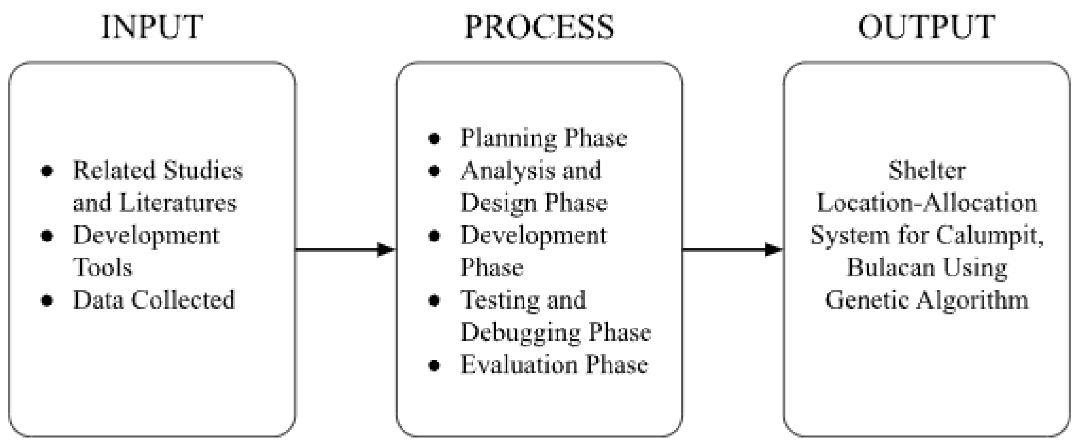
Conceptual Framework

This section provides an Input-Process-Output framework (IPO) as a basis for conceptual framework outlining the development and implementation of Shelter Location-Allocation System for Calumpit, Bulacan. The IPO model was first introduced in the context of computer programming and documentation using the Hierarchy plus IPO (HIPO) technique. Moreover, the concept of input and output has been used before in economics, back in the 1930s, Wassily Leontief first conceptualized input-output analysis to illustrate economic interrelationships. Figure 1 shows the IPO framework for this thesis.

The inputs for this project include related studies and literature, which provide a foundation for selecting and adapting an appropriate model for our system. These resources will be analyzed and synthesized to establish a strong

Figure 1

IPO Model



foundation in conducting this project. We also need to gather software and hardware requirements, such as the compatible Windows version and system prerequisites, to ensure a smooth development process. Additionally, real data from Calumpit, Bulacan, specifically community and shelter information, will be essential for testing the system.

The process begins with planning, where we outline the objectives and approach for building the system. Once a clear plan is established, we proceed to analysis and design, which involves creating mock-up designs, an ERD schema, and process flows to help developers visualize the system structure. Development phase is the longest phase, involving both frontend design and backend coding using the Qt framework. Once developed, the system undergoes rigorous testing to identify and correct any errors or anomalies, which will then be debugged and will be resolved. Finally, the system will be evaluated through a survey based on the ISO 25010 criteria to assess its acceptability.

The expected output is a fully functional decision support system(DSS) that incorporates the model adopted using a genetic algorithm as the solving method. The researchers will generate results showing the optimal shelter location-allocation for Calumpit using the developed system.

CHAPTER III

RESEARCH METHODOLOGY

This chapter outlines and expands upon the research methodology for the design and implementation of a shelter location-allocation system using a genetic algorithm for the optimization of shelter placement in disaster-prone areas. This methodology provides a systematic approach for a clear framework for system design, model implementation, and evaluation. Following this, data collection procedures are explained including the sources and techniques for gathering essential data on community demographics, geographic information, and shelter facilities.

Additionally, this chapter addresses the criteria for selecting, cleaning, and analyzing data, as well as the metrics used to evaluate the system's acceptability. Finally, ethical considerations such as data privacy are also discussed.

Research Design

The research design for this study is mixed-method applied research, this approach combines both quantitative and qualitative methods to provide a structured framework for development and evaluation of the shelter location allocation system.

Applied Research

The applied research aspect of this study focuses on developing and implementing a practical solution for shelter location-allocation in real-world scenarios. The primary objective is to create a shelter location-allocation system using a genetic algorithm. This applied research approach aims to deliver a functional and reliable shelter location-allocation system that local government units (LGUs) and disaster response agencies can easily deploy and adapt. By emphasizing incremental progress and user-centered development, this ensures that the research outputs are directly applicable and beneficial to communities in disaster-prone areas.

Quantitative Research

The quantitative research component of this study aims to measure and analyze the acceptability of the proposed system using TAM determinants and ISO/IEC 25010 standard. The approach will provide objective and measurable evidence to evaluate the system's usability, reliability, and overall quality performance. The quantitative methods will seek to quantify the use of genetic algorithms in the shelter location allocation system, providing valuable insights into the system's effectiveness for emergency management. Methods will include collecting user feedback and performance metrics through structured surveys and system testing to assess these attributes. The survey will gauge user satisfaction with system usability and functionality using a 10-point rating scale, providing quantifiable insights into the system's ease of use and accessibility. Incorporating quantitative research in this study is justified as it can provide empirical evidence supporting the shelter allocation system's acceptability.

Qualitative Research

The researchers will use qualitative research to understand the current issues of shelter location allocation from the stakeholders' perspectives. This approach requires engaging with the LGU offices to identify the additional requirements for the system. This ensures that the development of the shelter location-allocation system will address real-world challenges and support those involved in evacuating communities during natural disasters and be of acceptable quality. The researchers will conduct an interview to achieve this. The interview was based on Decision Thinking Framework which is a common framework for developing a product. This was chosen to provide a structured way to gather detailed feedback from the stakeholders about their experiences, challenges, information about the shelters, and expectations regarding shelter location-allocation and this study. This method allows the researchers to collect various opinions and insights, which is important for understanding the complex issues involved in disaster management and shelter allocation. This insight is important for ensuring the system's effectiveness, as it helps identify the challenges to ensure the proper functioning of the shelter location allocation system and meet the needs of the affected communities. By capturing these detailed perspectives, the system will be more practical, user-friendly, and responsive to the real-world needs of disaster management.

Model Adoption

The model adopted for this study is the Bilevel No-transfer (BNT) Model, which solves the shelter location-allocation problem under disaster scenarios. As discussed in a published paper by Manongas (n.d.), this model is effective when it assigns communities to shelters without allowing transfers between different shelter levels during recovery. Using the BNT Model, the researchers can optimize the allocation of communities to shelters, accounting for each shelter's capacity and travel distance for evacuees. The BNT Model includes a two-tiered shelter structure, consisting of level 1 and 2 shelters. Level 1 shelters are smaller facilities intended for immediate use, providing basic services for short-term stays. In contrast, Level 2 shelters are significantly larger and equipped with comprehensive services, including private rooms and extended support amenities, these shelters are intended for longer-term stays. However, once assigned to a shelter in the BNT Model, evacuees remain in that shelter until the disaster subsides, eliminating the need for transfers between shelters. The objective function for the BNT model can be expressed as follows:

Minimize

$$wt_{dist} \sum_{j=1}^{N} \sum_{i=1}^{M} d_{ij} P_i x_{ij} + wt_{cost} \sum_{k=1}^{2} \sum_{j=1}^{N} C_j^{(k)} y_j^{(k)} \tag{3.1}$$

The constraints of BNT model include the distance, capacity, assignment, and binary constraints, each of which plays a crucial role in ensuring the model functions effectively under the disaster response scenario. These constraints subject to the following:

Distance Constraint. Equation 3.2 ensures that each community is allocated to a shelter within a defined maximum distance.

$$d_{ij}x_{ij} \leq D_i, \forall i = 1, ..., M, \forall j = 1, ..., N \tag{3.2}$$

Capacity Constraint. Equation 3.3 guarantees that the total number of evacuees assigned to a shelter does not exceed its maximum capacity.

$$\sum_{i=1}^{M} LP_i x_{ij} \leq \sum_{k} Area_j^{(k)} y_j^{(k)}, \forall j = 1, ..., N, k = 1, 2 \tag{3.3}$$

Assignment Constraints. Equations 3.4 and 3.5 ensures that the total assigned shelters and level 2 shelter does not exceeds over the user defined parameters respectively. Equation 3.6 ensures that every community is assigned to exactly one shelter. Equation 3.7 ensures that the assigned shelter does not duplicate like being opened as level 1 and level 2 at the same time. This prevents problems in shelter allocation and ensures that each community has a designated place.

$$\sum_{k=1}^{2} \sum_{j} = 1^N y_j^{(k)} \leq MaxSh \tag{3.4}$$

$$\sum_{j} = 1^N y_j^2 \leq MaxL2 \tag{3.5}$$

$$\sum_{j=1}^{N} x_{ij} = 1, \forall i = 1, ..., M \tag{3.6}$$

$$\sum_{k=1}^{N} y_j^{(k)} \leq 1, \forall j = 1, ..., N \tag{3.7}$$

Binary Constraint. This constraint ensures that the model only takes binary variable, where can either be true (1) or false (0).

$$x_{ij}, y_j^{(1)}, y_j^{(2)} \in \{0, 1\}, \forall i = 1, ..., M, \forall j = 1, ..., N \tag{3.8}$$

Where:

wt_{dist} – weight given to the distance cost.

wt_{cost} – weight given to the fixed shelter cost.

M – total number of communities.

N – total number of potential shelter locations.

d_{ij} – distance between shelter i and community j.

P_i – population of the community i.

$C_j^{(k)}$ – fixed cost for establishing shelter j of level k.

x_{ij} – binary decision variable indicating if community j is assigned to shelter i.

$y_j^{(k)}$ – binary decision variable indicating if shelter j of level k is opened.

L - area allotted per individual

D_i – maximum distance that community i can be traveled.

$Area_j^{(k)}$ - area of shelter j of level k.

$MaxL2$ - maximum number of level 2 shelters to be opened.

$MaxSh$ - maximum number of shelters to be opened.

Feasibility Conditions

Checking if a solution exists based on the user defined parameters is a must in developing the system thus conducting feasibility checks before executing the algorithm. This adds a feature that allows users to view if their inputs are incorrect having an additional functionality and capability of the system.

The following conditions should satisfy else no solution exists:

$$Area_j^{(2)} \geq Area_j^{(1)}, \forall j = 1, ..., N \tag{3.9}$$

Condition 3.9 checks if shelter j area for level 2 is greater than or equal to their area for level 1.

$$MaxL2 \leq MaxSh \tag{3.10}$$

Condition 3.10 checks if the user defined number of maximum level 2 shelters is less than to number of maximum shelters.

$$\exists j \in d_{ij} \leq D_i, \forall i = 1, ..., M \tag{3.11}$$

Condition 3.11 checks if there exists a distance from community i to all shelters that is less than or equal to its max distance.

$$\exists i \in LP_i \leq Area_j^{(2)}, \forall j = 1, ..., N \tag{3.12}$$

Condition 3.12 checks if there exists a level 2 shelter that could accommodate a community i by their population multiplied by the area allotted per individual.

$$\sum_{i=1}^{M} P_i \leq L \sum_{j=1}^{N} Area_j, \forall i = 1, ..., M, \forall j = 1, ..., N \tag{3.13}$$

Condition 3.13 checks if the total population is less than or equal to the total area of shelters multiplied to area allotted per individual. If this fails, then it is theoretically impossible to allocate all individuals given with their shorted capacity of shelters.

Incorporating these feasibility conditions ensures that the model will produce atleast one feasible solution, and the system proceeds only with valid input configurations. By verifying these conditions, users receive instant feedback on whether their inputs are valid, allowing the model to proceed with solving. These conditions represent key feasibility checks but are not exhaustive, and infeasible solutions may still persist. An additional feature would employ a penalty function that would transform the model to an unconstrained model.

Penalty Function

The penalty function was used to handle the problem constraints. Instead of discarding infeasible solutions or chromosomes, they will be assigned a very large objective value making them not fit to be a solution. The type of penalty to be used is the Courant-Beltrami penalty function method, as shown in equation 3.14.

$$h(x) = (g^+(x))^2 \tag{3.14}$$

where

$$g^+(x) = max\{g(x), 0\} \tag{3.15}$$

where $g(x)$ is a constraint function of the form $g(x) \leq 0$.
The new objective function would be adding the initial objective value $f(x)$ to the penalty multiplied by some constant γ as shown in equation 3.16.

$$f_{new}(x) = f(x) + \gamma \sum_{i=1}^{n} (max\{g_i(x), 0\})^2 \tag{3.16}$$

where $g_1(x), g_2(x), ...g_n(x)$ are the constraints of the model of the form $g_i(x) \leq 0$, and $\gamma \in \mathbb{R}^+$ is sufficiently large, where for this thesis is set to 10^{20}. The penalty would add up to the objective value for each constraints it violated, otherwise it would not affect the objective value.

Optimization Technique

In a study created by Mathew (2012), Genetic Algorithms are based on the concept of natural selection and evolves possible solutions through operators such as selection, crossover, and mutation. This algorithm will iteratively evolve a population of potential solutions, utilizing operations to explore the population space and gradually converge toward an optimal solution.

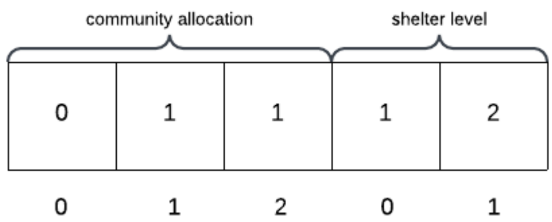
The BNT model was originally solved using Binary Genetic Algorithm implemented in MATLAB. However, since system integration will be conducted on this thesis, the model will be solved using Integer-based Genetic Algorithm implemented in Python. This decision derived for satisfying the assignment constraint of the model, and Python being a well suited programming language for both data simulation and system development.

We start by defining the some terms of genetic algorithm that will be used in the context of shelter location-allocation model.

Chromosome. An array or dictionary which represents the solution in a problem. A chromosome is composed of two parts, community allocation and shelter level. Community allocation refers to assigning shelter index to communities, and shelter level refers to assigning a value of 1 or 2 to represent as level to shelters. Figure 2 shows a solution where community 0 was allocated to shelter 0, and community 1 and 2 was allocated to shelter 1. Additionally, shelter 0 was assigned as level 1, and shelter 1 was assigned as level 2.

Figure 2

A chromosome with 3 communities and 2 shelters



Population. A group of chromosomes. This refers to a group of generated solutions on the problem that will be later on picked or selected.

Generation. A whole iteration process of genetic algorithm. This refers to the population on a certain generation which in theory, higher generations then the closer we get to the optimal solution.

Fitness. A value generated from the objective function. This refers to the objective value of a chromosome based on the implemented model.

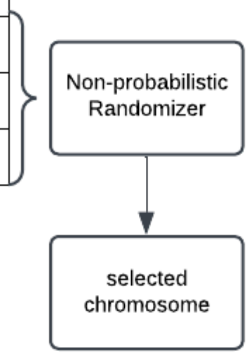
A genetic algorithm is composed of three key components: selection, crossover, and mutation. Each serves a distinct purpose in addressing optimization problems and simulates the evolution theory. Each component has various implementation methods tailored to specific objectives. (Wirsansky, 2020)

Selection. A process of selecting parents. This refers to selecting two chromosome based on their fitness value. The proposed system uses Roulette Wheel Selection, which is the likelihood of a chromosome to be selected is directly proportional to its fitness value. Figure 3 shows that the probability is inversely proportional to the fitness value, since we aim to minimize the objective. Moreover, a randomizer will select a chromosome based on the computed probabilities.

Figure 3

Selection process where probability is based on their fitness value.

chromosome	fitness value	chance of getting selected
A	100	54.55%
B	300	18.18%
C	200	27.27%



Crossover. A process of breeding and giving offspring by a two parents. This refers to combining two selected chromosome values and generating a new chromosome based on the combined values. The proposed system uses Uniform Crossover, which all the values from two parents has a change to be inherited by the offspring. Figure 4 shows a generated offspring with values based on their parents. Notice that if a value is different between parents, a randomizer will decide which value would be chosen.

Mutation. A process of altering some chromosome values. This refers to randomly selecting a chromosome from a population based on a predetermined mutation rate, then changing some of its values. The proposed system uses Random Reset Mutation, which picks randomly from a selected chromosome values, then changing it by generating a new random number. Figure 5 shows altering of a chromosome for the second community by a randomizer, allocating from shelter 1 to shelter 2.

Figure 4

Crossover process where parents generate a new offspring

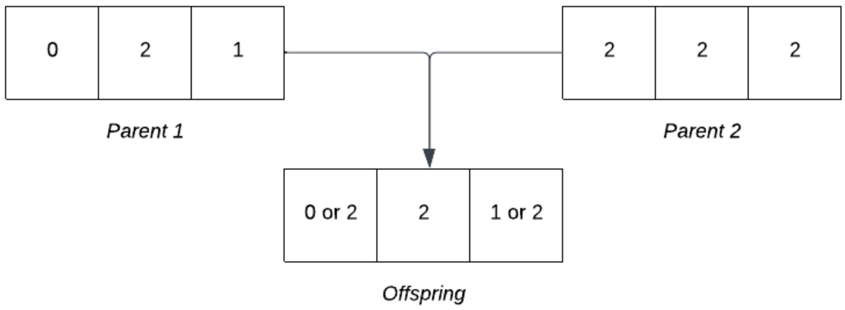
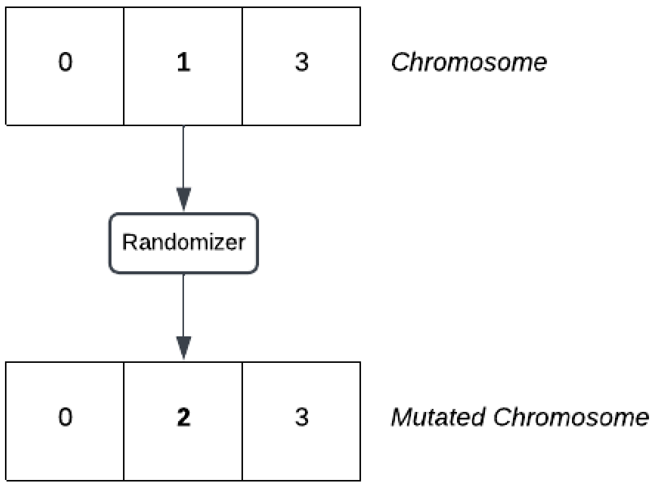


Figure 5

Mutation process where a value is randomly altered



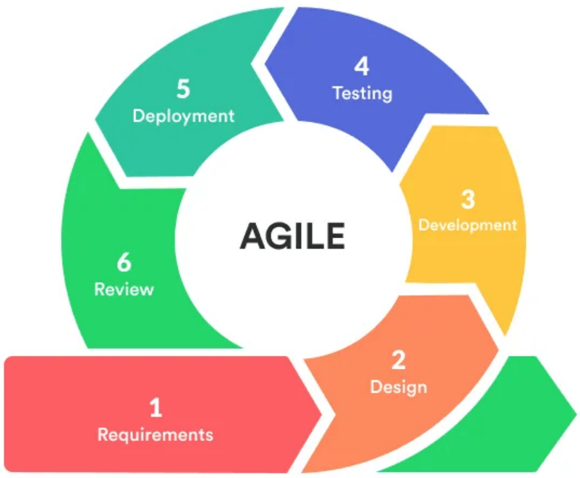
By applying these evolutionary principles, the genetic algorithm can efficiently navigate the large and complex problem space of shelter allocation, ensuring the most effective distribution of evacuees to shelters based on the model's constraints and objectives.

Process of Developing the System

This study employed a structured system development methodology following the Agile approach. Agile was chosen for its flexibility and iterative nature, which allows for continuous refinement and adaptation of the system based on feedback and testing results. Each development phase—planning, design, implementation, testing, and deployment—will include regular reviews and adjustments to ensure the system evolves effectively to meet technical and user needs. The system development process was divided into several distinct phases, each of which is designed to build upon the previous stage, ensuring a comprehensive and systematic approach. As shown in figure 6 illustrated by Jayathilaka (2020)

Figure 6

A representation of an Agile approach



Planning

In the initial phase, the researchers outlined the shelter location allocation system's scope, objectives, and requirements. This process identifies the key features and functionalities essential for the system. Additionally, this phase includes the thesis project plan, which details the project timeline. The Gantt chart outlines the phases of the thesis project, including thesis one output, thesis two output, data collection and preparation, paper miscellaneous, system design, system development, and system assessment. Each phase addresses specific objectives that contribute to completing the shelter location-allocation system. The Gantt chart is shown in Figure 7.

Figure 7

The Gantt Chart

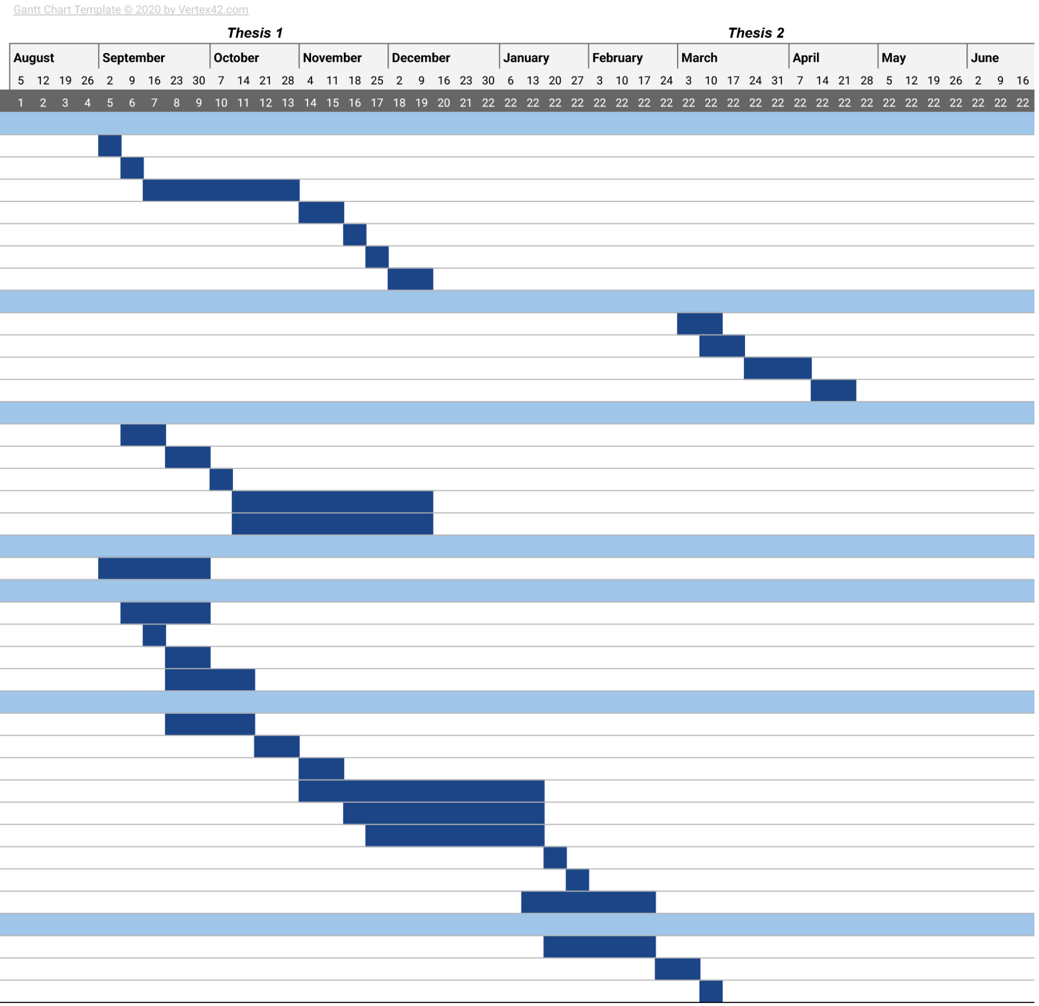
Shelter Location-Allocation System

MatTresist

Calulo, Cunanan, Fabian

Project Start: 8/21/2024

TASK	START	DAYS	END
Thesis 1 Output			
Overview, Rationale, Scope&Significance	8/31/2024	4	9/4/2024
Chapter 1	9/5/2024	8	9/13/2024
Chapter 2	9/14/2024	45	10/29/2024
Chapter 3	10/30/2024	13	11/12/2024
Proposal Manuscript	11/13/2024	6	11/19/2024
Proposal Slides/Script/MockDefense	11/20/2024	6	11/26/2024
Proposal Defense	11/27/2024	14	12/11/2024
Thesis 2 Output			
Chapter 4	3/1/2025	9	3/10/2025
Chapter 5	3/10/2025	11	3/21/2025
Mock Defense	3/21/2025	21	4/11/2025
Final Defense	4/11/2025	14	4/25/2025
Data Collection and Preparation			
Documents Proposal for LGU	09/05/2024	11	9/16/2024
Presentation of Proposal	9/17/2024	13	9/30/2024
Interview with the client	10/1/2024	7	10/8/2024
Data Collection (Online)	10/9/2024	61	12/9/2024
Data Collection (Onsite)	10/9/2024	61	12/9/2024
Paper Miscellaneous			
RRL Matrix	9/2/2024	29	10/1/2024
System Design			
GA program implementation	9/5/2024	25	9/30/2024
System UI Design	9/13/2024	9	9/22/2024
ERD/Schema	9/23/2024	7	9/30/2024
Flowchart	9/23/2024	26	10/19/2024
System Development			
Frontend	9/23/2024	26	10/19/2024
Entity Settings/ Data Integration	10/20/2024	14	11/3/2024
Model Integration	11/4/2024	13	11/17/2024
Dashboard	11/4/2024	76	1/19/2025
Solve Settings & Progress	11/18/2024	62	1/19/2025
Model Settings	11/25/2024	55	1/19/2025
Shelter Allocation Report	1/19/2025	7	1/26/2025
Report Protection	1/26/2025	7	2/2/2025
Testing and Debugging	1/7/2025	41	2/17/2025
System Assessment			
Survey Preparation	1/20/2025	34	2/23/2025
Survey Dissemination	2/24/2025	11	3/7/2025
Encoding of Data	3/8/2025	7	3/15/2025



Thesis One Output: This phase involves drafting the initial sections of the thesis, such as the overview, rationale, scope, and significance, along with Chapters one through three (Introduction, Review of Related Literature, and Methodology). Additionally, this phase includes preparing the proposal manuscript, slides, and script for the mock defense and proposal defense. Parallel to this is the Paper Miscellaneous, which includes the creation of the literature review matrix to organize and support the contents of Chapter 2. This approach maintains a well-structured reference base for literature review.

Thesis Two Output: Following the foundational work in the first thesis phase, this continues the development of this thesis document, focusing on Chapters 4 and 5 (Results and Conclusions) and preparing for the mock defense and final thesis defense. This phase signifies the completion of the thesis writing process.

Data Collection and Preparation: This critical phase entails gathering data required for system design and important data for the genetic algorithm. Tasks include submitting documents to the LGU, presenting the project proposal, conducting client interviews, and collecting online and onsite data.

System Design: This phase focuses on planning the technical aspects of the shelter allocation system, including genetic algorithm implementation, user interface design, entity relationship diagram, and flowchart development. These elements form the blueprint that guides the system's development.

System Development: The project's core phase involves the actual construction and coding of the system. Tasks include front-end development, data and model integration, dashboard creation, and implementing security features. This phase also includes testing and debugging to ensure system functionality.

System Assessment: The final phase, along with Thesis Two Output, is evaluating the system's acceptability and user satisfaction. Activities include preparing and distributing surveys, gathering user feedback, encoding and analyzing this data to assess system acceptability.

Requirement Analysis

During the requirement analysis phase, researchers gathered comprehensive information about the system requirements by reviewing relevant literature that pertains to the thesis. Moreover, an interview with the client was conducted to know more about the current issues LGUs are facing regarding to evacuation. This phase ensures that all necessary features are identified and prioritized based on their importance.

The system's primary features and requirements encompass an overview of data and model modification, data simulation, shelter tagging, and report protection. Data modification includes an access to user for managing and modifying community and shelter data. Model modification allows users to change parameters on data simulation.Data simulation utilizes the community and shelter data as inputs for the genetic algorithm applied in the shelter location allocation system, optimizing the placement of evacuees in shelters. Furthermore, shelter tagging enables the categorization of shelters based on criteria such as location, capacity, and suitability for various disaster scenarios, thereby facilitating efficient resource allocation. Lastly, report protection allows user to protect their generated report to prevent leaks in a computer system.

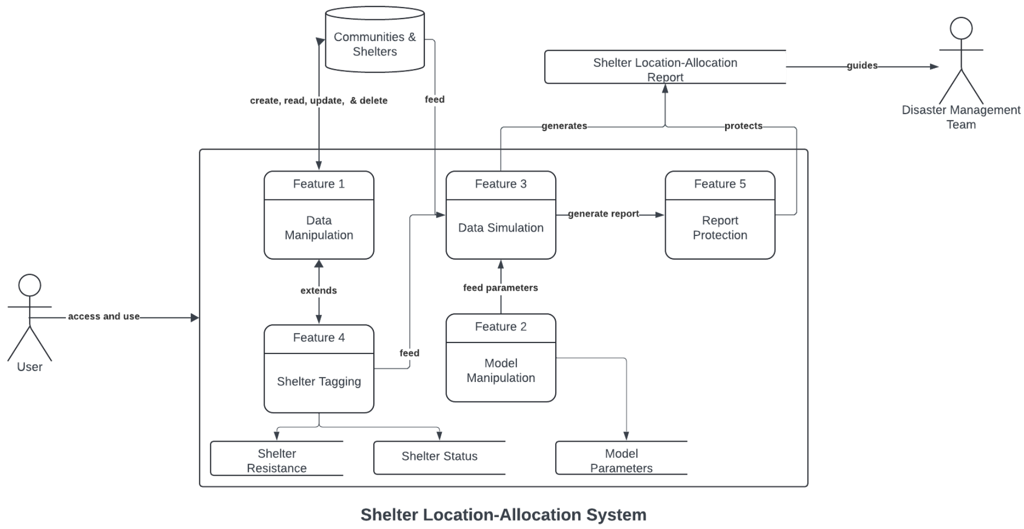
Design

During the design phase, the researchers created a detailed outline for the shelter location-allocation system's architecture and key components. The design process includes creating a mockup of the system's user interface and constructing flowcharts, an entity-relationship diagram (ERD), and a data flow diagram(DFD) to map out system processes and data relationships. The researchers designed mockups to visualize the user interface, ensuring it met the user's needs for accessibility and usability. The flowcharts provided a step-by-step breakdown of system processes, while the ERD defined the data structures and relationships.

These elements formed a cohesive blueprint to guide the system's development and ensure alignment with the requirements. Figure 8 shows the system architecture which combines DFD and the interaction of users.

Figure 8

System Architecture



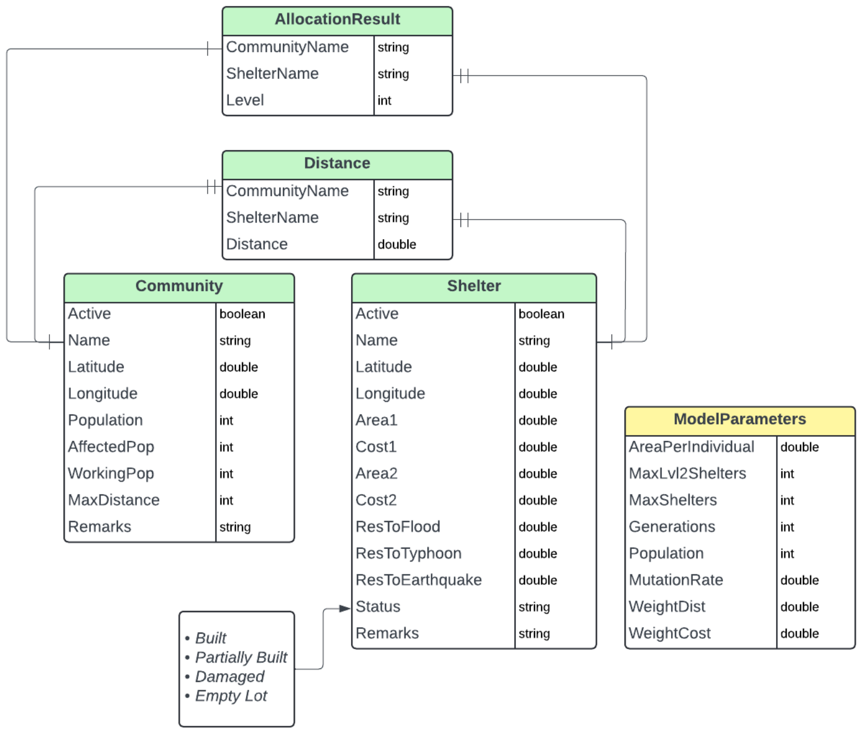
The system architecture involves the interaction of two actors, the user of the system and disaster management team. The community and shelter data will be fed into a system which features data manipulation and shelter tagging. With the cleaned or finished data, data simulation may begin together with the model parameters modified by the user. Finally, a report will be generated and can be protected or not. The report will be used by the disaster management team to guide them for decision making in allocation of residents to the correct shelter.

Figure 9 shows the entity relationship (ERD) which has 4 entities: Community, Shelter, Distance, and ModelParameters. Distances are derived from the location of Shelter and Community, then will be saved accordingly to be used in performing the system model. ModelParameters shows no relationship since it only saves the current settings for the model and algorithm.

As can be seen in Figure 10, The system mock-up shows the prototype of the system by designing the User Interface (UI) using a prototyping tool, Figma. This

Figure 9

The ERD Schema



shows the UI for different modules of the system: Dashboard, Entity Management, Shelter Allocation Report, Settings, and the Progress.

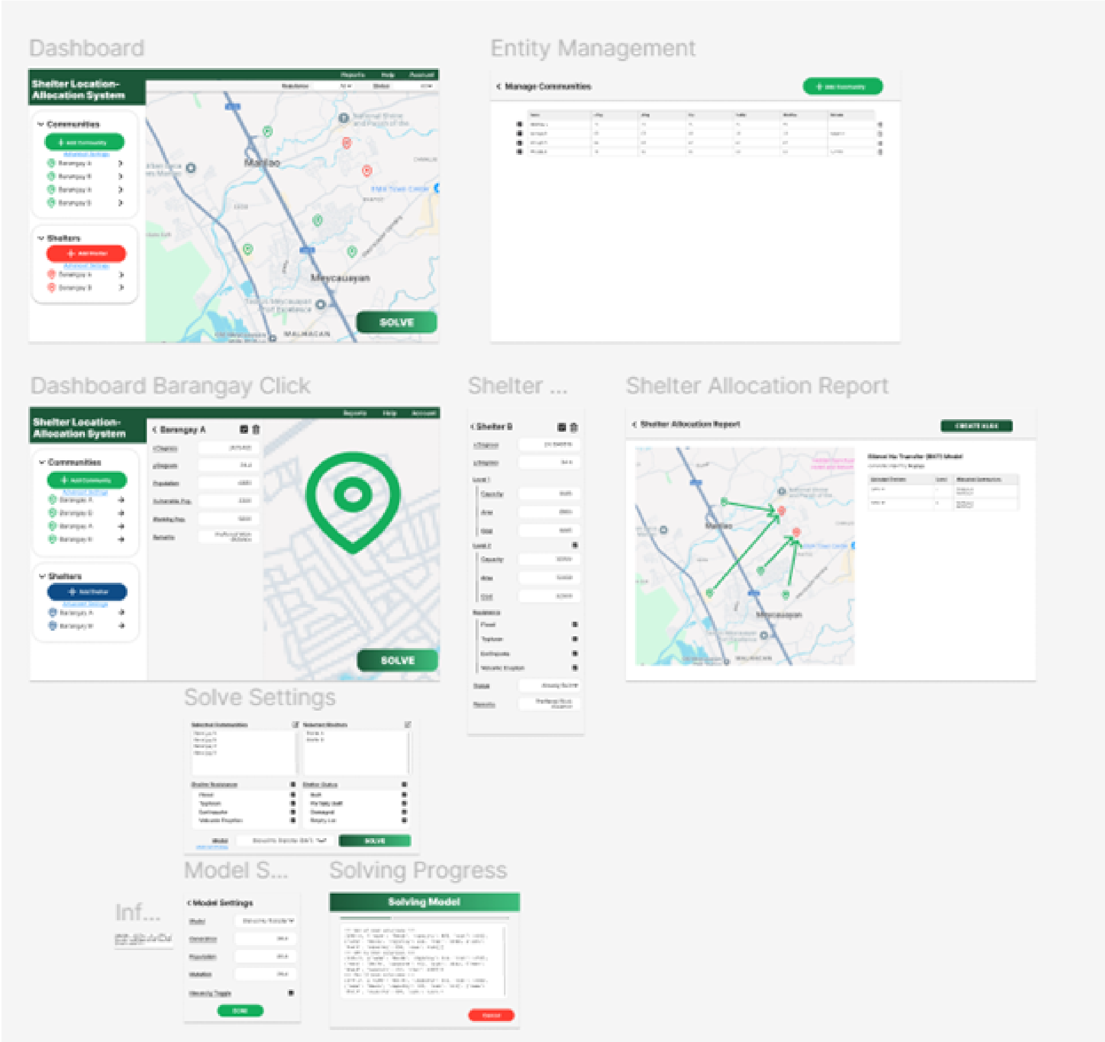
Development

The development phase includes coding and implementing the genetic algorithm for the shelter location allocation system. Utilizing the Agile system development life cycle, which includes weekly meetings and development reviews, the team can ensure that development remains on track and that any issues are promptly addressed. By following the Agile SDLC, the researchers can adapt quickly to any changes in requirements, maintain clear communication, and address any issues promptly.

Table 1 shows the list needed to start the development process. The system was developed using Python programming language, and Qt framework to efficiently implement the graphical user interface(GUI) of the system. Visual

Figure 10

Overview of System Mock-up



Studio Code will be utilized as the integrated development environment (IDE), and QtDesigner as an extension for creating frontend designs by Qt framework.

Developing the proposed system using Python allows us to use Python libraries. As shown in Table 2, displays all the libraries used to develop the system. PySide6 is responsible for the GUI that uses the Qt framework. Pandas and openpyxl are used for handling data. Folium, OSMnx, networkx, and scikit-learn are for displaying and calculating the map shown in the system. Lastly, numpy is used for executing genetic algorithm.

Table 1

List of tools and technologies used in the development process

Name	Version	Description
Visual Studio Code	1.96.3	IDE for the whole coding and debugging process
Python	3.12.5	Programming language known for extensive computation libraries
QtDesigner	5.11.1	GUI design tool which has drag and drop feature
GitKraken	10.6.1	Git client that is user friendly for executing Git commands
GitHub	Web	Repository host which used for collaboration and backup of the project

Testing and Debugging

The system underwent functionality, performance, and reliability testing during the testing phase. The researchers employed manual testing techniques to identify and resolve any bugs or issues that arise. Found any errors and anomalies within the system, it will be then fixed and debugged. Through this thorough testing and debugging approach, the researchers aim to ensure that the shelter location allocation system meets high quality, performance, and user satisfaction standards, making it ready for deployment.

Deployment

During the deployment phase, the shelter location-allocation system underwent pilot testing in collaboration with local government units (LGUs). This process involves configuring the system, establishing the necessary data inputs, and training users to utilize the platform effectively. Additionally, the deployment phase will continuously monitor the system's performance to ensure it operates efficiently and meets the objective of optimizing shelter locations.

Presentation of the application to the potential users, specifically the LGU of Calumpit will include a walk-through tutorial covering all essential features. The users was provided with the information necessary to operate the app effectively, including an overview of its purpose, functionalities, and how to input relevant

Table 2

List of libraries installed in Python

Name	Version	Description
PySide6	6.7.2	Uses Qt framework for frontend development
pandas	2.2.3	Reads and handles datasets
openpyxl	3.1.5	Opens and reads excel files
folium	0.17.0	Provides visualization and interactivity on a geographical map
osmnx	1.9.4	Retrieves OpenStreetMap(OSM) data and could calculate road paths
networkx	3.3	Creates and computes complex graphs such as road networks
scikit-learn	1.5.2	Provides simple machine learning tools and functions
numpy	1.26.4	Generates non probabilistic numbers
msoffcrypto-tool	5.4.2	Encrypts and decrypts excel files
XlsxWriter	3.2.2	Edits and writes excel contents
pyinstaller	6.12.0	Compiles project file into an executable file

data. Specifically, this includes entering shelter locations, population data, and accessibility metrics into the system to ensure accurate allocation results. Since a detailed explanation was provided during the system evaluation, this presentation focused on summarizing key points and addressing questions and feedback from the users.

Evaluation

Evaluation of system includes preparing ang distributing survey questionnaires based on TAM and ISO/IEC 25010 to our target sample. This phase will ensure that the developed system has feedback from potential users as well as from experts in software engineering and development.

Feedback gathered from the potential users will be important in identifying the areas for improvement. This feedback was collected through structured surveys and interviews to provide a comprehensive understanding of user needs and challenges. After the updates and adjustments to the application based on feedback to better align with users' needs, the new version of the application will be emailed to the LGU of Calumpit for operational use. This will ensure that they have access to the latest features and improvements. It is important to note that this application is copyrighted by Bulacan State University to protect its intellectual property and ensure proper recognition to the researchers, developers, and thesis adviser. This copyright also prevents unauthorized commercial use and distribution, ensuring that the application remains a free resource for its intended purpose. It will be not for sale.

System Preliminaries

Developing a system requires careful planning and analysis before implementing it. A communication between the potential users or clients and the researchers is essential to ensure all system requirements are met and improved. This phase aims to establish a foundational understanding of current disaster-response processes, along with gathering essential data for the system. Interviews was conducted with representatives from local government units (LGUs) specifically from the target population to understand their existing shelter allocation process, challenges, and expectations for a decision support system.

Client Interview

Conducting an interview with the client is essential to get to know with the potential users and the problems their facing. Questions formulated are derived from Design Thinking Framework which is according to Pereira and de F.S.M. Russo (2018) has resulted a greater approximation of end users and the development team who uses an Agile SDLC. This improves the quality and usability of the software.

Data Gathering

The model needed data to perform, specifically community and shelter data. Additionally, to ensure that the system produces outputs, data on shelters, disaster events, and typhoons will be collected. This includes accessing records on past typhoon impacts, available shelter locations, and their respective capacities.

Community or barangay data was sourced from publicly available databases, such as PhilAtlas, which provides detailed geographical and demographic information essential for accurate system modeling.

Data Preprocessing

The gathered information will undergo several stages. This ensures it meets the needs of the system and allows for an accurate assessment of its effectiveness.

All collected data will first be cleaned to remove any inconsistencies, duplicates, or irrelevant information. This process is crucial for ensuring the data's quality and reliability, particularly for a system that relies on precision in both inputs and outputs. Any insufficient data will be asked on the LGU to fill in the gaps of the datasets.

Table 3 presents all the data variables on communities and shelters used in the model, along with their respective sources. Affected population were derived from the population of community which is based on the study of Opdyke et al. (2024) that states 12% of households intends to evacuate on public evacuation sites. Improvement or rehabilitation cost is added for costs, which are based on a report for improvement of an evacuation center from "REGION III - CENTRAL LUZON : EVACUATION FACILITY in Sta. Rita" (2017) and "IMPROVEMENT/REHABILITATION OF EVACUATION CENTER IN BRGY STA. RITA" (2019) that costs approximately ₱7,700 per square meter. Meanwhile, data for Level 2 shelters are simulated, as the LGU does not have a data nor system for the hierarchy of shelters. The areas are assumed to be twice their initial size, and costs are estimated based on the contract cost of the Frances Evacuation Center, as detailed in the "List of Locally Funded Projects" (2022) and "Construction of Multipurpose Building at Brgy. Frances, Calumpit, Bulacan" (n.d.) reports, resulting in approximately ₱60,000 per square meter.

Researches added empty lots across Calumpit to be appended to shelter data. These lots are identified and selected to be resistant to hazards, specifically floods with the assistance of Nationwide Operational Assessment of Hazards (NOAH)

Table 3

Variables, Descriptions, and Sources for Community and Shelter Data

Variable	Source	Description
Community		
Name	LGU interview	Identity of a community
Longitude	Google Map & LGU interview	Longitudinal coordinates
Latitude	Google Map & LGU interview	Latitudinal coordinates
Population	Philippine Atlas (2020 population)	Number of individuals living in a community
AffectedPop	Assumed 12% of Population	Number of individuals affected during a disaster
MaxDistance	Maximum distance generated in distance calculation	Distance allowed to travel by a community
Shelter		
Name	LGU interview	Identity of a shelter
Longitude	Google Map & LGU interview	Longitudinal coordinates
Latitude	Google Map & LGU interview	Latitudinal coordinates
Area1	Google Map	Lot area of a shelter (level 1)
Cost1	Assumed 7,700 * Area1	Cost for constructing/maintaining a shelter with Area1
Area2	Assumed Area1 * 2	Lot area of a shelter (level 2)
Cost2	Assumed 60,000 * Area1	Cost for constructing/maintaining a shelter with Area2
ResToFlood	LGU interview	Resistance to flood indicator
ResToTyphoon	LGU interview	Resistance to typhoon indicator
ResToEarthquake	LGU interview	Resistance to earthquake indicator
Status	LGU interview	State of the physical structure of a shelter indicator
Distance between Community and Shelter		
distance	OpenStreetMap API	distance needed to travel by a community to a shelter

website. Table 4 shows the change of variables in area, cost, resistance and status for these appended shelter data. Additional cost is added due to property cost which according to Dot Property, approximately ₱12,500 per square meter was the average cost for land in Calumpit.

Table 4

Sources of Appended Shelter Data

Variable	Source
Cost1	Assumed Area1 * (60,000 + 12,500)
Cost2	Assumed (Area2 * 60,000) + (Area1 * 12,500)
ResToFlood	Assumed TRUE
ResToTyphoon	Assumed TRUE
ResToEarthquake	Assumed TRUE
Status	Already an Empty Lot

For justification of the target area's vulnerability, typhoon data spanning from 2006 to 2022 will be examined. This dataset includes the number of affected and evacuated individuals across various municipalities in Bulacan. The data will be grouped by municipality, summing the affected and evacuated residents over the specified period. This analysis helps justify the focus on the municipality and supports the rationale for the shelter allocation model's implementation in the municipality.

The cleaned shelter and community data will be fed into the system to facilitate accurate shelter location-allocation modeling. The system will use these inputs to generate optimized shelter placement recommendations based on the model adopted.

System Evaluation

System evaluation focuses on assessing acceptability of the shelter location allocation system using the TAM determinants and ISO/IEC 25010 standard. These standards provides a framework for evaluating the software's quality and acceptability. The system evaluation includes the evaluation instrument, determining the population and sample, outlining data collection procedures, and discussing the data analysis techniques used.

Evaluation Instrument

The evaluation instrument is a structured questionnaire designed to assess the acceptability of the shelter location allocation system based on the determinants of Technology Acceptance Model(TAM) and key quality attributes outlined in the International Organization for Standardization and International Electoral Commission (ISO/IEC) 25010 standard. Questionnaires based on TAM was distributed to the potential end-users of the system. On the other hand, questionnaires based on ISO/IEC 25010 was distributed to the experts in software development.

TAM questionnaire evaluates the system's acceptability by the user of the system. This model answers why users accept or reject information systems, and examines a system's acceptance based on their attitudes, preferences, and behaviors.(Davis, 1987)

The following criteria are based upon the four determinants defined in TAM:

Perceived Usefulness. This answers on how much a user believes using the system will improve their performance such as job tasks. It evaluates whether the users thinks the proposed system will be genuinely beneficial to LGUs or if it can assist other LGUs effectively.

Perceived Ease of Use. This answers on how much a user believes using the system will be efficient and user-friendly. It considers whether the proposed system can be used smoothly with minimal errors and without performance issues.

Attitude Towards Using. This answers on what user feels when using the system based on their enjoyment and satisfaction. A positive attitude towards the system often leads to accepting the technology.

Behavioral Intention to Use. This answers on willingness to use the system in the future. It determines whether users find the system valuable enough to incorporate into their long-term plans.

Additionally, ISO/IEC 25010 questionnaire evaluates various aspects of the system, including usability, reliability, performance efficiency, and overall user satisfaction. Through this instrument, the study aims to gather objective data that will help determine how well the system meets user needs and expectations. ("Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Product quality model," 2023)
The following criteria are based upon the nine quality characteristics for product quality model defined in ISO/IEC 25010:

Functional Suitability. This evaluates how well the system meets user needs and performs its intended functions. The questions will focus on the system's ability to allocate shelters effectively, manage community and shelter information, and provide accurate data.

Performance Efficiency. This attribute will evaluate the system's response time and processing capacity. The questionnaire will include items assessing the system's speed in performing functions, efficient use of resources such as memory and processing power, and ability to handle maximum load requirements. By examining performance efficiency, the study aims to determine whether the system can perform reliably under diverse operational conditions.

Compatibility. This will assess the system's ability to exchange and use information with other systems. The questionnaire will ask how well the system integrates with external databases, applications, or computer systems.

Interaction Capability. This will prioritize the system's usability, learnability, and overall user satisfaction. The questionnaire will gather detailed user feedback regarding their experiences with the system. The questionnaire will address aspects such as ease of navigation, effectiveness in completing tasks, and general user engagement.

Reliability. This attribute will assess the system's interaction capability, focusing on its ease of use, appropriateness for users, and ability to guide users in completing tasks effectively. The evaluation will include questions on how easily users can recognize if the system meets their needs, learn its functions, and operate it with minimal errors. Additional focus will be on user engagement, inclusivity, and the availability of assistance to support a diverse range of users.

Security. The system ensures that all collected data will remain confidential and solely for this research. No data will be uploaded online, and all information will be stored offline. Access to data will be limited to the researchers and users.

Maintainability. This will evaluate the system's ease of adaptability to meet new requirements, correct errors, and improve performance. The questionnaire will assess the system's reusability, analyzing how parts of the system can be leveraged in future developments or other systems, and its testability, ensuring that any necessary changes can be efficiently implemented and quickly identified so that testing can be done efficiently.

Flexibility. This will assess the system's ability to adapt to changing user needs and requirements. The questionnaire will evaluate the system's ability to support new features, incorporate updates, and seamlessly integrate with additional tools or systems as necessary. It will also examine how well the system accommodates changes in shelter allocation criteria, such as shifts in population density and shelter resistance.

Population and Sample

The population of this study consists of end-users and IT experts. For end-users, MDRRMO and MSWDO of the municipality of Calumpit. Meanwhile for IT experts, includes CICT professors from Bulacan State University, and someone who have experience in developing a system. The diversity of perspective of these are important for the comprehensive evaluation of the system's acceptability.

MDRRMO: The staff consists of Municipal Disaster Risk Reduction Management Office, who are responsible for formulating and implementing the province's disaster risk reduction plan. Their insights are vital for understanding the operational requirements considerations for implementing the shelter location allocation system, ensuring it aligns with established disaster response protocols and local needs.

MSWDO: The Municipal Social Welfare and Development Office plays a key role in managing the evacuation and welfare of the communities during disasters. Their expertise is essential in ensuring that the shelter allocation system aligns with evacuees' specific needs, such as accessibility and capacity to the shelter location allocation across the province. Their input will help tailor the system to address the welfare requirements of evacuee management during emergencies.

CICT professors: Coming from the College of Information and Communication Technology, professors have significant academic background and experience to technologies. This part of population will assess the system's performance and functionality with the help of their knowledge and expertise.

System Developers: Experts with extensive experience in system development play an important role in project evaluation. They are commonly found in businesses that design, propose, and develop systems for their clients. Their expertise enables them to understand and address real-world client requirements, guiding the system to be acceptable to users.

The sampling technique that was utilized for end-users is Stratified Sampling Technique, where the population is divided into a respective groups or strata, where in this study, our stratum is the MDRRMO and MSWDO. This ensures comprehensive representation, to capture the perspectives of different stakeholder groups proportionately. The sample size of end-users will be computed using G*Power, a statistical software tool. With a confidence level of 95% or 0.05 margin of error, the sample size would be 23. Since the sample size would be much smaller than the population size, then conducting system evaluation would be feasible.

Meanwhile, for IT experts, Purposive Sampling Technique will be employed. Researchers will purposively select 5 IT experts. These experts was chosen based on their qualifications and relevant experience to provide insights into the system's design, functionality, and performance. This technique ensures that the selected experts evaluating the system will provide comprehensible and accurate feedback while also ensuring its feasibility.

Data Collection Procedures

Evaluation phase gauges the system's acceptability and user satisfaction. To do this, a questionnaire was developed based on TAM and ISO/IEC 25010, which employs a 10-point rating scale, allowing participants to provide precise feedback on each quality criterion. The system was demonstrated to a selected sample population in a face-to-face presentation, where they will have the chance to interact with the system firsthand. This was followed by the completion of the questionnaire, enabling participants to provide feedback based on their experience using the system.

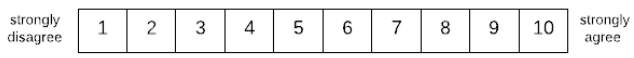
Following the research instruments ensures that the system meets its intended objectives and offers insights into potential areas for improvement, which will be critical for broader implementation in disaster-response operations. Through the data collection process, the researchers will ensure that all ethical considerations are thoroughly addressed to uphold the integrity and privacy of the participants

Data Processing and Analysis

This study's data processing involves structured analysis to interpret findings from the acceptability survey, aligning with the ISO/IEC 25010 standard and TAM determinants. This standard evaluates key quality attributes, and each attribute was assessed using a 10-point numerical rating scale. 1 = completely disagree, and 10 = completely agree, as shown in figure 11

Figure 11

10-point numerical rating scale



After the data collection, the rating scale categorizes the acceptability levels. Descriptive statistics was utilized to analyze the collected data. Analysis includes calculating the minimum, maximum, mean, and standard deviation for each category. Formula 3.17 shows the mean that computes the average score. This use of data allows both the system functionality and its user acceptability to be comprehensively assessed. Table 5 shows the verbal interpretation of the computed mean corresponds to the level of agreement and acceptable based on the study by Eladia et al. (2024).

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{3.17}$$

Where:

$\bar{x}$ - sample mean

n - sample size

x_i - data points

Formula 3.18 shows the standard deviation calculation which shows the dispersion of scores relative to the mean. A standard deviation that is closer to the value of 0 indicates the spread of data is closer to the mean.

Table 5

Mean Score Interval and its Verbal Interpretation

Mean Score Interval	Level of Agreement	Level of Acceptance
1.00 - 2.80	Strongly Disagree	Poorly Acceptable
2.81 - 4.60	Disagree	Fairly Acceptable
4.61 - 6.40	Neutral	Acceptable
6.41 - 8.20	Agree	Moderately Acceptable
8.21 - 10.00	Strongly Agree	Highly Acceptable

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \tag{3.18}$$

Where:

S - sample standard deviation

$\bar{x}$ - sample mean

n - sample size

x_i - data points

Ethical Considerations

Data gathered contained sensitive data so that ethical considerations should be practiced throughout the research. Informed consent obtained from each participant, providing them with a clear understanding of the research purpose, procedures, and their rights to withdraw at any time. To protect the participants' privacy, all responses will be anonymized and handled with strict confidentiality. Additionally, data usage was restricted to research purposes only, ensuring that participants' information remains safeguarded throughout the research process and beyond.

Informed Consent: All respondents are informed about the purpose, procedures, and potential impacts of the study before they agree to participate. The respondents will be given a detailed explanation of the study, including the nature of their involvement, the voluntary nature of participation, and their right to withdraw at any time.

Confidentiality and Anonymity: Personal identifiers are removed from the data to ensure that the respondents cannot be traced back to other respondents. Data are stored securely, and access will be restricted to the researchers. Any publications or presentations resulting from the study will use aggregated data with no individual responses disclosed, safeguarding the identity and privacy of all respondents.

Data Protection: The study will adhere to relevant data protection regulations, such as local data protection laws, ensuring the secure handling and storage of all collected data. Informing the respondents about how their data will be collected, stored, and used. Their rights to privacy and data protection will be respected, and only authorized researchers will have access to the information.

Minimizing Harm: The study will be structured to minimize any potential harm to respondents. This includes ensuring that all questions are respectful, non-discriminatory, and that the data collection process does not inconvenience the respondents. Any potential risks will be clearly communicated, and measures will be implemented to mitigate these risks and uphold the respondents well-being throughout the study.

Transparency and Honesty: The researchers will uphold transparency and honesty throughout every stage of the study. This commitment includes accurately reporting research findings, acknowledging limitations, and strictly avoiding data manipulation or bias. Respondents will be informed of the study's progress, purposes, and outcomes, ensuring they remain fully aware of how their contributions are utilized and valued within the research.

By adhering to these ethical principles, the study will safeguard respondents' rights and well-being, uphold the integrity of the research process, and enhance the credibility and reliability of its findings. This ethical approach shows trust between researchers and respondents, contributing to meaningful and responsible research outcomes.

CHAPTER IV

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

This chapter details the functionalities of the developed system, including its user interface design. Moreover, the system answers the optimal shelter location-allocation for Calumpit. It also presents the evaluation results gathered from the LGU and IT experts, assessing the system's acceptability and alignment with local needs.

The Developed System

The researchers and developers of this thesis developed a decision support system to optimize shelter location allocation since there was a lack of system development. Identifying the most optimal shelter facility for a community is the system's main function. Specifically, it has five key features that let users completely modify the input parameters, and output processing.

Data Modification

The process of creating, updating, or deleting data within the system to maintain accuracy and relevance. This ensures that all records are up-to-date and properly managed so they can effectively be used for shelter allocation.

The dashboard provides an overview of a list of shelters and communities as shown in figure 12. It also displays a map where shelters and communities are pinned. Users can see whether a shelter is active or inactive. Additionally, the user can manipulate the map to filter and display only active shelter as well as shelters that are built, partially built, damaged, empty lot, and resistance to flood, typhoon, and earthquake

Community management module manages the recorded details of barangays as shown in figure 13. It displays whether a barangay is active or inactive, along with its latitude, longitude, population, affected population, maximum distance, remarks, and a delete button. Users can also add new communities, download a template to ensure correct formatting when importing data, and

Figure 12

Dashboard

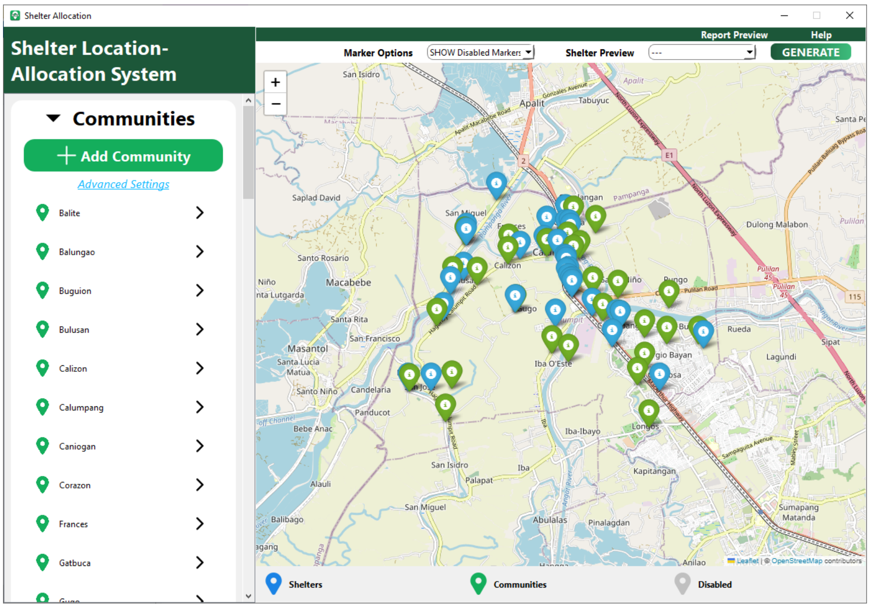
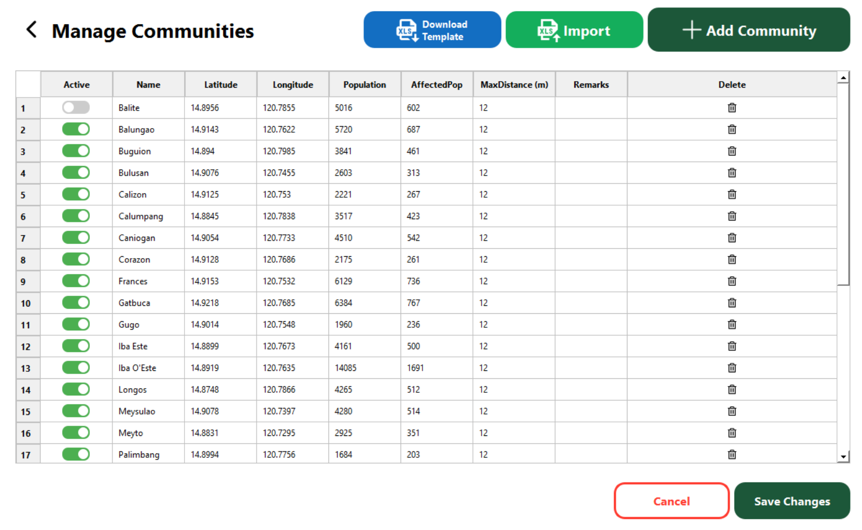


Figure 13

Community Management



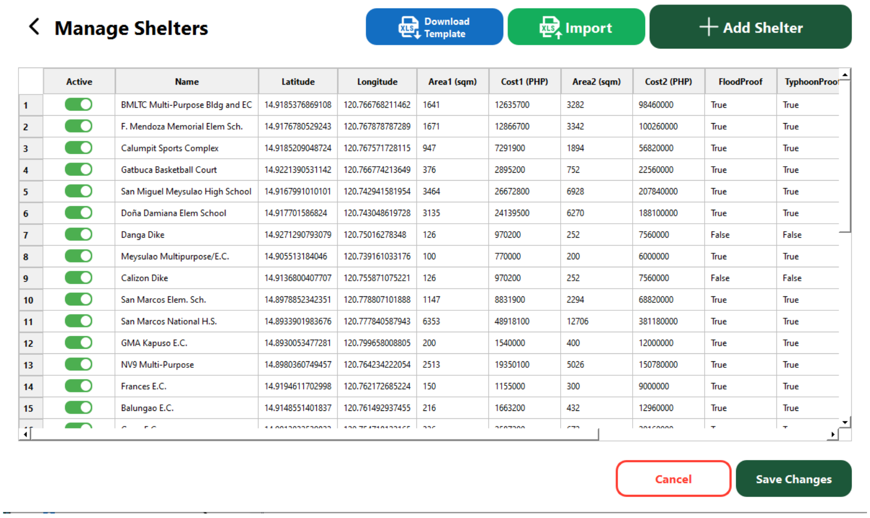
	Active	Name	Latitude	Longitude	Population	AffectedPop	MaxDistance (m)	Remarks	Delete
1		Balite	14.8956	120.7855	5016	602	12		
2		Balungao	14.9143	120.7622	5720	687	12		
3		Buguion	14.894	120.7985	3841	461	12		
4		Bulusan	14.9076	120.7455	2603	313	12		
5		Calizon	14.9125	120.753	2221	267	12		
6		Calumpang	14.8845	120.7838	3517	423	12		
7		Caniogan	14.9054	120.7733	4510	542	12		
8		Corazon	14.9128	120.7686	2175	261	12		
9		Frances	14.9153	120.7532	6129	736	12		
10		Gatbuca	14.9218	120.7685	6384	767	12		
11		Gugo	14.9014	120.7548	1960	236	12		
12		Iba Este	14.8899	120.7673	4161	500	12		
13		Iba O'Este	14.8919	120.7635	14085	1691	12		
14		Longos	14.8748	120.7866	4265	512	12		
15		Meysulao	14.9078	120.7397	4280	514	12		
16		Meyto	14.8831	120.7295	2925	351	12		
17		Palimbang	14.8994	120.7756	1684	203	12		

manage barangay-related information efficiently.

The shelter management module, as shown in figure 14, is similar to community management but includes different data fields. It contains information such as the shelter's name, latitude, longitude, and classification as a Level 1 or Level 2 shelter. The module also tracks the cost of construction and maintenance for each level. Additionally, it indicates whether the shelter is resistant to floods,

Figure 14

Shelter Management



typhoons, and earthquakes. Users can also view the shelter's status – whether it is built, partially built, damaged, or an empty lot.

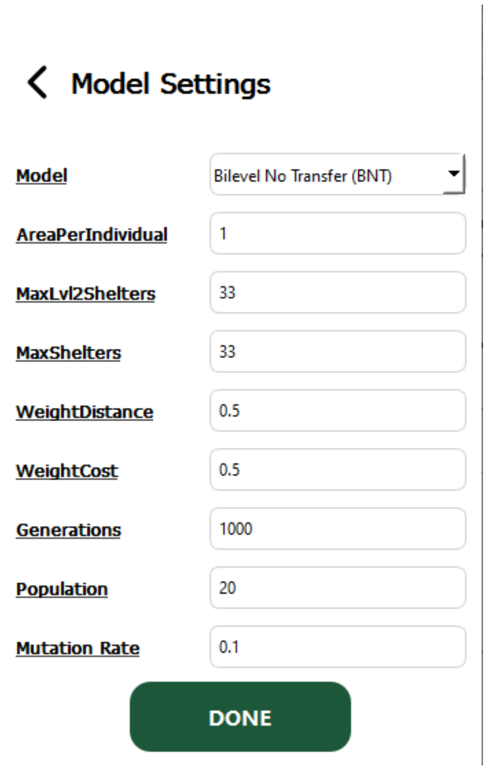
Model Modification

This concerns the parameters to be used in the model that may be modified for a more ideal setup depending on the preferences of the user. The parameters that may be changed here include the area per individual based on meters squared, the max number of level 2 shelters and shelters in general, the weights for both distance and cost, the number of generations, the number of populations in a generation, and the mutation rate. Measures are put in place to prevent entering of wrong values in these parameters such as letters or negative numbers.

These factors impact the time taken to simulate data as well as the efficiency of the simulation, it is recommended to keep the parameters at default values unless the user is knowledgeable about the model or the system. These parameters are modified in the Model Parameter Settings module as shown in figure 15, which may be accessed from the Solve Settings module by clicking Advanced Settings below Model.

Figure 15

Model Parameter Settings



Data Simulation

This pertains to solving the model by running the Genetic Algorithm, which determines the most optimal shelter location allocation. As the core functionality of the system, it processes input data of communities and shelters, applies defined model parameters, then generates and displays the best allocation of the municipality.

Progress dialog as shown in figure 16 provides real-time logs and tracks the progress of the simulation. The process starts by computing the distances between each community and each shelter using a Python library, OSMnx. Once the distances are calculated, the system proceeds with the Genetic Algorithm to optimize the allocation. Users also have the option to cancel the process at any time.

After the solving process is completed, report dialog appears displaying the final allocation results as shown in figure 17. It shows which communities are

Figure 16

Progress Dialog

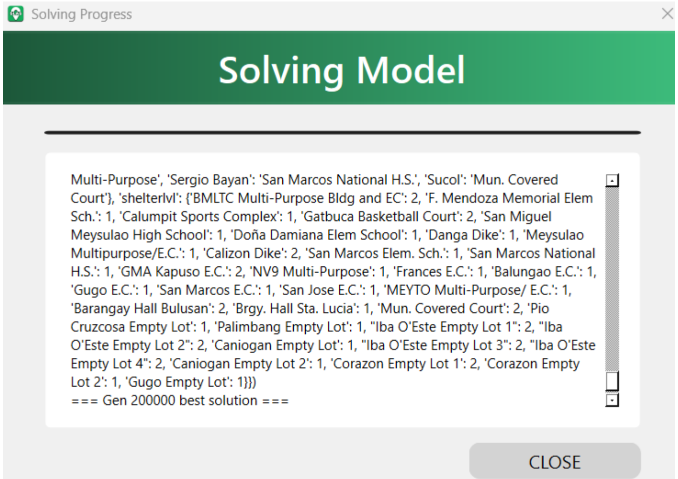
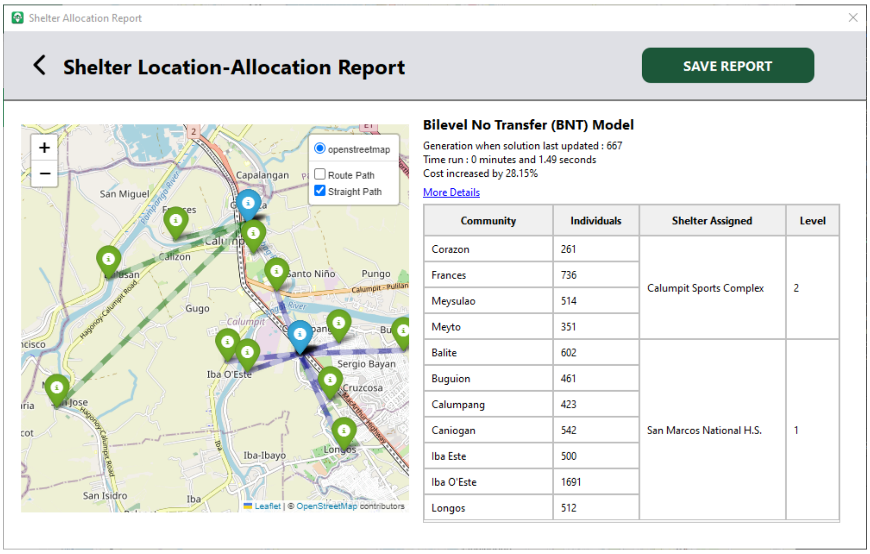


Figure 17

Report Dialog



assigned to shelters, and displays the paths they can take on a map. This helps users analyze the feasibility and efficiency of the allocation.

The Genetic Algorithm is implemented from scratch using Python, ensuring full control over its functionality and optimization process. The main functions in the code include fitness calculation, constraint enforcement, and the implementation of selection, mutation, and crossover.

Appendix B.14 details the fitness calculation, which represents the model's objective value. The first loop calculates the total distance, while the second loop determines the cost based on the level of the opened shelters.

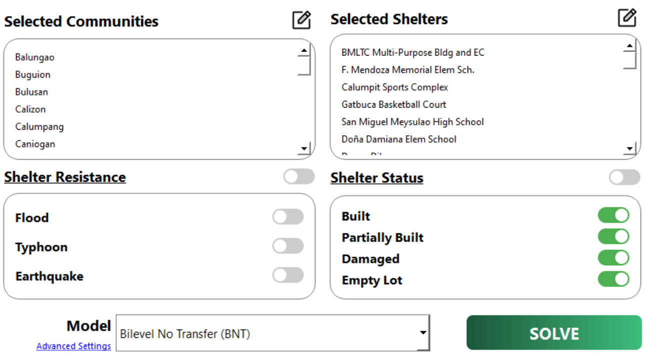
Appendices B.15, B.16, B.17, and B.18 implement the constraint functions, adding penalties to the objective value when violated. These constraints include maximum distance constraint, initial capacity constraint, maximum number of level 2 shelters that can be constructed/allocated, maximum number of shelters that can be constructed/allocated. Since the implemented Genetic Algorithm operates on integers, the constraints ensuring that each community is assigned only one shelter and one level are already satisfied.

Shelter Tagging

This concerns the classification of shelters based on both structural resilience and current condition, ensuring shelters are appropriately assigned to communities based on availability, cost, and risk levels. Shelters are categorized in both resistance capabilities and status; resistance capabilities include flood-resistant, typhoon-resistant, and earthquake-resistant, and are not mutually exclusive to one another, for example, a shelter can be both flood and typhoon resistant. In terms of status, shelters can be built, partially built, damaged, and empty lots, each with varying costs depending on maintenance and construction.

Figure 18

Solve Settings



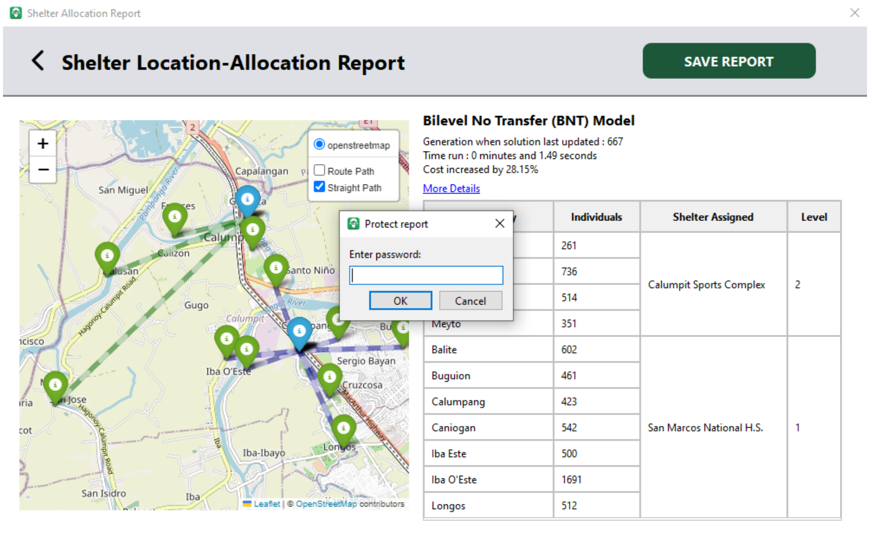
Selecting shelters with specific resistances and statuses in mind is done in the Solve Settings module as shown in figure 18, where selecting or deselecting a specific resistance will remove shelters that do not meet the criteria from the data simulation. This ensures users will not assign communities to shelters that are not suited to the situation. Users may also check the status and resistances of a specific shelter in either the dashboard module by selecting a shelter, or in the shelter advanced settings, displaying all shelters' statuses.

Report Protection

To maintain confidentiality and prevent the unauthorized modification of reports, a security mechanism has been implemented in the system. This module includes password authentication, report encryption and identification of the creator of a report based on device-specific attributes.

Figure 19

Input Password Popup



Upon finishing data simulation, the generated report may be saved in an excel format, and gives users the option to add password protection to the file through a popup as shown in figure 19. This ensures only intended users may access the report, the generated excel file itself is also read-only, without the ability to modify the data without authorization. The protected file was encrypted using a Python library, MSoffcrypto.

The excel file also contains identification of the creator of the report, containing three device-specific identifiers, the IP address or the location of the user's device, the MAC address or the identifier of the user's network interface, as well as the name of the device the report was generated in. This information is logged in the password protected excel file, enhancing security and ensuring unauthorized users are logged and tracked.

Generated Shelter Location-Allocation Report

This section discusses the process of generating reports for shelter location allocation. The report helps in optimizing shelter assignments for communities based on various parameters and ensuring efficient disaster response. The data used considers only 12% of the population in each barangay as affected. Additionally, the shelters have a maintenance cost, which are factored into the optimization process.

Table 6 shows the parameters used for the BNT model and the genetic algorithm. Table 7 presents the optimized shelter location-allocation results generated by the system. Five shelters were opened and assigned to respective communities. All shelters were opened as Level 1, except for Mun. Covered Court, which was upgraded to Level 2. This suggests that upgrading this shelter is better than opening an additional one.

Table 6

Model Parameters

Parameter	**Value**
Area Per Individual in m^2	1
Maximum Level 2 Shelters	33
Maximum Shelters	33
Weight Distance	0.5
Weight Cost	0.5
Generations	200000
Population	100
Mutation Rate	0.1

Table 8 shows the details of the result. Note that this report is generated by the system running on Huawei Matebook D15 with processor of Ryzen 7 5700U. The generated report can be downloaded as an Excel file. In the Report Module, a map displays where communities are allocated to their designated shelters. Figure 20 and 21 shows the generated map which visualizes the allocation result.

Figure 20

Community to Shelter Straight Path

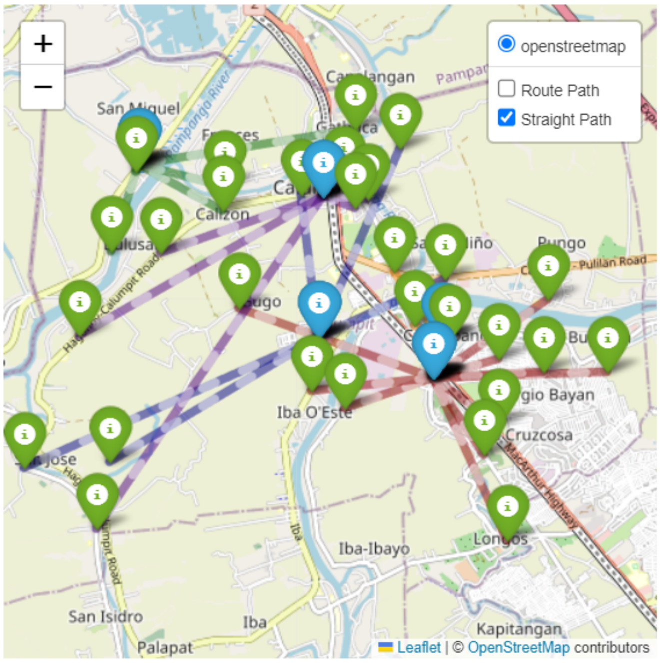
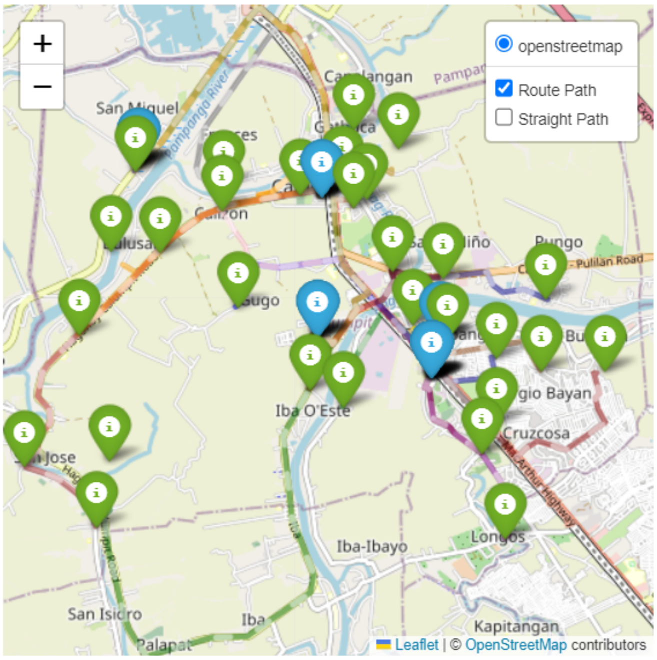


Figure 21

Community to Shelter Route Path



System Evaluation

The developed system underwent an assessment through survey questionnaires to evaluate its acceptability. The respondents included the target users, specifically the MSWDO and MDRRMO of Calumpit. In addition, IT experts with experience in system development participated in the evaluation to provide technical insights and ensure that the system met quality standards.

End-Users

The researchers conducted a survey to 23 respondents from the MSWDO and MDRRMO of Calumpit. The survey instrument was based on TAM which consists of four criteria: perceived usefulness, perceived ease of use, attitude towards using, and behavioral intention to use. The gathered data was analyzed to determine the users' acceptance of the system.

Table 9 shows the users' perceived usefulness of the system. The result shows a total mean score of 9.4, which corresponds to "Strongly Agree," indicating "Highly Acceptable" in terms of perceived usefulness. The standard deviations range from 0.54 to 0.8, implying low variation in the respondents' answers.

Table 10 shows the users' perceived ease of use of the system. The result shows a total mean score of 9.47, which corresponds to "Strongly Agree," indicating "Highly Acceptable" in terms of perceived ease of use. The standard deviations range from 0.58 to 0.66, implying low variation in the respondents' answers.

Table 11 shows the users' attitude towards using the system. The result shows a total mean score of 9.48, which corresponds to "Strongly Agree," indicating "Highly Acceptable" in terms of attitude. The standard deviations range on 0.59, implying low variation in the respondents' answers.

Table 12 shows the users' behavioral intention to the system. The result shows a total mean score of 9.41, which corresponds to "Strongly Agree," indicating "Highly Acceptable" in terms of behavioral intention. The standard deviations range from 0.58 to 0.7, implying low variation in the respondents' answers.

The results from the four criteria showed high ratings, with total mean scores ranging from 9.4 to 9.48, indicating the system is "Highly Acceptable" to the target users. This suggests that they are likely to adopt and use the system to support their work in strategic planning.

IT Experts

To evaluate the system's technical quality, the researchers surveyed five IT experts, from the faculty of the College of Information and Communications Technology (CICT) at Bulacan State University, and developers from a technology company. The survey instrument was based on the ISO/IEC 25010 software quality model, which includes eight criteria: Functional Suitability, Performance Efficiency, Compatibility, Interaction Capability, Reliability, Security, Maintainability, and Flexibility. The data gathered from this assessment provided valuable insights into the technical aspects and overall quality of the system.

Table 13 shows the score for Functional Sustainability of the system. The result shows a total mean score of 9.8, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of functional sustainability. The standard deviations are close to 0, implying little to no variation in the respondents' answers.

Table 14 shows the score for Performance Efficiency of the system. The result shows a total mean score of 9.67, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of performance efficiency . The standard deviations range from 0.44 to 0.55, implying low variation in the respondents' answers.

Table 15 shows the score for Compatibility of the system. The result shows a total mean score of 9, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of compatibility. The standard deviations range from 0.84 to 1.3, implying low variation in the respondents' answers.

Table 16 shows the score for Interaction Capability of the system. The result shows a total mean score of 9.33, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of interaction capability. The standard deviations range from 0.45 to 0.84, implying low variation in the respondents' answers.

Table 17 shows the score for Reliability of the system. The result shows a total mean score of 9.6, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of reliability. The standard deviations range from 0.45 to 0.71, implying low variation in the respondents’ answers.

Table 18 shows the score for Security of the system. The result shows a total mean score of 9.67, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of security. The standard deviations range from 0.45 to 1.3, implying low variation in the respondents’ answers.

Table 19 shows the score for Maintainability of the system. The result shows a total mean score of 9.24, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of maintainability. The standard deviations range from 0.45 to 1.14, implying low variation in the respondents’ answers.

Table 20 shows the score for Flexibility of the system. The result shows a total mean score of 9.5, which corresponds to "Strongly Agree," indicating “Highly Acceptable” in terms of flexibility . The standard deviations are close to 0, implying little to no variation in the respondents’ answers.

The results from the eight criteria showed high ratings, with total mean scores ranging from 9 to 9.8, indicating the system is “Highly Acceptable” based on the IT Experts. This suggests that the system developed met the international standards for a software product.

Comments and Suggestions

Based on feedback from IT experts, the system’s key strengths include its comprehensive functionality, effectively performing all required functions for its purpose. The implementation leverages Python and relevant libraries to optimize performance. It accurately identifies optimal shelter locations, demonstrating reliability and efficiency in processing data. Additionally, the user interface is simple and easy to navigate, minimizing complexity.

Several areas for improvement were identified by IT experts. The system needs to support new model configurations without requiring large code changes, and additional information should be displayed upon user interaction. The map interface could be cleaner and more visually organized, and enhancements are needed to ensure the protection of sensitive data.

To address these areas, IT experts provided several suggestions. Developing a mobile application would facilitate citizen connectivity with the platform. Including travel time estimates to shelters and implementing real-time data processing and display would further improve functionality. Allowing the configuration of new models through the UI would reduce the need for code alterations, and simplifying error messages would ensure clarity for non-IT users.

In addition to the feedback from IT experts, members of the Local Government Unit (LGU) of Calumpit provided valuable insights. Specifically the importance of ensuring the exact identification of lots for shelter placement. Continuing to refine the system would enhance its usability and performance, and adding more intuitive features would improve accessibility and understanding for non-technical users.

This feedback from the surveyed IT experts and LGU employees provide a clear guide for future improvements in the system, providing understandability, adaptability, usability, and effectiveness.

Table 7

Generated Shelter Location-Allocation for Calumpit

Community	Shelter Assigned	Level
Calizon	Doña Damiana Elem School	Level 1
Frances		
Gatbuca		
Meysulao		
San Miguel		
Bulusan	Mun. Covered Court	Level 2
Corazon		
Panducot		
Poblacion		
Santa Lucia		
Sucol		
Balungao	NV9 Multi-Purpose	Level 1
Meyto		
San Jose		
Santo Niño		
Sapang Bayan		
Caniogan	San Marcos Elem. Sch.	Level 1
Palimbang		
San Marcos		
Balite	San Marcos National H.S.	Level 1
Baguion		
Calumpang		
Gugo		
Iba Este		
Iba O'Este		
Longos		
Pio Cruzcosa		
Pungo		
Sergio Bayan		

Table 8

Result Details

Item	Value
Objective Value	72034087
Time Run	73 minutes and 30.96 seconds
Cost of Opened Shelters	144019600
Generation when solution last updated	136256

Table 9

Perceived Usefulness Evaluation

Statement	**Mean**	**VI**	**SD**
Using the system improves my performance in completing tasks such as planning shelter locations for disaster response.	9.35	Strongly Agree	0.71
The system helps me accomplish choosing shelter locations and assigning communities more quickly.	9.22	Strongly Agree	0.80
The system increases my productivity.	9.22	Strongly Agree	0.60
The system enhances my effectiveness in completing tasks such as in disaster strategic planning.	9.43	Strongly Agree	0.59
Overall, I find the system useful in my job.	9.74	Strongly Agree	0.54
TOTAL MEAN	**9.40**	**Strongly Agree**	

Table 10

Perceived Ease of Use Evaluation

Statement	**Mean**	**VI**	**SD**
Learning to operate the system is easy for me.	9.39	Strongly Agree	0.58
The system is easy to use.	9.39	Strongly Agree	0.58
My interaction with the system is clear and understandable.	9.43	Strongly Agree	0.66
I find it easy to become skillful at using the system.	9.61	Strongly Agree	0.58
I find the system easy to operate.	9.52	Strongly Agree	0.59
TOTAL MEAN	**9.47**	**Strongly Agree**	

Table 11

Attitude Towards Using Evaluation

Statement	**Mean**	**VI**	**SD**
I have a positive attitude towards using the system.	9.52	Strongly Agree	0.59
I enjoy using the system.	9.39	Strongly Agree	0.58
I am satisfied with using the system.	9.52	Strongly Agree	0.59
TOTAL MEAN	**9.48**	**Strongly Agree**	

Table 12

Behavioral Intention to Use Evaluation

Statement	Mean	VI	SD
I intend to use the system regularly.	9.30	Strongly Agree	0.70
I will continue to use the system in the future.	9.30	Strongly Agree	0.70
I would recommend the system to others.	9.61	Strongly Agree	0.58
TOTAL MEAN	**9.41**	**Strongly Agree**	

Table 13

Functional Suitability Evaluation

Statement	Mean	VI	SD
The system provides all the required functions without any missing functionalities.	9.80	Strongly Agree	0.45
The functions are implemented correctly without any errors.	10.00	Strongly Agree	0
The functions are appropriate for the tasks and meet user needs effectively.	9.60	Strongly Agree	0.55
TOTAL MEAN	**9.80**	**Strongly Agree**	

Table 14

Performance Efficiency Evaluation

Statement	Mean	VI	SD
The system responds within acceptable time limits and maintains consistent response time under different conditions.	9.60	Strongly Agree	0.55
The resource usage is within acceptable limits and the system efficiently uses available resources.	9.60	Strongly Agree	0.55
The system can handle the expected load and is scalable to accommodate future growth.	9.80	Strongly Agree	0.45
TOTAL MEAN	**9.67**	**Strongly Agree**	

Table 15

Compatibility Evaluation

Statement	Mean	VI	SD
The system can coexist with other systems without conflict and has no compatibility issues.	8.88	Strongly Agree	1.30
The system can interact with other systems as required and data exchange between systems is seamless.	9.20	Strongly Agree	0.84
TOTAL MEAN	**9.00**	**Strongly Agree**	

Table 16

Interaction Capability Evaluation

Statement	Mean	VI	SD
The purpose of the system is easily recognizable and the functions are easy to understand.	9.20	Strongly Agree	0.84
The system is easy to learn for new users and there are adequate training materials available.	9.60	Strongly Agree	0.55
The system is easy to operate with intuitive and user-friendly controls.	9.60	Strongly Agree	0.55
The system protects users from making errors and provides clear and helpful error messages.	9.20	Strongly Agree	0.45
The user interface is aesthetically pleasing with a consistent and professional design.	9.80	Strongly Agree	0.45
The system is accessible to users with disabilities and includes features to support accessibility.	8.60	Strongly Agree	0.55
TOTAL MEAN	**9.33**	**Strongly Agree**	

Table 17

Reliability Evaluation

Statement	Mean	VI	SD
The system is mature and stable with no frequent crashes or failures.	9.80	Strongly Agree	0.45
The system is available when needed with no downtime issues.	9.00	Strongly Agree	0.71
The system can tolerate faults and continue operating with mechanisms for fault detection and recovery.	9.80	Strongly Agree	0.45
The system can recover from failures quickly with backup and recovery procedures in place.	9.80	Strongly Agree	0.45
TOTAL MEAN	**9.60**	**Strongly Agree**	

Table 18

Security Evaluation

Statement	Mean	VI	SD
The system ensures the confidentiality of data with measures to protect sensitive information.	9.60	Strongly Agree	0.55
The system ensures the integrity of data with mechanisms to prevent data corruption.	9.80	Strongly Agree	0.45
The system can verify the identity of users and actions are traceable to specific users.	9.20	Strongly Agree	0.84
The system provides accountability for actions with maintained logs and audit trails.	9.20	Strongly Agree	0.84
The system verifies the authenticity of data and users with measures to prevent unauthorized access.	8.80	Strongly Agree	1.30
TOTAL MEAN	**9.32**	**Strongly Agree**	

Table 19

Maintainability Evaluation

Statement	**Mean**	**VI**	**SD**
The system is modular and easy to modify with well-defined and independent components.	8.60	Strongly Agree	1.14
The system components can be reused in other contexts with reusable libraries or modules.	9.60	Strongly Agree	0.55
The system is easy to analyze for defects with tools to support analysis.	9.20	Strongly Agree	0.84
The system is easy to modify and update with documented and manageable changes.	9.00	Strongly Agree	1.00
The system is easy to test with automated testing tools available.	9.80	Strongly Agree	0.45
TOTAL MEAN	**9.24**	**Strongly Agree**	

Table 20

Flexibility Evaluation

Statement	**Mean**	**VI**	**SD**
The system can be adapted to different environments with configuration options available.	8.80	Strongly Agree	1.10
The system can scale to meet increased demand with mechanisms to support scalability.	9.40	Strongly Agree	0.55
The system is easy to install with clear and straightforward installation procedures.	10.00	Strongly Agree	0.00
The system can be easily replaced with another system with procedures for system replacement in place.	9.80	Strongly Agree	0.45
TOTAL MEAN	**9.50**	**Strongly Agree**	

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

As the system was fully developed and the evaluation process was completed, this chapter presents a summary of the key findings obtained in the study. The conclusions were drawn based on the results of the system evaluation, and generated shelter location allocation. Furthermore, this chapter provides recommendations for future researchers and developers.

Summary of Findings

As the Philippines ranks at the top of the World Risk Index as of 2024, and with Calumpit, Bulacan identified as highly vulnerable to typhoons and floods, researchers developed a system to assist LGUs in disaster response planning. The Shelter Location-Allocation System was created to find the optimal assignment of communities to shelters. It adopts the Bilevel No Transfer Model, which considers distance, cost, capacity, and the hierarchy of evacuation centers. Additionally, the model was solved using a genetic algorithm, which is also integrated into the system.

With the help of the LGU of Calumpit, the necessary data for simulation was gathered and processed using the system. The following features are highlighted in the developed Shelter Location-Allocation System:

1. Data Modification: Allows users to create, read, update, and delete input community and shelter data.
2. Model Modification: Allows users to update or edit model parameters for both the Bilevel No Transfer (BNT) model and genetic algorithm.
3. Data Simulation: Solves and generates optimal shelter location-allocation results based on given data and model parameters using genetic algorithm.
4. Shelter Tagging: Filters shelters based on their resistance and status data.

5. Report Protection: Secures and protects generated reports with password protection.

The system generated an optimal shelter location-allocation for the municipality of Calumpit after 200,000 generations with a time run of 73 minutes. Five shelters were opened to be used as an evacuation center:

1. Doña Damiana Elem School opened as level 1 accommodates barangay Calizon, Frances, Gatbuca, Meysulao, and San Miguel.

2. Mun. Covered Court opened as level 2 accommodates barangay Bulusan, Corazon, Panducot, Poblacion, Santa Lucia, and Sucol

3. NV9 Multi-Purpose opened as level 1 accommodates barangay Balungao, Meyto, San Jose, Santo Niño, and Sapang Bayan

4. San Marcos Elem. Sch. opened as level 1 accommodates barangay Caniogan, Palimbang, and San Marcos

5. San Marcos National H.S. opened as level 1 accommodates barangay Balite, Baguiomn, Calumpang, Gugo, Iba Este, Iba O'Este, Longos, Pio Cruzcosa, Pungo, and Sergio Bayan.

The system was evaluated by 23 respondents from the MSWDO and MDRRMO of Calumpit, representing the intended end-users of the system to assess the acceptability of the system towards their job. Additionally, 5 IT experts were surveyed to assess the system's functionality, usability, and overall quality. Based on their responses, the following findings were gathered:

1. The end-user respondents overall strongly agreed that the system demonstrates a high level of acceptability based on the Technology Acceptance Model (TAM). The evaluation resulted in the following scores: perceived usefulness – 9.4, perceived ease of use – 9.47, attitude towards using – 9.48, and behavioral intention – 9.41. All criteria were interpreted as "Strongly Agree", with low variability in responses.

2. IT Experts overall strongly agrees as well that the system demonstrates a high level of acceptability based on the ISO/IEC 25010. The evaluation resulted in the following scores: functional suitability – 9.8, performance efficiency – 9.67, compatibility – 9, interaction capability – 9.33, reliability – 9.6, security – 9.32, maintainability – 9.24, and flexibility – 9.5. All criteria were interpreted as "Strongly Agree", with low variability in responses.

3. According to the comments and suggestions from the evaluation forms, IT experts praise the system's functionality, reliability, and interface, while suggesting improvements such as mobile app development, more elaborate data processing, model configurability and better data protection. Meanwhile, feedback from LGUs suggest the need for better lot identification and better accessibility and usability features.

Conclusion

Based on the aforementioned summaries, the following conclusions can be derived:

1. The Shelter Location-Allocation System was designed and implemented for the Municipality of Calumpit, Bulacan, to assist decision-makers in optimally assigning and selecting shelters as evacuation centers for communities. The system was developed as a desktop app using Python programming language with the Qt framework, integrating the BNT model and genetic algorithm for optimization computations. It features comprehensive functionalities such as Data Modification, Model Modification, Data Simulation, Shelter Tagging, and Report Protection, all contributing to an effective and quality decision support system for disaster response planning.

2. The generated shelter location-allocation for Calumpit opens only five shelters, with one required to be a level 2 shelter. This suggests that upgrading an existing shelter is more optimal than opening an additional

one. It also indicates that other built shelters may remain closed to minimize maintenance costs. Additionally, no empty lots were selected, which may imply that constructing a new shelter is not yet necessary. However, it is important to note that actual affected population and cost considerations may differ based on the decision maker's assessments. The system allows users to adjust data and model parameters as needed.

3. The system got high scores in system evaluation from end-users ranging from 9.4 to 9.48, which is interpreted as "Highly Acceptable". This suggests that they are likely to adopt and use the system to support their work in disaster response planning.

4. The system got high scores in system evaluation from end-users ranging from 9 to 9.8, which is interpreted as "Highly Acceptable". This suggests that the system developed met the international standards for a software product.

Recommendations

Several areas for improvement have been identified to further enhance and expand this study, providing valuable insights for future researchers and developers. Implementing the following recommendations can refine the study's methodology, improve the system's effectiveness, and ensure its adaptability to evolving disaster response needs:

1. To improve the efficiency of shelter planning, the addition of other shelter location-allocation models may also be explored. Alongside with the BNT model, the Single-level with Workplace Distance Inclusion Model (WORK) can help optimize shelter placement by considering the proximity of workplaces. Additionally, using the Bilevel Non-Sequential Transfer Model (BNST) and Bilevel Sequential Transfer Model (BST) can show other insight and allow for comparisons between different shelter location models.

2. Enhancing data accuracy is important for an effective and efficient disaster response and shelter allocation. The addition of an integrated real-time data collection, geographic information system (GIS), and census based projections to improve the accuracy of population estimates. Additionally, incorporating historical disaster data and demographic trends can improve the shelter and resource allocation.

3. The system's effectiveness may be tested in different provinces and municipalities to evaluate its effectiveness in varying geographic and demographic conditions. Conducting pilot studies in other high risk disaster areas can provide valuable insights into necessary adjustments. Furthermore the integration of local government disaster plans and policies can help enhance the future systems.

4. An optimized way to function seamlessly across different devices such as desktops, tablets, and mobile phones as well as expanding support to other operating systems like macOS and Linux would enhance accessibility.

REFERENCES

Cabanilla, K. I. M., Enriquez, E. A. T., Mendoza, R., & Mendoza, V. M. P. (2021). Optimal selection of covid-19 vaccination sites in the philippines at the municipal level. https://doi.org/10.1101/2021.06.20.21259194

Cavdur, F., & Sebatli, A. (2019). A decision support tool for allocating temporary-disaster-response facilities. *Decision Support Systems*, *127*. https://doi.org/10.1016/j.dss.2019.113145

Construction of multipurpose building at brgy. frances, calumpit, bulacan. (n.d.). https://dpwh.gov.ph/dpwh/sites/default/files/webform/civil_works/advertisement/25cc0240_plan-construction_of_multi-purpose_building_at_brgy._francescalumpit_bulacan-c_2-storey300_square_meters.pdf

Davis, F. D. (1987). User acceptance of information systems : The technology acceptance model (tam). *Man-Machine Studies*, *1993*, 475–487. https://www.researchgate.net/publication/30838394_User_acceptance_of_information_systems_the_technology_acceptance_model_TAM

Eladia, C. P., Legaspi, J. J. B., Navarro, M. U., & Tanig, T. D. (2024). Eye on ai: Investigating the intention to use and acceptance of generative artificial intelligence in bulacan state university. *Educational Administration Theory and Practice journal*, *30*. 10.53555/kuey.v30i8.6458

Flebus, C. G. (1941). Air raid shelters. *The Military Engineer*, *33*, 37–42. https://www-jstor-org.dclibrary.idm.oclc.org/stable/44555538?seq=1

Galvan, E., & Stapleton, F. (2020). Semantic based distance approaches in multi-objective genetic programming. *2020 IEEE Symposium Series on Computational Intelligence*, 149–156. doi.org/10.1109/SSCI47803.2020.9308386

Gozum, I. (2023). Hope never sinks in flooded bulacan. *Rappler*. https://www.rappler.com/philippines/luzon/hope-never-sinks-in-flooded-bulacan/

Improvement/rehabilitation of evacuation center in brgy sta. rita. (2019). https://t-subaybayan.dilg.gov.ph/projects/37493

Iuchi, K., Jibiki, Y., Solidum, R., & Santiago, R. (2019). Natural hazards governance in the philippines. http://dx.doi.org/10.1093/acrefore/9780199389407.013.233

Jayathilaka, C. (2020). Agile methodology. https://medium.com/@chathmini96/agile-methodology-30ec4cdf3fc

List of locally funded projects. (2022). https://www.dilg.gov.ph/PDF_File/reportorial/dilg-reportorial-2022712_2b19cd0795.pdf

Lomer, A. R. B., Rezaeian, M., Rezaei, H., Lorestani, A., Mijani, N., Mahdad, M., Raeisi, A., & Arsanjani, J. J. (2023). Optimizing emergency shelter selection in earthquakes using a risk-driven large group decision-making support system. *Sustainability*, *15*. https://doi.org/10.3390/su15054019

Ma, Y., Xu, W., Qin, L., & Zhao, X. (2019). Site selection models in natural disaster shelters: A review. *Sustainability*, *11*. https://doi.org/10.3390/su11020399

Maghawry, A., Hodhod, R., Omar, Y., & Kholief, M. (2020). An approach for optimizing multi-objective problems using hybrid genetic algorithms. *Soft Computing*, *25*, 389–405. https://doi.org/10.1007/s00500-020-05149-3

Mananghaya, J. (2009). Ondoy' leaves 95 dead; 247,555 affected by floods. *philstar Global*. https://www.philstar.com/headlines/2009/09/28/508947/ondoy-leaves-95-dead-247555-affected-floods

Manongas, L. M. C. G. (n.d.). *Emergency shelter selection models with modification on transferability and evacuation distance minimization*.

Mathew, T. (2012). Genetic algorithm. https://datajobstest.com/data-science-repo/Genetic-Algorithm-Guide-[Tom-Mathew].pdf

Miyaji, M., Okazaki, K., & Ochiai, C. (2020). A study on the use of cyclone shelters in bangladesh. *Japan Architectural Review*, *3*, 4. 10.1002/2475-8876.12177

Opdyke, A., Bodo, D. D., & Smyth, J. (2024). Higher ground or into harm's way? household storm surge sheltering and evacuation plans. *International Journal of Disaster Risk Reduction*, *106*. https://doi.org/10.1016/j.ijdrr.2024.104452

Pereira, J. C., & de F.S.M. Russo, R. (2018). Design thinking integrated in agile software development: A systematic literature review. *Procedia Computer Science*, *138*, 775–782. https://doi.org/10.1016/j.procs.2018.10.101

Region iii - central luzon : Evacuation facility in sta. rita. (2017). https://t-subaybayan.dilg.gov.ph/projects/20357

Reyes-Estrope, C. (2021). Heavy rainfall submerge 35 bulacan villages in floodwater.

Shakibamaesh, A. (2015). Public shelters: Towards secure urban planning and designing in terms of passive defense. *GEOGRAFIA Online*, *11*, 01–Sep. https://journalarticle.ukm.my/9219/1/1x.geografia-mac15-amir-bi-edam.pdf

Systems and software engineering — systems and software quality requirements and evaluation (square) — product quality model. (2023). *International Organization for Standardization and International Electoral Commission*. https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-2:v1:en

Wang, Y., & Xu, Z. (2022). A multi-objective location decision making model for emergency shelters giving priority to subjective evaluation of residents. *INTERNATIONAL JOURNAL OF COMPUTERS COMMUNICATIONS & CONTROL*, *17*. https://doi.org/10.15837/ijccc.2022.4.4749

Wirsansky, E. (2020). Hands-on genetic algorithms with python: Applying genetic algorithms to solve real-world deep learning and artificial intelligence problems, 346. https://books.google.com.ph/books?hl=en&lr=&id=A0vODwAAQBAJ&oi=fnd&pg=PP1&dq=Python+programming+language+as+an+efficient+language+for+genetic+algorithm&ots=

FGEJG99oB5&sig=sGwtWbd0S7KEQNki1uSQBtsPSHc&redir_esc=y#v=onepage&q&f=false

Yin, Y., Zhao, X., & Lv, W. (2023). Emergency shelter allocation planning technology for large-scale evacuation based on quantum genetic algorithm. *Front. Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.1098675

Zhao, X., Coates, G., & Xu, W. (2019). A hierarchical mathematical model of the earthquake shelter location-allocation problem solved using an interleaved mpso–ga. *Geomatics, Natural Hazards and Risk*, *10*, 1712–1737. https://doi.org/10.1080/19475705.2019.1609605

APPENDICES

APPENDIX A

SYSTEM FLOW CHART

Figure A.1

Genetic Algorithm

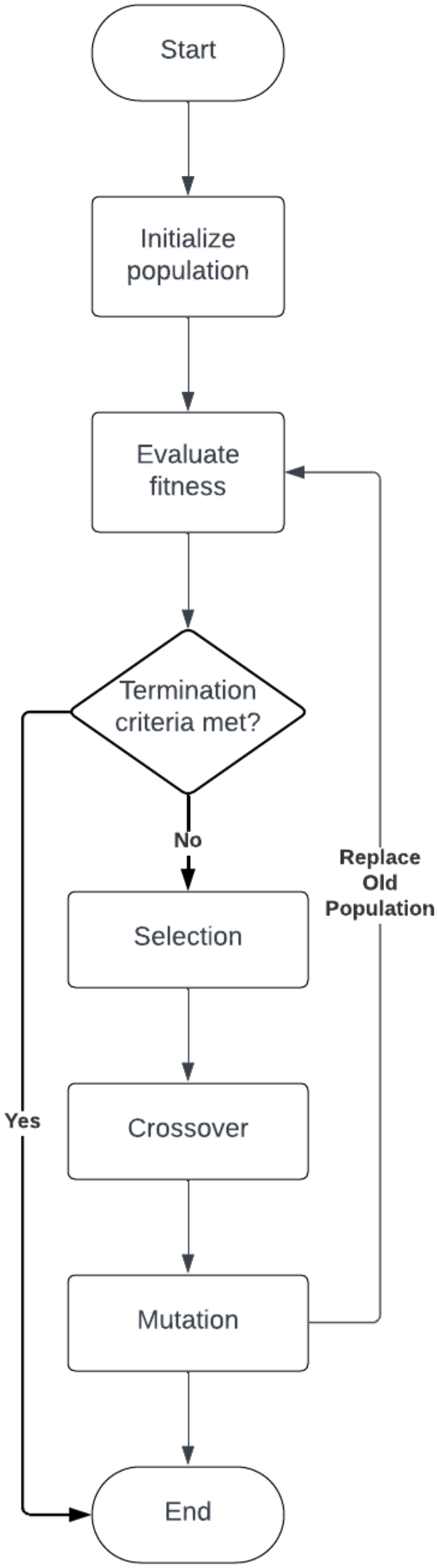


Figure A.2

Genetic Algorithm - Selection

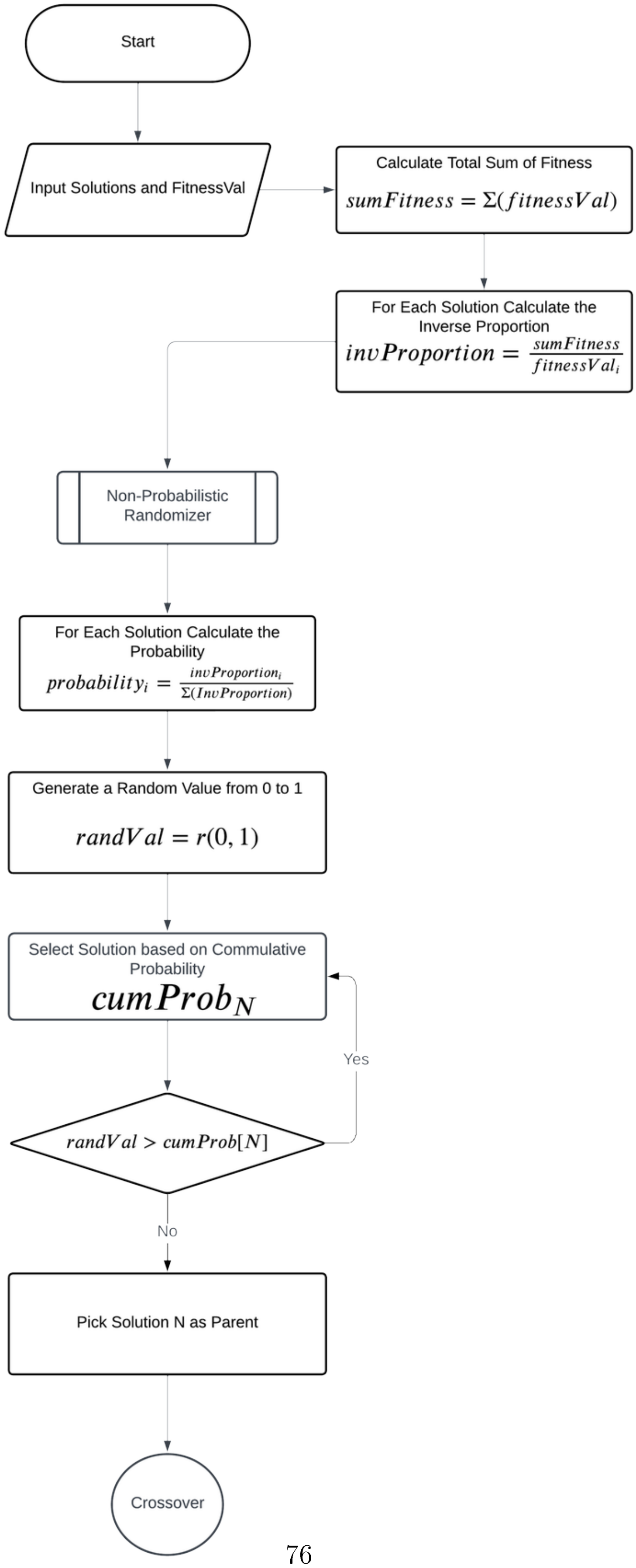


Figure A.3

Genetic Algorithm - Crossover

Figure A.4

Genetic Algorithm - Mutation

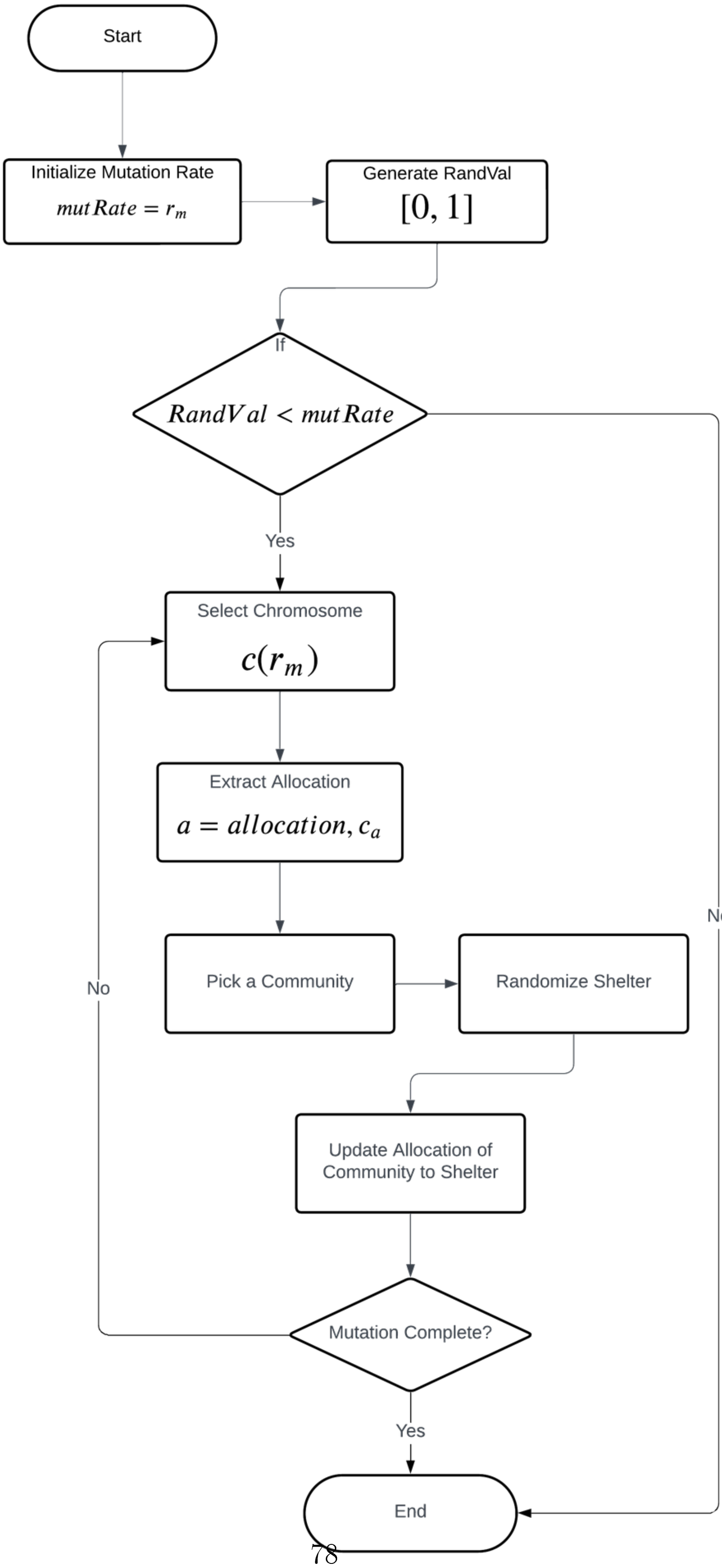


Figure A.5

Data Modification Feature

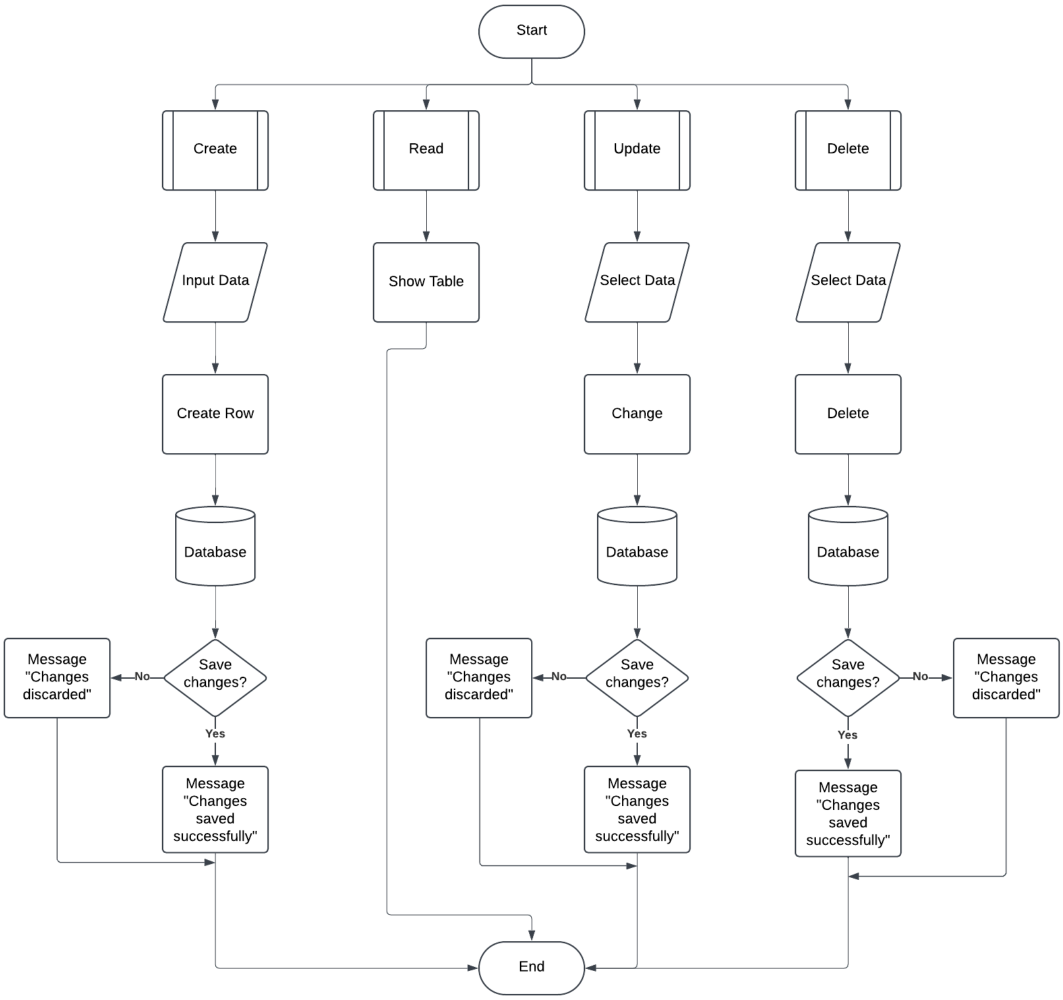


Figure A.6

Model Modification Feature

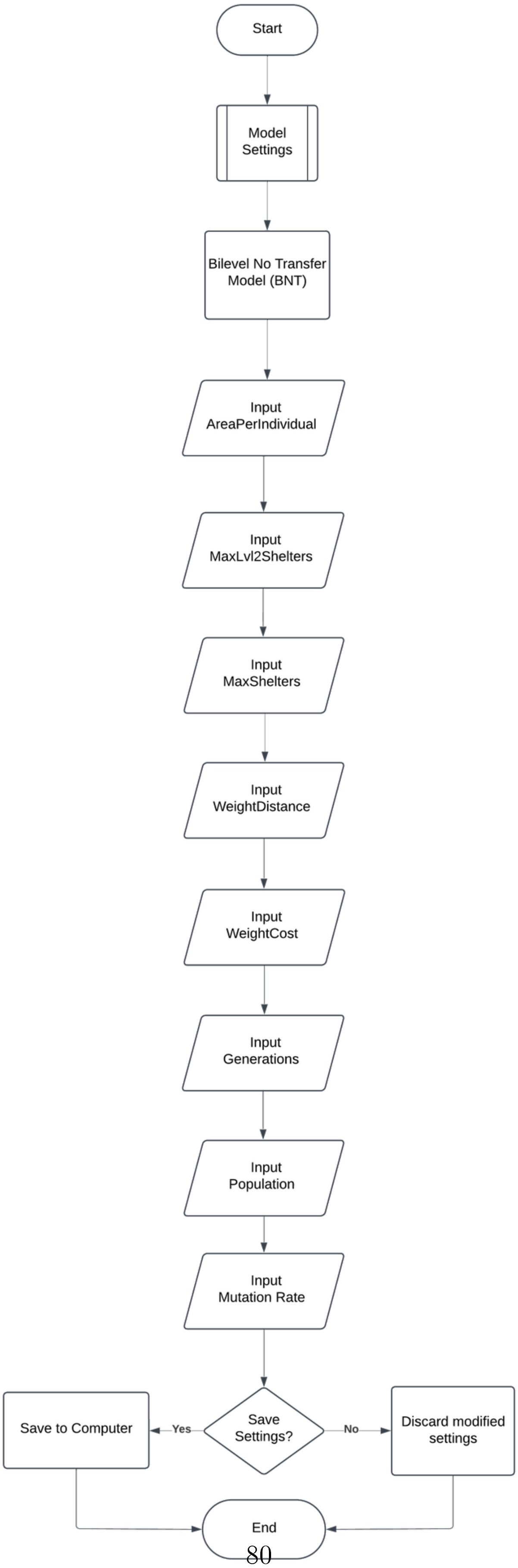


Figure A.7

Data Simulation Feature

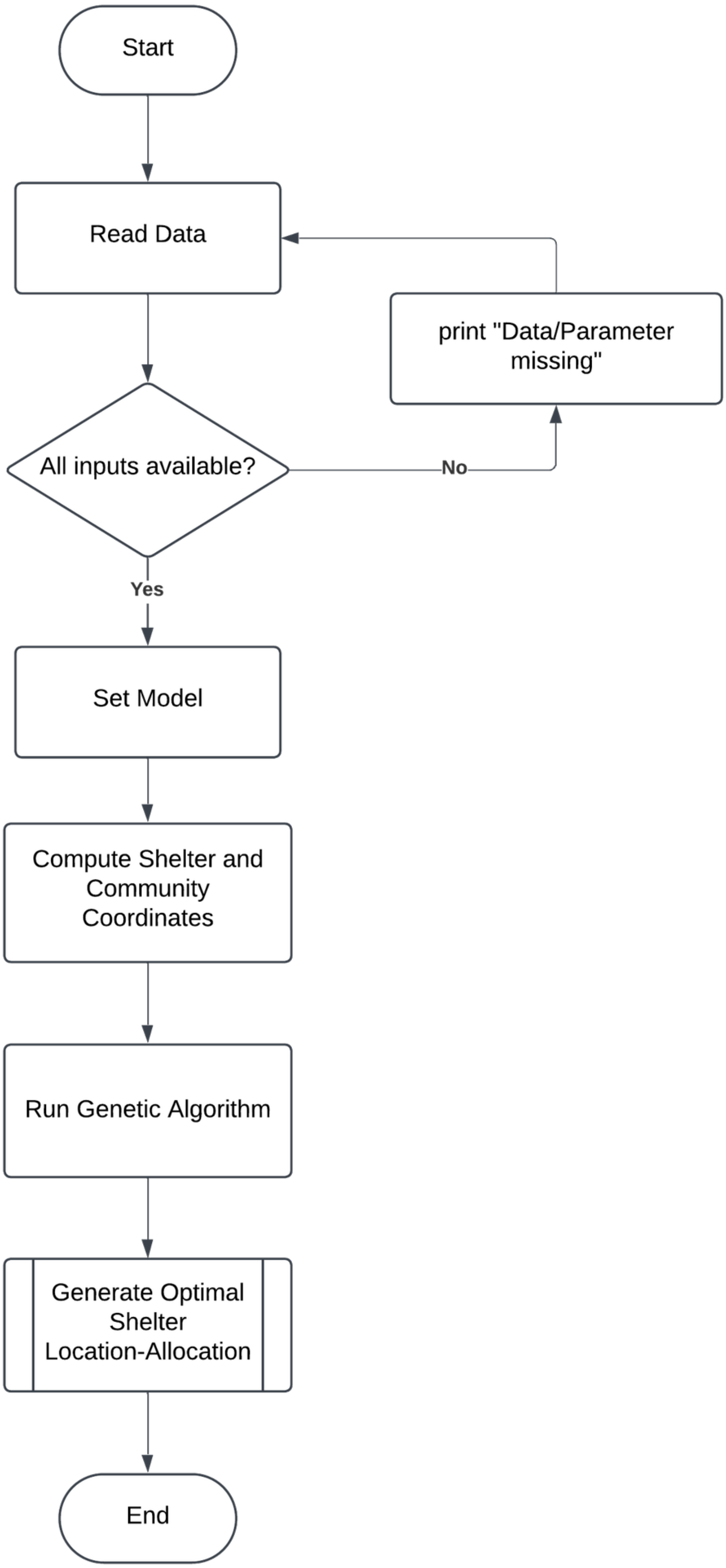


Figure A.8

Shelter Tagging Feature

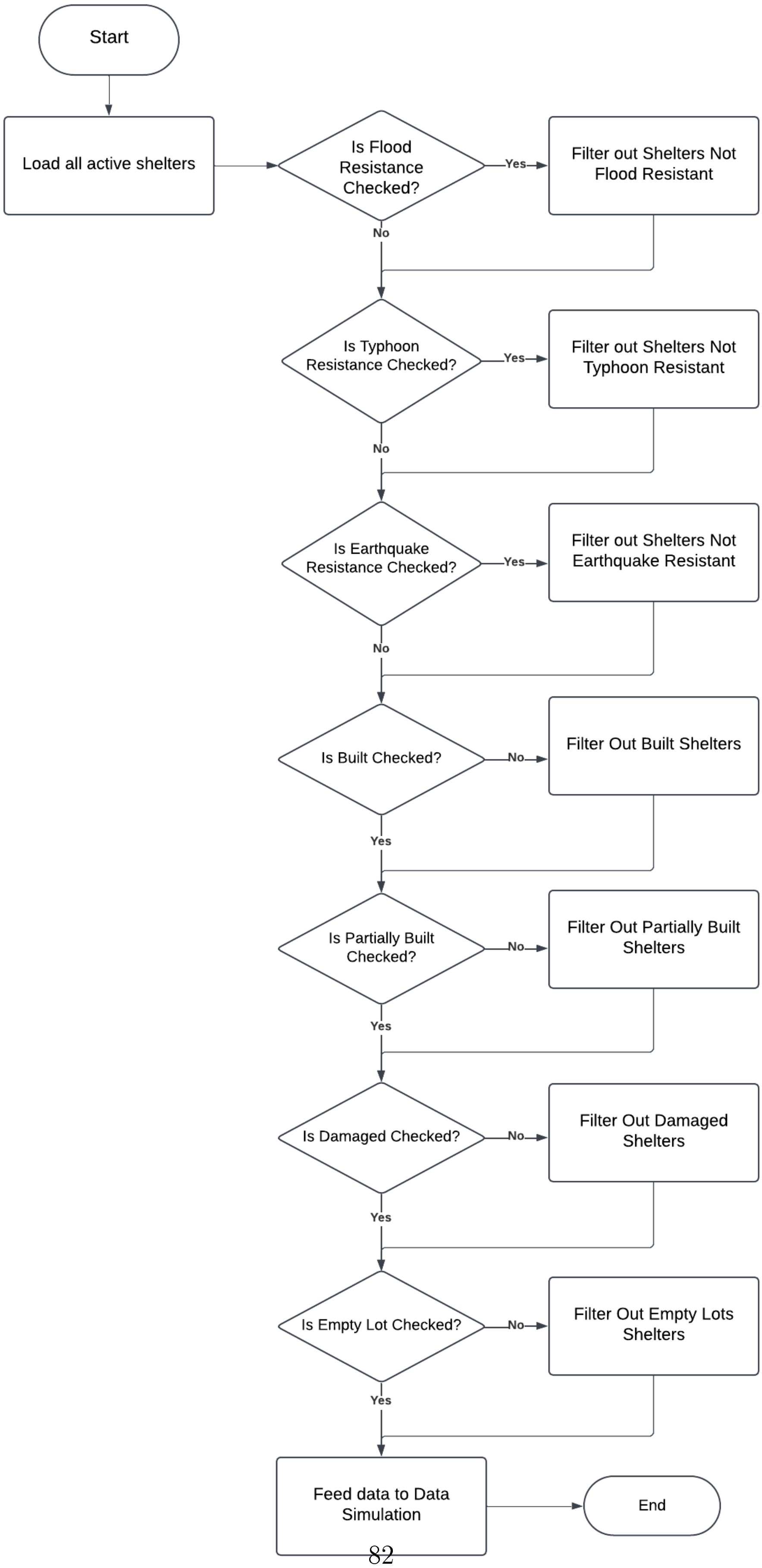
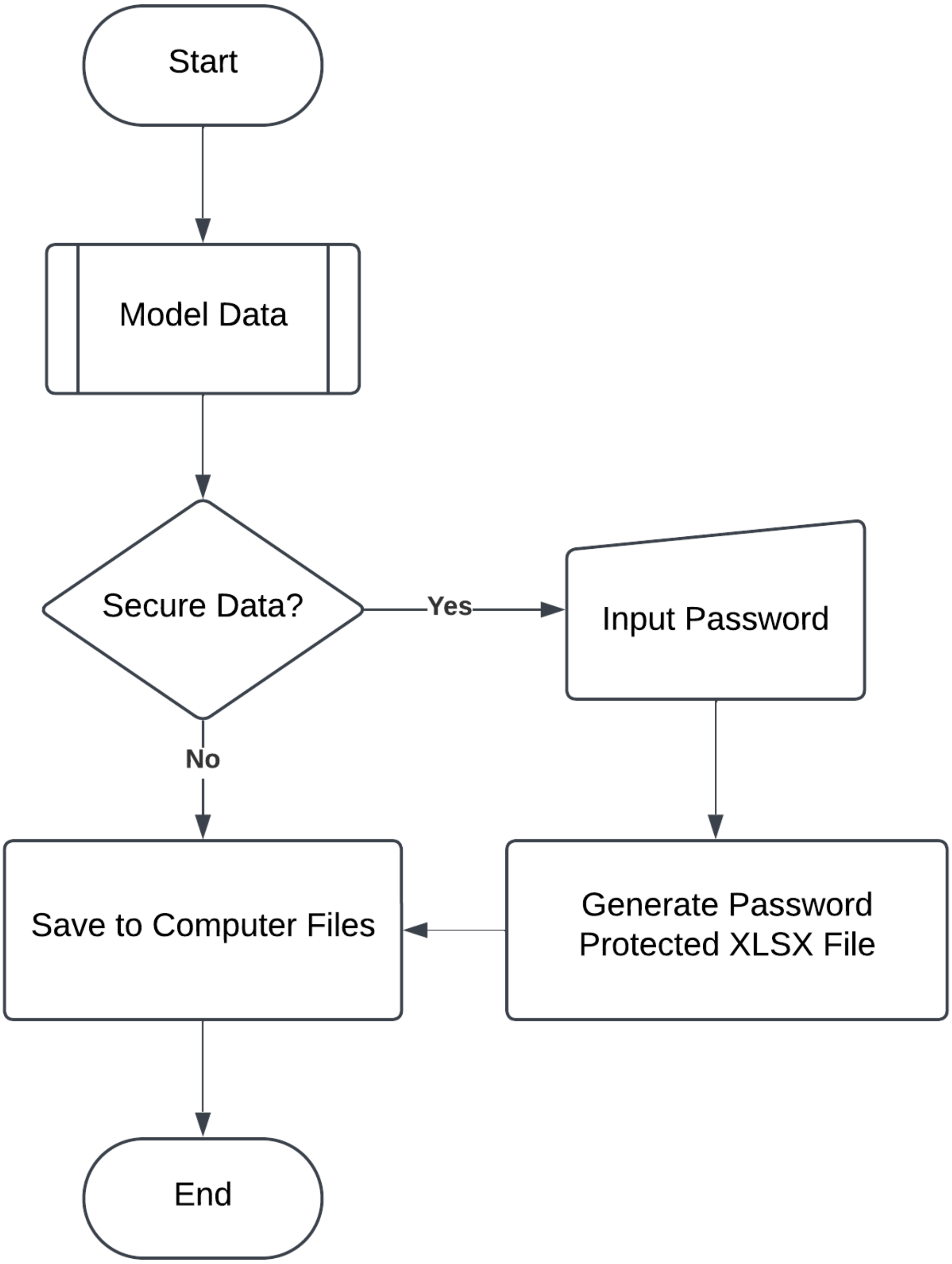


Figure A.9

Report Protection Feature



APPENDIX B

RELEVANT CODES

Figure B.10

Genetic Algorithm

```
generation_last_updated = 0

for _ in range(num_solutions):
    solution = spawn()
    solutions.append(solution)

# generations
for generation in range(num_generations):
    # check for cancellation
    if self.cancelled:
        self.progress_dialog("Genetic algorithm cancelled.")
        return

    # sorting from best to worst solutions
    ranked_solutions = [(fitness(sol), sol) for sol in solutions]
    ranked_solutions.sort(key=lambda x: x[0])

    # initiate selection and crossover
    new_population = []
    for i in range(num_solutions):
        mother = selectParent(ranked_solutions)[1]
        father = selectParent(ranked_solutions)[1]
        offspring = generate_offspring(mother, father)
        new_population.append(offspring)

    # initiate mutation
    mutated_population = []
    for solution in new_population:
        if random.random() < mutation_rate:
            solution = mutate(solution)
        mutated_population.append((fitness(solution),solution))

    # getting the top half solutions
    best_solutions = mutated_population + ranked_solutions
    best_solutions = sorted(best_solutions, key=lambda x: x[0])[:num_solutions]

    if (generation+1) % 100 == 0 :
        self.progress_dialog(str(best_solutions[0]))
        print(best_solutions[0])
        self.progress_dialog(f"=== Gen {generation+1} best solution ===")

    prev_best_solution = fitness(solutions[0])
    # replace old population
    solutions = [sol[1] for sol in best_solutions]
    new_best_solution = fitness(solutions[0])
    #update generation_last_updated
    if(prev_best_solution != new_best_solution):
        generation_last_updated = generation+1
```

Figure B.11

Genetic Algorithm - Selection

```python
def selectParent(solutions):
    sum_fitness = sum(fitness for fitness, _ in solutions)
    inv_proportions = [sum_fitness/ fitness for fitness, _ in solutions]
    sum_inv_proportions = sum(inv_proportions)
    probability = [inv_proportion / sum_inv_proportions for inv_proportion in inv_proportions]
    solution_indices = np.arange(len(solutions))

    selected_solution = np.random.choice(solution_indices, p=probability)

    return solutions[selected_solution]
```

Figure B.12

Genetic Algorithm - Crossover

```python
def generate_offspring(parent1, parent2):
    offspring = {"initial":{},"shelterlvl":{}}
    for community in Community:
        #for initial
        shelters = {parent1["initial"][community["name"]], parent2["initial"][community["name"]]}

        if shelters:
            chosen_shelter = random.choice(list(shelters))
        else:
            chosen_shelter = random.choice([shelter["name"] for shelter in Shelters])

        offspring["initial"][community["name"]] = chosen_shelter

    for shelter in Shelters:

        #for shelterlvl
        levels = {parent1["shelterlvl"][shelter["name"]], parent2["shelterlvl"][shelter["name"]]}

        if shelters:
            chosen_lvl = random.choice(list(levels))
        else:
            chosen_lvl = random.choice([1,2])

        offspring["shelterlvl"][shelter["name"]] = chosen_lvl

    return offspring
```

Figure B.13

Genetic Algorithm - Mutation

```python
def mutate(allocation):
    new_allocations = copy.deepcopy(allocation)

    for _ in range(mutation_iteration) :
        key_rand = random.choice(list(allocation.keys()))
        gene_to_mutate = random.choice(list(allocation[key_rand].keys()))
        current_value = allocation[key_rand][gene_to_mutate]

        if key_rand == "initial" or key_rand == "transferred":
            available_choices = [shelter["name"] for shelter in Shelters if shelter["name"] != current_value]
        elif key_rand == "shelterlvl":
            available_choices = [1,2]
            available_choices.remove(current_value)

        if available_choices:
            new_value = random.choice(available_choices)
            new_allocations[key_rand][gene_to_mutate] = new_value

    return new_allocations
```

Figure B.14

Objective Value

```python
def fitness(allocation):

    initial_shelters = set(allocation['initial'].values())
    Shelters_dict = {shelter["name"]: shelter for shelter in Shelters}

    total_distance = 0
    total_cost = 0

    for community in Community:
        # add distance * population
        shelter_name = allocation["initial"][community["name"]]
        distance = community["distances"][shelter_name]
        total_distance += distance * community["population"]


    for shelter_name in initial_shelters:
        # add cost based on shelter level
        shelter = Shelters_dict.get(shelter_name)
        if (allocation["shelterlvl"][shelter_name] == 1):
            total_cost += shelter["cost1"]
        elif (allocation["shelterlvl"][shelter_name] == 2):
            total_cost += shelter["cost2"]
        else:
            print("Shelter exceeded 2 levels. Something is wrong")

    # the actual model
    objective_value = weight_dist * total_distance + weight_cost * total_cost
    penalty_value = penalty_constant * getPenaltySum(allocation)

    # handle division by zero
    if objective_value + penalty_value == 0:
        return 1

    return int(objective_value + penalty_value)
```

Figure B.15

Maximum Distance Constraint

```python
def check_max_distance(allocation):

    penalty = 0

    for community in Community:
        shelter_name = allocation["initial"][community["name"]]
        distance = community["distances"][shelter_name]
        max_distance_community = community["maxdistance"]
        # check if distance is greater than max dist
        if (distance > max_distance_community):
            print("maximum distance constraint failed")
            penalty += distance - max_distance_community

    return penalty
```

Figure B.16

Capacity Constraint

```python
def check_initial_capacity(allocation):
    shelter_areas = {shelter["name"]: shelter[f"area{allocation["shelterlvl"][shelter['name']]}"] for shelter in Shelters}
    used_area = {shelter["name"]: 0 for shelter in Shelters}

    penalty = 0

    for community in Community:
        shelter_name = allocation["initial"][community["name"]]
        if shelter_name:
            # add to used_area based on population
            required_area = community["population"] * area_per_individual
            used_area[shelter_name] += required_area

            if used_area[shelter_name] > shelter_areas[shelter_name]:
                print("initial capacity constraint failed")

    for shelter in Shelters:
        shelter_name = shelter["name"]
        penalty_value = used_area[shelter_name] - shelter_areas[shelter_name]
        penalty += max(0,penalty_value)

    return penalty
```

Figure B.17

Maximum Shelter Constraint

```python
def check_max_shelters(allocation):
    used_shelters = set()
    penalty = 0

    for community in Community:
        shelter_name = allocation["initial"][community["name"]]
        used_shelters.add(shelter_name)

    # If the number of unique shelters exceeds the max allowed
    if len(used_shelters) > max_shelters:
        print("max shelters constraint failed")
        penalty += len(used_shelters) - max_shelters

    return penalty
```

Figure B.18

Maximum Level 2 Shelter Constraint

```python
def check_max_lvl2_shelters(allocation):

    lvl2_shelters_ctr = sum(1 for level in allocation["shelterlvl"].values() if level == 2)
    penalty = 0

    if lvl2_shelters_ctr > max_lvl2_shelters:
        print("max lvl2 shelters constraint failed")
        penalty += lvl2_shelters_ctr - max_lvl2_shelters

    return penalty
```

APPENDIX C

LETTERS

February 19, 2025

Hon. Glorime M. Faustino
Mayor
Municipality of Calumpit, Bulacan

Dear Mayor Faustino,

Good day! We are writing to formally request a meeting with the Municipal Disaster Risk Reduction Management Office (MDRRMO) to present a project that aims to enhance disaster preparedness and optimize shelter location-allocation in some areas in Calumpit. We would also like to request your participation in our survey in the evaluation of our system.

As you may be aware, the Philippines was ranked as the most disaster-prone country in the World Risk Index 2024. It faces a wide range of natural disasters annually since it is located within the typhoon belt and the "Pacific Ring of Fire". Some areas in Bulacan are particularly vulnerable to typhoons and floods. Thus, efficient shelter allocation is crucial in such areas, as it directly affects the safety and well-being of the population during disasters.

In extension of this ongoing project, my research team and I developed a system that utilizes genetic algorithm to optimize shelter allocation based on factors such as accessibility, cost-efficiency, and community proximity. This decision-support tool aims to provide the local government units of Bulacan with data-driven solutions to improve their disaster preparedness and response strategies.

The primary objective of the proposed meeting is to present this project and seek the support of the provincial government for its completion. Since the system was completed, we would be grateful for you to participate and provide valuable feedback to assess the system quality by showing the demo of the system and asking you to fill up a survey. We might need to have at least **16 participants** for this system and if possible, we would like to hold the meeting itself either on **February 26 or 27, 2025**.

Your support will be instrumental in the successful implementation of this project, which seeks to benefit not only the local government and its disaster response mechanisms but also the citizens of Calumpit.

We would greatly appreciate your consideration of this request and look forward to discussing how this project can enhance disaster management in Calumpit. Please let us know your availability for the proposed meeting at your earliest convenience.

Thank you for your time and attention. We look forward to your favorable response.

Respectfully yours,

VALENTINE BLEZ L. LAMPAYAN, Ph.D.
Chair, Mathematics Department

February 19, 2025

Hon. Glorime M. Faustino
Mayor
Municipality of Calumpit, Bulacan

Dear Mayor Faustino,

Good day! We are writing to formally request a meeting with the Municipal Social Welfare Development Office (MSWDO) to present a project that aims to enhance disaster preparedness and optimize shelter location-allocation in some areas in Calumpit. We would also like to request your participation in our survey in the evaluation of our system.

As you may be aware, the Philippines was ranked as the most disaster-prone country in the World Risk Index 2024. It faces a wide range of natural disasters annually since it is located within the typhoon belt and the "Pacific Ring of Fire". Some areas in Bulacan are particularly vulnerable to typhoons and floods. Thus, efficient shelter allocation is crucial in such areas, as it directly affects the safety and well-being of the population during disasters.

In extension of this ongoing project, my research team and I developed a system that utilizes genetic algorithm to optimize shelter allocation based on factors such as accessibility, cost-efficiency, and community proximity. This decision-support tool aims to provide the local government units of Bulacan with data-driven solutions to improve their disaster preparedness and response strategies.

The primary objective of the proposed meeting is to present this project and seek the support of the provincial government for its completion. Since the system was completed, we would be grateful for you to participate and provide valuable feedback to assess the system quality by showing the demo of the system and asking you to fill up a survey. We might need to have at least **8 participants** for this system and if possible, we would like to hold the meeting itself either on **February 26 or 27, 2025**.

Your support will be instrumental in the successful implementation of this project, which seeks to benefit not only the local government and its disaster response mechanisms but also the citizens of Calumpit.

We would greatly appreciate your consideration of this request and look forward to discussing how this project can enhance disaster management in Calumpit. Please let us know your availability for the proposed meeting at your earliest convenience.

Thank you for your time and attention. We look forward to your favorable response.

Respectfully yours,

VALENTINE BLEZ L. LAMPAYAN, Ph.D.
Chair, Mathematics Department

2 December 2024,

Jayson Victoriano, DIT
Faculty, College of Information and Communication Technology
Bulacan State University

Dear Dr. Victoriano,

Greetings!

Our senior BS Mathematics students with a specialization in Computer Science are currently engaged in their Undergraduate Thesis, which aims to develop their technical skills by applying various mathematical concepts and/or programming languages and systems tools applications. Their research projects typically involve either a mathematical exposition applying mathematical concepts in model formulation, finding solutions to real-life problems, or developing a programmed system to address these problems. As a requirement for the course, they ought to complete their thesis proposal (Chapters 1 – 3) before the end of the first semester of the current school year.

In this regard, we would be honored if you could join us as one of the panel evaluators for the thesis titled

Design and Implementation of a Shelter Location-Allocation System in Calumpit, Bulacan

The group is composed of the following researchers:

Bryan Jett T. Calulo,

Elijah Iñigo C. Fabian,

Lovely Angeline OL. Cunanan

and the proposal defense is scheduled to take place on

December 10, 2024, 8:15AM at the **CS Conference Room.**

As a panel evaluator, your responsibilities will include:

1. Reviewing the thesis proposal document.
2. Providing constructive feedback and suggestions to the students.
3. Evaluating the feasibility and academic rigor of the proposed research.
4. Assessing the students' presentation and defense of their proposal.

Your expertise and insights would be invaluable to the students and greatly contribute to the quality of their research. We sincerely hope that you will consider this request favorably.

Please let us know at your earliest convenience if you are able to accept this invitation.

Thank you for your time and consideration.

Sincerely,

Harris R. Dela Cruz
Thesis Instructor

I have read the responsibilities and expectations outlined and

☑ I agreed to serve as a panel evaluator for this group.

☐ I declined to serve as a panel evaluator for this group.

____
Signature over Printed Name

Date: ___________________

2 December 2024,

Aarhus M. Dela Cruz
Faculty, College of Science
Bulacan State University

Dear Mr. Dela Cruz,

Greetings!

Our senior BS Mathematics students with a specialization in Computer Science are currently engaged in their Undergraduate Thesis, which aims to develop their technical skills by applying various mathematical concepts and/or programming languages and systems tools applications. Their research projects typically involve either a mathematical exposition applying mathematical concepts in model formulation, finding solutions to real-life problems, or developing a programmed system to address these problems. As a requirement for the course, they ought to complete their thesis proposal (Chapters 1 – 3) before the end of the first semester of the current school year.

In this regard, we would be honored if you could join us as one of the panel evaluators for the thesis titled

Design and Implementation of a Shelter Location-Allocation System in Calumpit, Bulacan

The group is composed of the following researchers:

Bryan Jett T. Calulo,

Elijah Iñigo C. Fabian,

Lovely Angeline OL. Cunanan

and the proposal defense is scheduled to take place on

December 10, 2024, 8:15AM at the **CS Conference Room.**

As a panel evaluator, your responsibilities will include:

1. Reviewing the thesis proposal document.
2. Providing constructive feedback and suggestions to the students.
3. Evaluating the feasibility and academic rigor of the proposed research.
4. Assessing the students' presentation and defense of their proposal.

Your expertise and insights would be invaluable to the students and greatly contribute to the quality of their research. We sincerely hope that you will consider this request favorably.

Please let us know at your earliest convenience if you are able to accept this invitation.

Thank you for your time and consideration.

Sincerely,

Harris R. Dela Cruz
Thesis Instructor

I have read the responsibilities and expectations outlined and

- [x] I agreed to serve as a panel evaluator for this group.
- [ ] I declined to serve as a panel evaluator for this group.

Barlius M. Dela Cruz
Signature over Printed Name

Date: 12/02/2024

2 December 2024,

Arcel F. Galvez
Faculty, College of Science
Bulacan State University

Dear Mr. Galvez,

Greetings!

Our senior BS Mathematics students with a specialization in Computer Science are currently engaged in their Undergraduate Thesis, which aims to develop their technical skills by applying various mathematical concepts and/or programming languages and systems tools applications. Their research projects typically involve either a mathematical exposition applying mathematical concepts in model formulation, finding solutions to real-life problems, or developing a programmed system to address these problems. As a requirement for the course, they ought to complete their thesis proposal (Chapters 1 – 3) before the end of the first semester of the current school year.

In this regard, we would be honored if you could join us as one of the panel evaluators for the thesis titled

Design and Implementation of a Shelter Location-Allocation System in Calumpit, Bulacan

The group is composed of the following researchers:

Bryan Jett T. Calulo,

Elijah Iñigo C. Fabian,

Lovely Angeline OL. Cunanan

and the proposal defense is scheduled to take place on

December 10, 2024, 8:15AM at the **CS Conference Room.**

As a panel evaluator, your responsibilities will include:

1. Reviewing the thesis proposal document.
2. Providing constructive feedback and suggestions to the students.
3. Evaluating the feasibility and academic rigor of the proposed research.
4. Assessing the students' presentation and defense of their proposal.

Your expertise and insights would be invaluable to the students and greatly contribute to the quality of their research. We sincerely hope that you will consider this request favorably.

Please let us know at your earliest convenience if you are able to accept this invitation.

Thank you for your time and consideration.

Sincerely,

Harris R. Dela Cruz
Thesis Instructor

I have read the responsibilities and expectations outlined and

- [x] I agreed to serve as a panel evaluator for this group.
- [ ] I declined to serve as a panel evaluator for this group.

ARCEL F. GALVEZ
Signature over Printed Name

Date: 6 December 2024

APPENDIX D

QUESTIONNAIRES

Shelter Location-Allocation System Evaluation Survey

Name: ___________________________________

Designation: ______________________________ Office/Department: ____________________

Field of Expertise: __________________________ Years of Experience: ___________________

Instruction : Please pick a score below with the following statements about the Shelter Location-Allocation System.

strongly disagree	1	2	3	4	5	6	7	8	9	10	strongly agree

Functional Suitability	Score (1-10)
1. The system provides all the required functions without any missing functionalities.	
2. The functions are implemented correctly without any errors.	
3. The functions are appropriate for the tasks and meet user needs effectively.	
Performance Efficiency	
1. The system responds within acceptable time limits and maintains consistent response time under different conditions.	
2. The resource usage is within acceptable limits and the system efficiently uses available resources.	
3. The system can handle the expected load and is scalable to accommodate future growth.	
Compatibility	
1. The system can coexist with other systems without conflict and has no compatibility issues.	
2. The system can interact with other systems as required and data exchange between systems is seamless.	
Interaction Capability	
1. The purpose of the system is easily recognizable and the functions are easy to understand.	
2. The system is easy to learn for new users and there are adequate training materials available.	

3. The system is easy to operate with intuitive and user-friendly controls.	
4. The system protects users from making errors and provides clear and helpful error messages.	
5. The user interface is aesthetically pleasing with a consistent and professional design.	
6. The system is accessible to users with disabilities and includes features to support accessibility.	
Reliability	
1. The system is mature and stable with no frequent crashes or failures.	
2. The system is available when needed with no downtime issues.	
3. The system can tolerate faults and continue operating with mechanisms for fault detection and recovery.	
4. The system can recover from failures quickly with backup and recovery procedures in place.	
Security	
1. The system ensures the confidentiality of data with measures to protect sensitive information.	
2. The system ensures the integrity of data with mechanisms to prevent data corruption.	
3. The system can verify the identity of users and actions are traceable to specific users.	
4. The system provides accountability for actions with maintained logs and audit trails.	
5. The system verifies the authenticity of data and users with measures to prevent unauthorized access.	
Maintainability	
1. The system is modular and easy to modify with well-defined and independent components.	
2. The system components can be reused in other contexts with reusable libraries or modules.	
3. The system is easy to analyze for defects with tools to support analysis.	

4. The system is easy to modify and update with documented and manageable changes.	
5. The system is easy to test with automated testing tools available.	
Flexibility	
1. The system can be adapted to different environments with configuration options available.	
2. The system can scale to meet increased demand with mechanisms to support scalability.	
3. The system is easy to install with clear and straightforward installation procedures.	
4. The system can be easily replaced with another system with procedures for system replacement in place.	

What do you consider to be the ***main strength*** of the system?

What do you consider to be the ***main weakness*** or areas for improvement in the system?

Do you have any specific **suggestions** for improving the system? Please provide any additional comments or suggestions for improvement:

Data Privacy and Signature Agreement

We ensure that all responses will be treated in absolute confidentiality in accordance with the Data Privacy Act of 2012. Your signature is solely required to ensure that your responses are unique and to prevent duplicate entries. By signing below, you acknowledge your participation in this survey.

Signature over Printed Name: ______________________________ Date:________________

Shelter Location-Allocation System Evaluation Survey

Name(Optional): ___________________________ Office/Department: _____________________

Instruction : Please pick a score below with the following statements about the Shelter Location-Allocation System.

strongly disagree	1	2	3	4	5	6	7	8	9	10	strongly agree

Perceived Usefulness	Score (1-10)
1. Using the system improves my performance in completing tasks such as planning shelter locations for disaster response.	
2. The system helps me accomplish choosing shelter locations and assigning communities more quickly.	
3. The system increases my productivity.	
4. The system enhances my effectiveness in completing tasks such as in disaster strategic planning.	
5. Overall, I find the system useful in my job.	
Perceived Ease of Use	
1. Learning to operate the system is easy for me.	
2. The system is easy to use.	
3. My interaction with the system is clear and understandable.	
4. I find it easy to become skillful at using the system.	
5. I find the system easy to operate.	
Attitude Towards Using the System	
1. I have a positive attitude towards using the system.	
2. I enjoy using the system.	
3. I am satisfied with using the system.	

Behavioral Intention to Use	
1. I intend to use the system regularly.	
2. I will continue to use the system in the future.	
3. I would recommend the system to others.	

Do you have any **comments or suggestions** for improving the system? Please provide any additional comments or suggestions for improvement:

Data Privacy and Signature Agreement

We ensure that all responses will be treated in absolute confidentiality in accordance with the Data Privacy Act of 2012. Your signature is solely required to ensure that your responses are unique and to prevent duplicate entries. By signing below, you acknowledge your participation in this survey.

Signature over Printed Name: ______________________________ Date:________________

CURRICULUM VITAE

Bryan Jett T. Calulo

BS Mathematics graduate

bryanjettcalulo@gmail.com 0915-112-0027

github.com/Lucianono Meycauayan, Bulacan, 3020

Dedicated and analytical Computer Science major with a strong foundation in Mathematics. Skilled in programming languages, and software development tools. Highly adept at leveraging mathematical thinking to solve complex problems and deliver efficient software solutions.

Education

Bulacan State University - College of Science (2021 - 2025)
Bachelor of Science in Mathematics with Specialization in Computer Science

- President's Lister
- Finalist - UP Stat-is-eeks
- Finalist - Math Wizards
- Top 8 - UPLB Code Wars
- Class Mayor BSM-CS 4A
- CS Band Keyboardist
- CS Band Marketing Lead
- DOST JLSS Scholar

Experiences

Reysan Photography Services | Graphic Designer & Operator

- Contributed to the family business specializing in photography and printing services, such as designing photographic layouts, and operating technical aspects of services.

Direc Business Technologies Inc | Research & Development Intern

- Developed and finished web application featuring inventory and employee management, and IoT programming.

Projects

Maia: Posture, Break, Reminder App

- Developed a mobile app to using Android Studio, published the app on Amazon Appstore, and monetized with Google AdSense

Modeling and Detecting SMS Fraud in the Philippines using Machine Learning Research

- Conducted research on AI and mathematical modeling to detect SMS fraud, highlighting Filipino language messages, using Google Colab, with the model achieving a 99% accuracy score
- Recommended for local publication conference with the assistance of our research instructor

An Equal Share (Hating Kapatid): Scale-themed GMTK Game Jam 2024 entry

- Planned and developed a game in 3 days from scratch which ranked top 25% overall among 7500 entries.

Skills

Programming Languages: C/C++ • Java • C# • Python • HTML/CSS • JavaScript • PHP • MySQL • MATLAB
Development Frameworks: ASP.NET • PySide/PyQt • Express.js
Software Development Tools: Git/GitHub • Unity • Visual Studio • VS Code • Android Studio
Soft Skills: Team Work • Leadership • Adaptability • Arts & Design • Problem Solving

Lovely Angeline OL. Cunanan

BS Mathematics graduate
angelcunanan15@gmail.com   0926-364-3246
github.com/captainpandamonkey5   Malolos, Bulacan, 3000

Highly motivated computer science major seeking a position to leverage technical, mathematical expertise, and passion for building innovative applications. Adept at front-end and back-end technologies, commited to delivering high-quality, user friendly solutions. Eager to collaborate with cross-functional teams and contribute to project success while continuously expanding skillset.

Education

Bulacan State University - College of Science (2021 - 2025)
Bachelor of Science in Mathematics with Specialization in Computer Science

- 1st Year: 1.760, 1.880
- 2nd Year: 2.125, 2.103
- 3rd Year: 1.725, 1.594

Experiences

Highly Succeed Inc. | Backend Developer

- Maintained backend components of web applications using Laravel, REST APIs, Bitbucket and Postman.
- Assisted cross-functional teams including IT Sales and the Unleash Department
- Collaborated with team members in debugging Laravel-based applications.
- Contributed to the Features Library by documenting project workflows and processes under the guidance and the head web developer, improving documentation clarity for future interns.
- Completed Project Management Training

Projects

AJC Bike Shop Point of Sale Website (Team Project)

- Collaborated with a team to develop core functionalities using HTML5, CSS3, JavaScript, MySQL, and PHP to enable data storage, retrieval, and processing.
- Developed the customer database with user roles, security protocols, and permissions, and the documentation of the AJC Bike Shop: Development of an Automated Data Management System.
- Assisted in designing the UI/UX for an intuitive user experience, improving overall usability.

Skills

Programming Languages: HTML5 • CSS3 • JavaScript • Python • MySQL
Development Frameworks: React • Bootstrap • PHP • TailwindCSS • Laravel • PySide6 • PyQT
Software Development Tools: Git • Github • Bitbucket • Gitkraken • npm • Postman • VS Code • QT Designer
Soft Skills: Team Work • Time Management • Adaptability • Creativity • Continuous Learning • Problem Solving
Interest: Cryptocurrency Investing and Trading • Reading Self Help and Fantasy Books

Elijah Iñigo C. Fabian

BS Mathematics graduate

elijahinigofabian0704@gmail.com 0936-760-8022
github.com/Edelweiss-eli Malolos, Bulacan, 3000

A Computer Science major that is equipped with strong problem-solving skills and a solid foundation in programming. Experienced in handling diverse programming projects, with a keen ability to apply analytical thinking to develop efficient solutions.

Education

Bulacan State University - College of Science (2021 - 2025)
Bachelor of Science in Mathematics with Specialization in Computer Science

GWA:
3rd year: 1.375
2nd year: 1.698, 1.760
1st year: 1.54, 1.64

Experiences

City Municipality of Malolos | Councilor Aide

- Contributed to the office mainly with data evaluation, manning the front desk, and editor of public materials and general graphic designer.
- Designed calling cards and trophy plaques, as well as operating technical aspects in the office.

Class Treasurer | 4th Year College

- Nominated for the fourth year of college, operating the finances of the room and communicating with merchandise collaborations.

Projects

MediEvaluate: A Medical Article, Generic Medicine Checker App

- Developed a mobile app using Python and Kivy, commissioned for a capstone project to be published.

ACTIVATED CARBON FROM POLYSTYRENE (C8H8) AS CARBON DIOXIDE FILTER

- Conducted research on the use of activated carbon derived from polystyrene or styrofoam as a filter for carbon dioxide.

Skills

Programming Languages: C/C++ • Java • Python • HTML/CSS • JavaScript • Kotlin • Swift • MATLAB
Development Frameworks: Express.js • PySide/PyQT • Kivy
Software Development Tools: Git/Github • VS Code • Ubuntu • Unity • GitKraken • Qt Designer
Soft Skills: Adaptability • Graphic Design • Problem Solving • Teamwork • Communication Skills