UNIVERSITI TEKNOLOGI MARA

EGOVERNMENT FRAMEWORK FOR BUDGETING USING FUZZY RULES

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SUPERVISOR APPROVAL

EGOVERNMENT FRAMEWORK FOR BUDGETING USING FUZZY RULES

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ABSTRACT

Nowadays, the current performance-based budget system facing struggles due to uncertainty in determining aid eligibility for various socioeconomic backgrounds that cause to inaccurate budget assessments and misuse of funds. This study proposes a fuzzy rule-based budgeting framework that integrates the Analytic Hierarchy Process (AHP) and the Mamdani Fuzzy Rule-Based System to address this problem. This research effort is motivated by the need of improve efficiency and transparency in distributing public assistance programs such as Budi MADANI and Sumbangan Tunai Rahmah (STR). This framework goals to improve the accuracy, fairness and reliability of aid distribution in uncertain conditions. The objectives are to identify suitable algorithms, develop an integrated framework and evaluate the effectiveness in accessing the eligibility of aid recipients. This study employs synthetic data by using the data from the Department of Statistics Malaysia (DOSM) for simulation that used for focuses on financial assistance in eGovernment Malaysia, covering indicators, socioeconomic factors, eligibility assessment and fund allocation. For ensure transparency and equitable decisions, this framework developed using PHP and MySQL that can offering a robust framework for complex budget structures and serving as a decision support tool for government agencies. After carrying out the development process, the results showed that the combination of fuzzy rules and AHP was effective in resolving data ambiguity and providing transparent application decisions to applicants based on mathematics. Therefore, it successfully achieved the study objective where this project offers a prototype that serves as an important decision support tool for government agencies in the distribution of assistance by determining the eligibility of applications. This finding leads to a significant reduction in administrative overhead, minimizing subjective bias and increasing accountability in the eGovernment framework. This research also can contribute to the public sector financial management and pave the way for more equitable resource allocation.

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LIST OF SYMBOLS

Symbols

A	Fuzzy set
$\mu_A(x)$	The Membership Function represent the degree of membership to determine x in Set A
l	Lower limit value (minimum possible value)
m	Modal value
u	Upper limit value (maximum possible value)
$\widetilde{J_l}$	Fuzzy geometric mean equation of criterion i
$\widetilde{f_{1_n}}$	Fuzzy value in pairwise comparison of criteria element
$\widetilde{w_l}$	Fuzzy weights equation
$\widetilde{w_l}^{norm}$	Normalization fuzzy weights equation
$\sum_{i=1}^{n} w_i$	Total sum of defuzzified weights

LIST OF ABBREVIATIONS

Abbreviations

PHP	Hypertext Processor
DOSM	Department of Statistics Malaysia
STR	Sumbangan Tunai Rahmah
AHP	Analytical Hierarchical Process
AI	Artificial Intelligent
PBB	Performance Based-Budgeting
GPA	Grade Point Average
ERD	Entity Relationship Diagram
OKU	Orang Kurang Upaya (Persons with Disabilities)
SDLC	Software Development Life Cycle
SQL	Structured Query Language
COA	Center of Area
LHDN	Lembaga Hasil Dalam Negeri (Inland Revenue Board)
TFN	Triangular Fuzzy Number

CHAPTER 1
INTRODUCTION

1.1 Research Background

Nowadays, the Malaysian government places great emphasis on efficiency and transparency in the distribution of public assistance, especially programs involving financial assistance and subsidies such as the Sumbangan Tunai Rahmah (STR) and Budi MADANI. In general, Malaysia practices performance-based budgeting, which is a budgeting system that aims to use to allocate funds that have been allocated by focusing on needs centrally.

However, the performance-based budgeting system leads to uncertainty in the context of distributing assistance to citizens based on the eligibility of applications and assessing priorities from diverse socio-economic backgrounds across the country. Not only that, according to Fernandez-Cortez et al. (2020), budget allocation based on public policy presents a variety of challenges for governments and occasionally, specific budgetary items are distributed according to law, custom, or even partisanship.

With the emergence of Artificial Intelligence (AI) after the operation of eGovernment with the integration of Information and Communication Technology (ICT) into government operations, there is a need to develop a good framework to support fairer and more transparent decision-making, especially in the context of aid distribution. And one of the appropriate approaches to be used in determining the eligibility of aid distribution is the integration of a fuzzy rule framework in the eGovernment budget system.

Fuzzy rules are a principle developed by Zadeh (1965) through fuzzy set theory that uses a binary approach with a range between 0 and 1 for each preposition to deal with uncertainty or ambiguity. This method is seen to be able to support the decision to distribute aid to those who are eligible based on what has been allocated in the budget which is seen as complex and uncertain. In fuzzy rules, it can increase transparency and ensure fairness in the allocation of financial aid by taking into

account factors such as income, household size, employment status, geographical location and aid history for existing aid applicants.

1.2 Problem Statement

Despite government efforts to modernize the budgeting planning system through digitalization, the aid distribution mechanism in eGovernment has not yet shown efficiency in determining eligibility based on what is requested by the people. This is because the existing eGovernment system is difficult to make accurate decisions in situations involving vague or uncertain data such as unstable income, family size and also the level of need required by the applicant. According to Hatami-Marbini et al. (2022), the absence of a conceptual model to assess the budgeting system and assist policymakers and decision-makers in making better informed decisions. This shows that the existing framework is not designed to handle ambiguous and complex socio-economic conditions which make it unable to handle real-life scenarios of incomplete applicant data in the eligibility determination process.

Most existing budgeting models are uncertain in nature where they are seen to fail to address the eligibility of government assistance made by applicants who are seen as vague that can be adjusted to real data due to several factors including income size. This can also lead to the problem of incomplete budget evaluation where minor or large changes are required if the budget does not follow policy or if actual spending exceeds predictions (Khoo et al., 2024). Not only that, according to Mohd Shakil et al. (2023), some people may try to abuse financial assistance programs by making false claims or other crimes, which can make some people uncomfortable approaching the government for applying government assistance.

Existing research focuses more on the technical aspects of budget management in general but places less emphasis on the development of a framework for government aid distribution in eGovernment that addresses the problem of information uncertainty and various decisions in the context of government aid distribution. It can refer to the failure of fuzzy logic to determine uncertainty and vagueness when determining a performance-based budgeting system's maturity level (Hatami-Marbini et al., 2022). This can have an impact on people's trust in the use of e-Government according to

(Shayganmehr et al., 2023) , the primary shortcoming identified in earlier research is the lack of a thorough methodology to assess broader facets of e-Gov trust. Therefore, there is a critical need to develop a fuzzy rules-based budgeting framework by using Mmadani's Fuzzy Rules Based System integrate with Analytical Hierarchical Process (AHP) in eGovernment in government aid distribution with the aim of improving the accuracy, fairness and reliability of aid distribution mechanisms in uncertain conditions.

1.3 Research Objectives

a) To identify the suitable algorithms for the determination of the eligibility of aid recipients.

b) To develop the application of fuzzy rules framework by using Analytical Hierarchical Process (AHP) techniques for the eligibility of applicants for aid in eGovernment.

c) To evaluate the effectiveness of the algorithms in application of the eligibility of aid recipients.

1.4 Research Question

i) What is the most appropriate algorithm for determining an applicant's eligibility for government assistance based on their socio-economic and demographic indicators?

ii) How can a fuzzy rule framework integrate with Analytical Hierarchy Process (AHP) techniques be designed and developed to assess the eligibility of applicants for assistance in the eGovernment system?

iii) How effective is the proposed algorithm in accurately determining the eligibility of aid recipients when used in a fuzzy rules-based eGovernment framework?

1.5 Research Scope

This research focuses on the development of a fuzzy rules-based budgeting framework that will be adapted to the distribution of financial assistance in the Malaysian eGovernment system where it covers several aspects such as indicators, socio-economic, eligibility assessment and decision-making on allocation of funds. This can only focus on the use of the public sector, especially the welfare programs of the federal governments such as Sumbangan Tunai Rahmah (STR).

The data that will be used in this research is obtained from public data such as DOSM as references sets such as population statistics, income where dataset will be used as synthetic data for simulation use. The project to be used is PHP and MySQL to design and simulate the proposed framework by referencing to the Sumbangan Tunai Rahmah. To publish the results of the group assistance eligibility, it will be implemented by creating a special website to publish the eligibility results only using PHP. Due to time constraints and data availability, the research will not include large-scale deployment or real-time government integration but will simulate scenarios based on existing welfare structures such as Sumbangan Tunai Rahmah (STR) and Budi MADANI.

1.6 Research Significance

This study will help the field of public sector financial management in the context of eGovernment by aiming to contribute to existing knowledge by introducing a new conceptual framework that uses fuzzy rules in dealing with problems related to complex and parallel structures in the budgeting system. Compared to traditional and current budgeting systems, which are always struggling with uncertainty, with fuzzy rules, it can solve it by integrating it more dynamically and transparently.

From a theoretical point of view, this study will contribute to the improvement of the literature in computational intelligence, government resource allocation and decision support systems where it can address critical research gaps by combining fuzzy rules with structural performance assessment in the budgeting system. This

combination also offers new perspectives for researchers in developing intelligent budgeting assessment tools for more complex government systems.

From a practical point of view, the proposed framework can offer a decision support tool for government agencies involved in government financial planning, especially in the field of aid distribution. The ability to model and evaluate budgeting performance under uncertainty can also help policymakers and government financial planners such as the Ministry of Finance in making more transparent and fair decisions. With this approach, this study can improve the efficiency and fairness in the distribution of public funds, especially involving citizens who depend on government assistance.

The findings of this research are also expected to benefit various stakeholders including government agencies, policymakers, financial analysts and the wider public administration sector. The use of this framework may support the transformation of the budgeting system in Malaysia to a more responsive process and transform technology in line with the country's digital transformation goals under eGovernment.

In summary, this study can address the urgent need in the domain of public financial management and introduce a stronger framework with the aim of improving the budgeting process. It also lays the foundation for future studies in integrating smart systems into public sector governance while at the same time encouraging innovation in the management of more complex financial data structures.

1.7 Summary

This chapter provided the background, problem statement, research questions, and objectives related to the eGovernment budgeting framework based on fuzzy rules in order to enhance the distribution of public assistance in Malaysia. It also highlighted how ineffective the current budgeting system is in handling uncertainty and complicated data formats. The goal of the study is to develop and assess a fuzzy logic-based method that improves resource allocation and decision-making. The study's importance and scope were also described, with a focus on how it advances both academic understanding and real-world government budgets. The literature that has

already been written about fuzzy logic, public budgeting, and decision support systems will be reviewed in the following chapter.

CHAPTER 2
LITERATURE REVIEW

In this chapter, a review of past studies related to the use of fuzzy rules framework in eGovernment for the aid distribution process. The focus of this chapter is to identify the approaches, algorithms and technologies used and how the proposed model can improve existing models.

2.1 Introduction

This chapter will present a comprehensive review of past studies that related to the application of fuzzy rules framework in eGovernment systems, especially for budgeting and aid distribution. The aim is to explore existing theories of fuzzy rules, models and practices by examining existing research gaps that can be addressed in the development of this study. Previous studies that have been reviewed have focused on the approaches, algorithms and technologies of fuzzy rules used and highlighted how the proposed model uses fuzzy rules that can enhance decision-making and improve existing models in the public sector. Furthermore, this chapter will also examine how fuzzy rules can be used to determine ambiguity and uncertainty which arise when the government has difficulty making decisions, especially in determining the eligibility of applicants in determining aid distribution.

2.2 Overview of eGovernment Budgeting System

2.2.1 eGovernment in Financial Management: Definition and Concept

eGovernment is a one-stop shop for citizens, businesses, and other governmental organizations to access national or local government services online or through other digital channels (Husin et al., 2017). It was also created to increase efficiency in the operation of government departments in line with current technology. In Malaysia, eGovernment was officially launched after the Multimedia Corridor (MMC) was launched in 1996 with the aim of building a strong ICT foundation and reimagining the government administration system (Yasin & Hamid, 2025) and among the eGovernment services used by the Malaysian government are Electronic Procurement

(e-procurement), E-Syariah, E-land and Human Resource Management Information System (HRMIS).

In the context of financial management, eGovernment plays an important role in ensuring that all government financial transactions are made transparent and at the same time increases positive cooperation between firms and agencies which leads to a reduction in corruption in government bureaucracy Fazli & Hamid (2010). This also makes the people accept the needs of eGovernment in financial management. Through the digitization of existing financial operations, eGovernment can enable the decision-making process to be made faster and streamline financial allocations more accurately.

2.2.2 Current Public Budgeting System Practices in Malaysia

Public budget systems around the world have undergone several changes over time with the aim of improving efficiency, transparency and accountability. According to Myers & Boothe (2018) , Finance Ministries around the world have adopted Performance Based Budgeting (PBB) where this budgeting system provides more realistic expectations based on evidence and also the logic of the program structure, which in this system offers a more transparent perspective than the traditional budget line items. It is also a link to the medium-term national policy for the annual budget process. This system has a positive impact on the government because it provides advantages in terms of offering rewards for delivering better public services.

However, in Malaysia, according to Myers & Boothe (2018), in the early 1990s, Malaysia introduced the Modified Budget System (MBS) which integrated the idea of giving more power to managers while creating an accountability structure that was centred on the determination of program outputs and measurable goals. This system ran for about 20 years before switching to Outcome Based Budgeting (OBB) following changes in national planning.

Outcome Based Budgeting (OBB) is an evolutionary stage in the implementation of Performance-Based Budgeting (PBB) in Malaysia where the system encompasses bottom-up budgeting and reporting after top-down strategic planning and alignment with the guidance of the national development plan for the next five years

which serves as the framework for the budget approach (Myers & Boothe, 2018). National strategy, ministry results, programme results, and activity results are some of the stages connected by OBB. Among the features of Outcome Based Budgeting (OBB) is that the national budget is more focused on outputs to outcomes, and budget activities are mapped to programs to improve accountability and transparency. In addition, funds allocated for operating and development expenditures can be reflected in the program budget.

2.2.3 Challenges of the Current eGovernment Budget System for Aid Distribution

Despite the digitalization of the budget system, the current eGovernment system in Malaysia faces problems in the context of aid distribution. According to Myers & Boothe (2018), the OBB has enhanced the Modified Budget System (MBS) by adding previously absent revenue data and training and capacity building for ministries and departments with the aim of helping them improve their program specifications, activities and performance indicators. This is because the MBS has been implemented in the government in a situation where performance deviates from the set range but these requirements are not always followed and reports often cover inappropriate topics. However, until January 2018, ministries are not required to report performance following the budget circular that requires ministries to report their performance indicators every quarter.

Throughout the implementation of the OBB, the Ministry of Finance has realized that there are several weaknesses faced by the OBB approach that can lead to lack of transparency and leakage and this automatically affects the distribution of aid, among which according to Myers & Boothe (2018), is that there is no mechanism to verify the quality of the data submitted. This is because there is uncertainty in determining the accuracy of the data which can lead to inaccurate selection of aid recipients, thus risking leakage and recipients not being eligible for the benefits. Secondly, there is no detailed mechanism in enforcement to ensure that ministries submit data when required. It creates delays and inconsistencies in the decision-making process in determining the eligibility of aid recipients. And finally, the volume of data generated can generate risks that could potentially burden government staff, leading to

ambiguity in findings. All of these issues stated can directly impact the effectiveness of aid distribution which should be accurate, fair and transparent.

2.3 Aid Distribution in Public Sector

The distribution of government assistance begins with the presentation of the budget announced by the Prime Minister based on the budget that has been approved in Parliament (Khoo et al., 2024). In the budget, it contains budget proposals from each ministry with the aim of achieving the country's economic goals and promoting the welfare of the people. After the announcement of government assistance announced by the Prime Minister has been approved by Parliament and has received the consent of the Yang di-Pertuan Agong, the implementation phase of the distribution of government assistance begins with careful monitoring to ensure that the allocated budget goals can be achieved (Khoo et al., 2024).

Then, the ministry responsible for the assistance will begin to advertise applications for government assistance through official government channels such as the ministry's official website and official social media. Among the government assistance provided by the government to the people are financial assistance, housing, healthcare and education where these aids are created as support for the needs of the people. This can help reduce the income gap of the people and reduce the risk of poverty for those facing extreme financial problems (Mohd Shakil et al., 2023).

Among the government assistance offered by the government are the Rahmah Cash Contribution (STR), Budi MADANI and the mySALAM Community Protection Scheme. To be eligible for government assistance, applicants must be Malaysian citizens, with the status of (Household/Senior/Single). To qualify, applicants need to declare their income and sometimes some government applications will automatically profile applicants through the income tax system managed by the Inland Revenue Board (IRB) or through the Employees Provident Fund (EPF) or SOCSO such as the Kindly Cash Contribution (STR).

To qualify for government assistance, applicants must be Malaysian citizens, have a job, status (Household/ Senior Citizen/ Single), health status and disability

status. For assistance registration, applicants can apply at the office of the government agency that manages assistance applications, make an application online and there are some government assistance applications made automatically using existing income data that has been registered under the management of the Inland Revenue Board (LHDN) or the Employees Provident Fund (EPF). Then, applicants need to submit supporting documents such as a copy of MyKad, a copy of income slip, marriage certificate, birth certificate, divorce certificate and health report. For those who do not have an income slip, they need to state their income in writing if they work informally and do not have an official salary slip (Abdul Nasir, 2021). To determine the eligibility of the application made by the applicant, the application will be reviewed by government officials to filter the applications sent by the applicant which takes a long time to process. Finally, after successfully filtering the application, the government agency that manages government assistance will notify the applicant of the status of the application via a website specifically for government assistance.

However, the existing conventional methods in determining eligibility for government assistance have several limitations, among which (Abdul Nasir, 2021) stated are the long time it takes to approve applications, the challenge of finding reliable applicant information, and the current applicant's condition not being in line with the eligibility criteria. For the approval of applications for government assistance, the time to approve them has become a major problem when the country is facing severe economic problems that have caused some people to apply for assistance for emergency reasons in addition to supporting their lives at a time of rising inflation. This is because reliance on manual verification and bureaucratic procedures according to existing regulations can cause delays in the distribution of assistance. In addition, the government faces the challenge of finding reliable applicant information because there are several cases where several government agencies rely on existing static databases such as those from the IRB or EPF which are seen to not reflect the current status of applicants, especially those who are unemployed, self-employed or working informally. Finally, the current condition of applicants is often not in line with the real-world socio-economic conditions of the applicant. For example, some individuals who are in dire need of assistance may be excluded due to not meeting strict technical requirements such as having an official income slip or a registered address. As a result

of these constraints, it can reduce flexibility and adaptability in the current framework and highlight the need for fairer decision-making mechanisms.

2.4 Fuzzy Logic and Fuzzy Rules in Decision-Making

Fuzzy Logic is an approach used in computer science to mimic the way humans make decisions based on vague or uncertain information. This approach is derived from fuzzy sets introduced by Zadeh in 1965. According to Zadeh (1965), fuzzy sets are a class of objects that use a range of membership grades where each object is given a value between zero and one. According to Sakharov (2024), through this logic, each atom with a constant argument has a truth value where the interval value (0,1) is fuzzy while 0 and 1 are clear truth values. However, separate atoms may have different truth values. This logic also introduces concepts such as "somewhat true", "somewhat true", "somewhat false" and so on which can be defined based on the "membership function" by allowing prepositions to accept a range of values in the interval value [0,1] (Hosseini & Montazer, 2024). This approach is very useful for applications of government aid distribution when applicant information is incomplete, and it is difficult to determine the eligibility of the applicant. Equation 2.1 shows the definition of a fuzzy set named A in a space X:

$$A = \{(x, \mu_A(x) : x \in X)\} \tag{2.1}$$

Fuzzy-Rule Based System (FRBS) are a set of "if-then" statements that form the basis of a fuzzy-based system. They are also rules that express human-understandable knowledge using linguistically fuzzy variables as antecedents and consequences (Varshney & Torra, 2023). This structure are using Linguistic variable and it was easy to understand by understanding how humans formulate rules based on experience and observation. It can be interpreted by humans and can be used to understand the operation of the system Varshney & Torra (2023). The equation 2.2 shows the preposition condition of fuzzy rules:

$$if\ x\ is\ A\ then\ y\ is\ B \tag{2.2}$$

In the context of making decisions in determining the eligibility of applicants for government assistance distribution, fuzzy logic is very functional in various branches such as risk management, environmental monitoring, health, and also education. This is because each input provided is no longer processed in black and white, but is instead given a level of membership in several categories holistically with the aim of enabling analysis of a decision to be made holistically. Among them is the study conducted by Mundzir et al. (2023) with the idea of innovating scholarship design using fuzzy logic. In his study, he focused on the use of fuzzy logic in the design of a student scholarship selection system by allowing the assessment of student eligibility to be done more fairly and comprehensively by combining fuzzy logic with the Analytics Hierarchy Process (AHP) method to assess student criteria such as academic achievement, parental income, number of family dependents and distance from home. The approach used in this system, the assessment used is based on membership in low, medium and high categories using fuzzy triangular membership functions or triangular membership functions. The following is the decision-making process in determining the government aid distribution eligibility by implement the study by Mundzir et al. (2023) in determining scholarship allocation:

1. Problem statement: Need to understand the core goal by ensuring equitable and inclusive provision and identify the complex variables by using applicant's eligibility.
2. Data collection: Collect data of applicant such as their details, salary and health conditions.
3. Fuzzification: A process where to determine fuzzy sets for each category.
4. Rule Based Creation: Determine IF-THEN rules based on expert judgement such as "IF SALARY ARE RM1500 AND HEALTH CONDITION ARE HEART ATTACK, THEN AID DISTRIBUTION ARE ACCEPT."
5. Inference Engine: In Fuzzy Rule Based System (FRBS), According to Varshney & Torra (2023), Mamdani's method serves as the basis for classical fuzzy systems where it is used to determine fuzzy values for input data using membership functions. It is used to match the rule with the provided value to make an evaluation of the firing strength of the rule

by using the min-max operation. Figure 2.1 shows the generic structure of Mamdani's method.

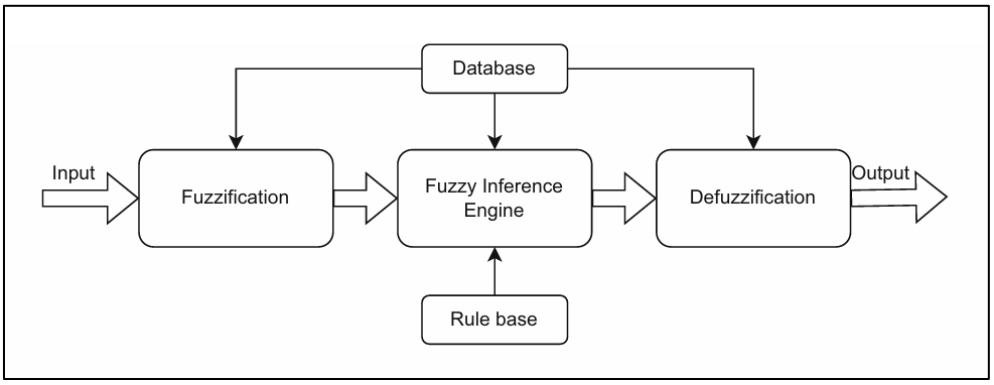


Figure 2.1 Generic structure of Mamdani's method. (Varshney & Torra, 2023)

6. Defuzzination: A process of creates a mapping from fuzzy values to the output domain with real values (Varshney & Torra, 2023).
7. Output Decision: The result will appear after the decion-making have been made.

2.5 Application of Fuzzy Logic in Eligibility Assessment of Aid Applicants

Fuzzy logic is now increasingly recognized as an effective method for dealing with ambiguity-related decision-making, especially in the public sector. In situations where input data is ambiguous, its capacity to mimic human thinking under ambiguity in determining eligibility for government assistance applications. For example, budgeting decision-making through a study conducted by Hatami-Marbini et al. (2022) where this study is measuring maturity levels of a performance based-budgeting system using fuzzy logic. In this study, fuzzy logic is applied to deal with subjective and ambiguous information that arises in the process of collecting indicators found in the Performance-Based Budgeting (PBB) system where it is used to develop and monitor public budget resources to improve management options based on the agency's actual performance metrics (Hatami-Marbini et al., 2022). This study was conducted in Iran with a focus on the extent to which government agencies implement the PBB framework. By incorporating fuzzy logic, the model can process subjective and fuzzy indicators such as guideline compliance, transparency and policy quality, all of which are difficult to measure, leading to agency performance that can be assessed in a more

nuanced way and capture partial degrees of success. The study conducted by Hatami-Marbini et al. (2022) illustrates that fuzzy logic is well suited in an environment where performance assessment relies on qualitative and quantitative data. It also supports strategic budget reforms by providing a more accurate picture of the maturity and readiness of government agencies.

For the context of resource allocation, fuzzy logic can also be used as in the study used by Hatami-Marbini et al. (2022) where it emphasizes the need to evaluate both financial and operational performance indicators in a two-tier parallel structure which reflects the real world budget system where different government agencies and departments operate simultaneously and interdependently. Not only that, fuzzy logic can also deal with uncertainty and ambiguity in input and output data in a complex system such as the budget. According to Hatami-Marbini et al. (2022), the internal parallel structure of the budget system with the presence of unknown input and output data, as well as the hierarchical configuration of each indicator and has not been examined by several previous studies, and it only focuses on resource allocation which is certainly significant. With this study, it has integrated fuzzy logic with Data Envelopment Analysis (DEA) by taking into account uncertain data and the configuration of hierarchical indicators such as the system established by Hatami-Marbini et al. (2022) for this study which is a CI model based on a multi-layer parallel network DEA with the aim of measuring the efficiency level of the Performance Based Budgeting (PBB) system with various components.

Among the main advantages of fuzzy logic is handling ambiguity and vagueness which often occurs in government decision-making. In a study conducted by Hatami-Marbini et al. (2022), it was proven by saying that Fuzzy set theory, created by Zadeh in 1965, is an effective technique in dealing with ambiguity or vagueness. This fuzzy logic is usually used using linguistic variables when involving incomplete human judgment Hatami-Marbini et al. (2022). Not only that, fuzzy logic also deals with uncertainty by allowing values to exist on a continuum where they represent degrees of truth rather than focusing on absolute values. This makes the system more systematic and inclusive and at the same time, it also leads to more reasonable decisions and in line with the complexity faced by aid recipients.

2.6 Integration of Fuzzy Rules and Analytical Hierarchy Process (AHP) in Decision-Making Systems

The integration of Analytical Hierarchical Process (AHP) and Fuzzy Rules Based Systems (FRBS) has demonstrated good efficacy in enhancing decision-making incorporating many criteria and uncertainties, particularly in domains including aid distribution, budgeting, and resource allocation. Fuzzy Rules Based Systems are frequently used to simulate human behaviour and problem-solving processes utilizing traditional IF THEN rules (Varshney & Torra, 2023). This makes the framework more tolerant when dealing with uncertainties in the real world.

For AHP, it is a method that formulates and examines complex problems using mathematical calculations by considering the relative importance of several factors Mahbub et al. (2021). This process also allows the decomposition of complex problems into a hierarchy of simple criteria that are then evaluated using pairwise comparisons. AHP is only involved in the comparison of alternatives and is a tool in solving uncertain and complex decision problems (Kahraman et al., 2003). Figure 2.2 shows how to perform AHP:

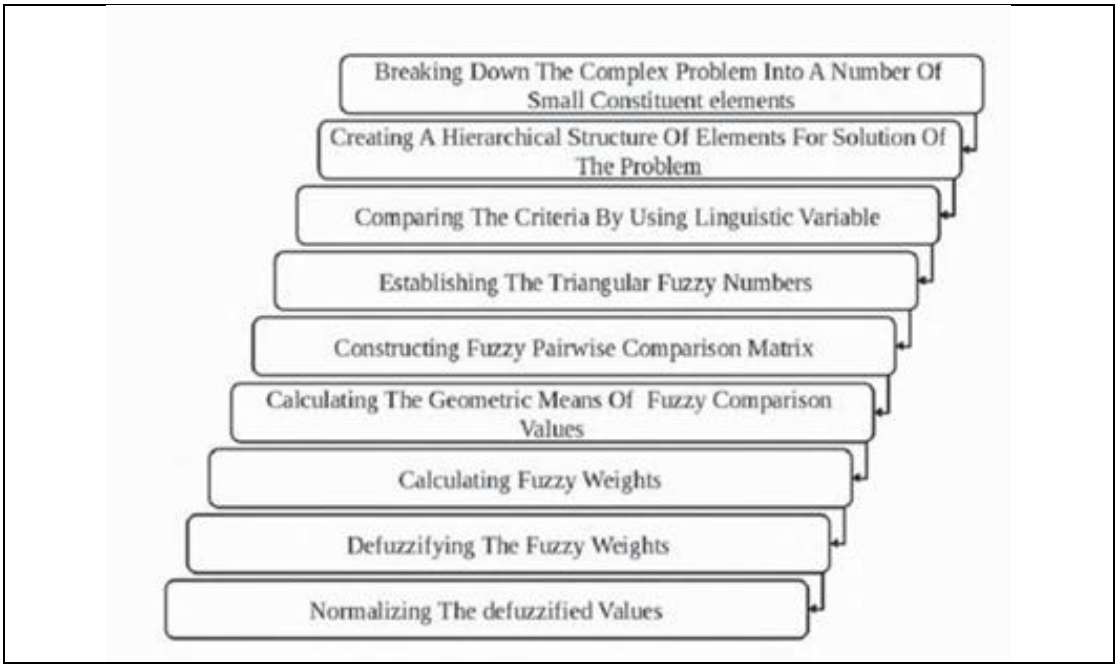


Figure 2.2 Steps To Perform AHP (Mahbub et al., 2021)

The effectiveness can be seen in the study conducted by Mundzir et al. (2023) in innovating the design of scholarship selection using fuzzy logic where the author introduces this approach by considering scholarship eligibility as a spectrum rather than the binary that is commonly used in traditional fuzzy methods. Secondly, users use a comprehensive fuzzy inference system as a methodology that is seen to be able to evaluate the diversity of scholarship applicant criteria with the aim of equality in the scholarship allocation process. With the integration of fuzzy rule and Analytical Hierarchical Process (AHP), it directly increases uncertainty in this matter by allowing a structured approach to further evaluate complex criteria such as GPA, parental income, number of dependents and distance. This can be proven in Table 2.1 which shows factors evaluated using a decision matrix based on scholarship eligibility.

Table 2.1
The Analysis Of Criteria Based On Factors Of Qualification

Alternatives	**Criteria**			
	GPA (C1)	**Income of parents (C2)**	**Number of dependents of parents (C3)**	**Distance (C4)**
A1	2.95	2,000,000	3	12
A2	3.40	1,100,000	5	25
A3	3.2	2,500,000	4	18
A4	2.90	4,200,000	5	27
A5	2.70	1,800,000	3	29
A6	3.55	2,300,000	2	5

Source: (Mundzir et al., 2023)

For the initial phase, decision support will follow fuzzy logic by assigning evaluations to the criteria based on the decision matrix based on the Table 2.2, Table 2.3, Table 2.4 and Table 2.5.

Table 2.2

GPA Criteria

Variable	**GPA Data Range**
Low	[0 – 2.80]
Medium	[2.60 – 3.10]
High	[3.00 – 4.00]

Source: (Mundzir et al., 2023)

Table 2.3

Criteria of parental income

Variable	Data range of parental income
Low	4,000,000 – 6,500,000
Medium	2,000,000 – 3,800,000
High	0 – 1,900,000

Source: (Mundzir et al., 2023)

Table 2.4

Criteria for parental responsibility

Variable	Data range parental responsibility
Low	[1 – 2]
Medium	[3 – 4]
High	[5 – 8]

Source: (Mundzir et al., 2023)

Table 2.5

Criteria for distance data range

Variable	Distance data range
Low	[0 – 8]
Medium	[7 – 16]
High	[14 – 32]

Source: (Mundzir et al., 2023)

Then, fuzzy triangular is used with the aim of expanding the criteria that have been stated in the decision matrix and the corresponding data range as shown in Figure 2.3.

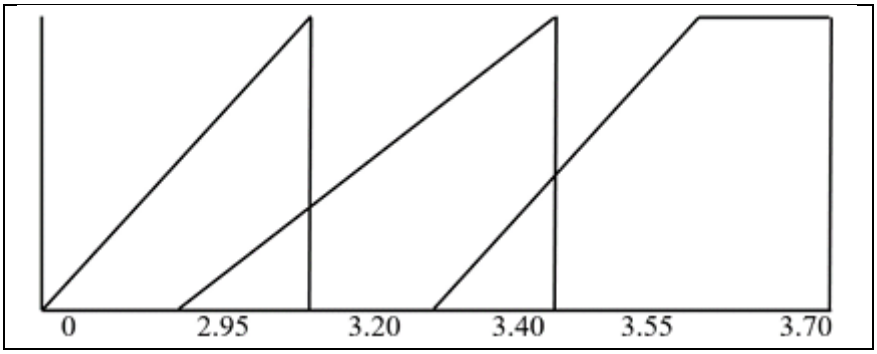


Figure 2.3 Generic structure of Mamdani's method. (Mundzir et al., 2023)

Finally, the study shows significant benefits where the results from Fuzzy logic integrated with AHP show that it offers a higher level of flexibility and accuracy compared to traditional methods. The conclusion that can be made is that the integrated approach of both techniques can ensure whether the applicant is eligible or not by increasing transparency to achieve the objectives.

2.7 Comparison Fuzzy Rules Model Type in Determine Aid Applicants Eligibility

In this section, there are some differences between fuzzy rules model type in determining aid applicants' eligibility suitable for the proposed system with its strengths, limitations and effectiveness.

Table 2.6
The Comparsion Fuzzy Rules Model Type in Determin Aid Applicants Eligibility

Model Type	Key Strengths	Limitations	Effectiveness	References
Mamdani Fuzzy Rules	Simple to implement and widely used for expert knowledge.	Lack of flexibility that cause to difficulties of optimization tasks.	Effective for qualitative decision-making	Varshney & Torra (2023)
Fuzzy Association Rules	Discover relationships between variables	Require large dataset and elaborate into full fuzzy variables	Effective in predicting outcomes based on dataset	Hosseini & Montazer (2024)
Fuzzy Network DEA	Integrates fuzzy uncertainty by using subjective and qualitative indicators	Complexity and implementation difficulty for fuzzification	Effectives for evaluates the Performance Based Budgeting (PBB) maturity and manage uncertainty.	Hatami-Marbini et al. (2022)

Fuzzy AHP	Structured multi-criteria for complex decision-making	Time consuming to calculate pairwise comparisons	Effectives for decision-making support and provide structured security assessment	Mahbub et al. (2021)

2.8 Similar Systems

2.8.1 Sumbangan Tunai Rahmah (mySTR)

Sumbangan Tunai Rahmah (mySTR) is the main system for the government to carry out the people's cash assistance program by channelling it under the Ministry of Finance (MOF) agency, the Inland Revenue Board (LHDN). This system is implemented every year where it is a rebranding of the people's cash assistance program, Bantuan Rakyat 1 Malaysia (BR1M) which is then changed every time the government changes and this system will announced by government for the applications. Through this system, new applicants require to submit application by filling out the form available in the system then users need to register a user account to find out the status and approval of their application.

Figure 2.4 The UI main page of Sumbangan Tunai Rahmah (mySTR) (Lembaga Hasil Dalam Negeri (LHDN), 2025)

2.8.2 Budi MADANI

Budi MADANI is a system that implements the Malaysian Government's initiative through Ministry of Finance (MOF) in targeting petrol and diesel subsidies to address the problem of leakage that causes smuggling of petrol and diesel. This system is divided into two parts, namely Budi Madani Diesel and Budi Madani RON95 (BUDI95).

Figure 2.5 The UI main page of Budi MADANI (Kementerian Kewangan Malaysia, 2025)

To get this initiative, Malaysians need to check their eligibility via the Budi MADANI website by entering their identity card number. Then, the application process is different according to the category, for example for BUDI95, they need to log in to their account via myDigital on the BUDI95 website, while for BUDI Madani Diesel, they need to log in using their identity card number as an eligibility check, if they do not have an account, they need to register their account on the Budi MADANI Diesel website.

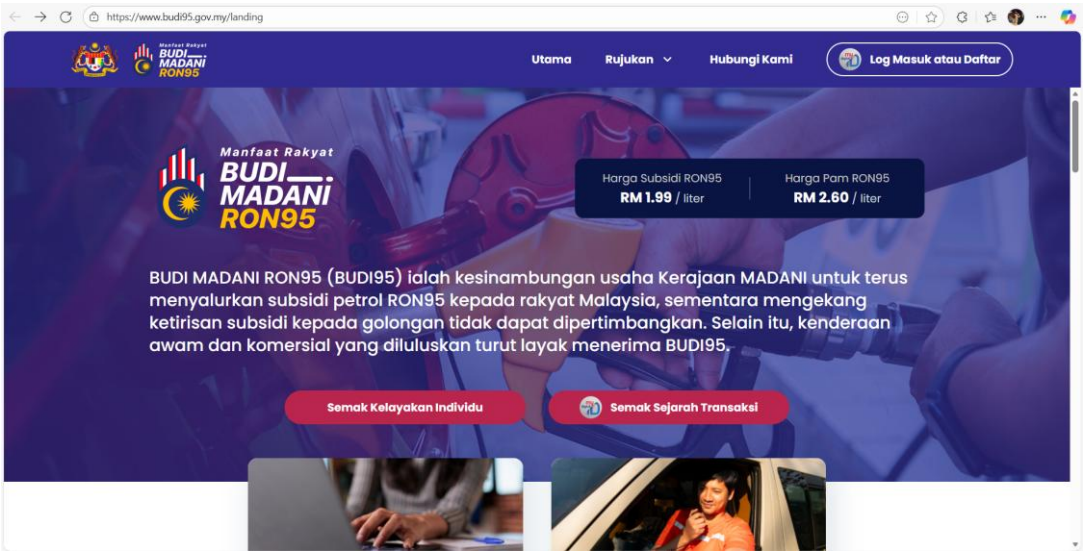


Figure 2.6 The UI main page of Budi MADANI RON 95 (BUDI95) (Kementerian Kewangan Malaysia, 2025)

Figure 2.7 The UI main page of Budi MADANI Diesel (Kementerian Kewangan Malaysia, 2025)

2.8.3 eBantuan JKM

eBantuan JKM is an online assistance system developed by the Department of Social Welfare (JKM), Ministry of Women, Family and Community Development (KPWKM) to manage the application and review of welfare assistance online to help the needy. Through this system, applicants need to make an application by filling in the required information then the applicant needs to go to the District Social Welfare Office to bring supporting documents within 14 days after the application has been

made. The assistance provided by the Department of Social Welfare (JKM) is divided into two categories, namely the Productive Assistance Scheme and the Non-Productive Assistance Scheme.

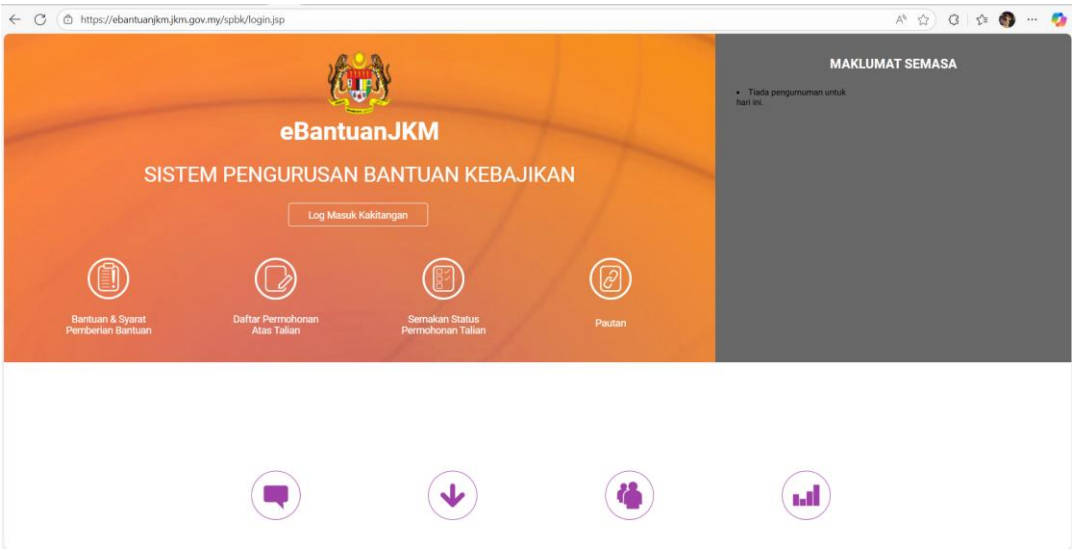


Figure 2.8 The UI main page of eBantuan JKM (Jabatan Kebajikan Masyarakat (JKM), 2025)

2.8.4 Comparison of Similar Systems

Table 2.7 below explains the summary of the comparison between Sumbangan Tunai Rahmah (mySTR), Budi MADANI, eBantuan and the proposed system. Among the aspects that can be seen are as follows:

Table 2.7
Comparison of Similar Systems

Aspect / Features	Sumbangan Tunai Rahmah (mySTR)	Budi MADANI	eBantuan JKM	Proposed System
System Type	Government financial aid portal	Government petrol and diesel distribution portal	Government social welfare management system	Government financial aid portal with the decision support system by using Fuzzy AHP
Architecture	Centralized web portal	Centralized web portal	Centralized web portal	Centralized web portal with integration Fuzzy

				AHP
Data Input / Sources	MyKAD, Income info, LHDN info	MyKAD, JPJ registration, mySTR info	MyKAD, JKM registration	MyKAD, Income info, LHDN info
Eligibility logic rules	Threshold-based (hard rules)	Threshold-based (hard rules)	Threshold-based (hard rules), mySTR info	Fuzzy rules + Analytical Hierarchical Process (AHP)
Automation Level	Medium	Low	Medium	High
Application Method	Online portal	Online portal	Manual and online portal	Online portal
Output of approval	Approved / rejected	Approved / rejected	Approved / rejected	Approved / rejected include eligibility score
Strengths	Simple and widely used	Covers targeted individuals or groups such as small farmers	Targets social welfare groups	Integrated AI in the process of multi-criteria decision-making in determine applicants based on the eligibility.
Handling uncertainty	Minimal	Minimal	Minimal	Depends on fuzzy membership functions

2.9 Literature Matrix

Table 2.8
The Literature Matrix

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
1	Hatami-Marbini et al..	2022	Extending a fuzzy network data envelopment analysis model to measure maturity levels of a performance based-budgeting system: A case study	Data Envelopment Analysis (DEA) based Composite Indicator (CI) + Fuzzy Set Theory; Case study in Iran	Multi Layered approach can improve dimension reduction problems. The budgeting system's evaluation method uses fuzzy set theory to manage the uncertainties of qualitative data. The proposed budget maturity assessment framework can be used on assessing maturity in other areas.	Fuzzy Logic, Data Envelopment Analysis (DEA), Linear Programming, Weight Restriction	Highlight the fuzzy rules that can be measure the eligibility of the aid applicants.
2	Zadeh	1965	Fuzzy Sets	Mathematics formulation (real-valued membership),	Foundation of the Fuzzy Logic	Set theory, real-valued functions, propositional logic, and logic algebra.	The main core for understanding fuzzy sets and their functions that implement in the aid distribution of eGovernment

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
							framework
3	Khoo et al.	2024	An evaluation of the influence of budgeting process on budget performance in Malaysia	Cross-sectional survey, Descriptive and regression analysis	Influence of two predictors in budget performance: budget participation and budget implementation. Budget preparation didn't have significant budget performance.	cross-sectional survey questionnaire, Cronbach's Alpha, Average Variance Extracted (AVE), and Composite Reliability (CR)	Understand the comparison in the budget process and its process and the aid distribution process in the public sector which serves as a reference for creating fuzzy rules.
4	Mohd Shakil et al.	2023	Nexus between Government Assistance and Savings: Preliminary Analysis of Households in Malaysia	Questionnaire, Correlation model	Government assistance programs prioritize immediate consumption needs and offer individuals and households facing financial constraints; there is exploration of policy interventions or modifications of government assistance programs.	Microsoft Forms, Correlation equation	To know the behavior and financial savings of aid recipients and used as supporting evidence in Chapter 2
5	Shayganmehr et al.	2023	A framework for assessing trust in e-government	Fuzzy delphi method, interval-valued	"Trust in Government" more affects citizen;s trust in	Fuzzy set theory	Highlight several different fuzzy

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
			services under uncertain environment	intuitionistic fuzzy set (IVIFS), fuzzy evaluation method (FEM)	eGovernment than "Maintenance and support" on the user's intention of using eGovernment services.		methods in knowing people's trust in eGovernment and it helped me in choosing the appropriate method to implement in the eGovernment framework in the context of aid distribution.
6	Husin et al.	2017	Increasing e-government adoption in Malaysia: MyEG case study	Theoretical framework - technology acceptance model	The identification of different factors that influence public acceptance by providing a new vision of the perspective in developing MyEG and achieving good results in the development of the future platform; fills the current gap in eGovernment research in Malaysia and contributes to the	Technology acceptance model (TAM); Questionnaire; Theoretical research	Highlighting by find out how the eGovernment process works, one of the eGovernment systems used by the Malaysian government is MyEG, and is a supporting detail in chapter 2.

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
					literature on public user perspectives on eGovernment services.		
7	Yasin & Hamid	2025	The Evolution of E-Government in Malaysia: Institutional Mechanisms and Public Service Transformation at the Federal and State Levels	Empirical Examination, Comparative Analysis,	Improving the level of efficiency and effectiveness in eGovernment by adapting the diversity of features under public services; the challenge of ensuring equal access to eGovernment services across different demographics; institutional coordination and policy continuity are essential for the successful implementation of eGovernment.	Data Collection Tools, Web Analytics	Highlights the eGovernment system in Malaysia including a timeline and used as supporting details for Chapter 2.
8	Fazli & Hamid	2010	E-Government and Malaysia: A Theoretical Consideration	Theoretical Analysis, Analytical Analysis	Information Technology (IT) through eGovernment becomes a tool that can renovate bureaucracy with the	Theoretical research	Highlighting the theory of eGovernment in Malaysia and the

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
					aim of driving change in existing government systems and in the same time enabling government to be reengineered to deliver better services; eGovernment failures lead to bureaucratic problems.		impact of its implementation and used as supporting details in Chapter 2.
9	Myers & Boothe	2018	Governance Global Practice Budgeting For Performance In Malaysia A Review Of The Design, Implementation And Application Of Malaysia's Outcome Based Budgeting System	Team-based preparation, Stakeholder engagement, Workshops and Logical Frameworks	Performance-Based Budgeting (or Overview Budgeting) as a global reform budgeting system; Malaysia is a reference in the reform of Performance-Based Budgeting (PBB) by refining its implementation; Linking national strategies to budget activities; Reorienting the process of budget preparation to achieve policy outcomes; Existence of overlaps in budget implementation.	MyResult (a system to support OBB), Project Monitoring System II (SPP II),	Highlight the budgeting process carried out by the government, including the history of budgeting that has been carried out, the functions of the budgeting system that is carried out, and the challenges faced.

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
10	Abdul Nasir	2021	A Mixed-Method Evaluation Of The Financial Aid System For Disabled Persons In Malaysia	Online questionnaire, Analytical analysis	The OKU community is in dire need of financial assistance, but they have concerns about the current financial system which is not keeping up with the times and they need assistance allocation according to criteria such as financial status, number of dependents, and illness.	Google Form, social media, Foucauldian analytical framework	Highlights critical challenges in the distribution of assistance such as eligibility criteria which can be overcome by using fuzzy rules
11	Hosseini & Montazer	2024	Designing an Interpretable Credit Scoring System Using Fuzzy Association Rules	Fuzzy Association Rules, Confusion Matrix, Fuzzy System	Successfully developed an interpretable system that achieved high accuracy in classifying loan applicants.	Fuzzy Association Rules, Fuzzy Apriori Algorithm, Fuzzy Set Theory, Fuzzy System, Confusion Matrix	Support fuzzy system by using a table define fuzzy variable at the pre-processing stage.
12	Varshney & Torra	2023	Literature Review of the Recent Trends and Applications in Various Fuzzy Rule-Based Systems	Fuzzy Rules Based System (FRBS)	FRBS faces challenges such as representation uncertainty, high number of rules, loss of interpretability, and long	Genetic fuzzy system; Hierarchical fuzzy systems; Neuro-fuzzy systems;	Becomes reference in selecting appropriate fuzzy rules for decision making.

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
					computation time, but various extensions have been developed to overcome them.	Evolutionary fuzzy systems; FRBS; Interpretation capabilities in FRBS FRBS using cluster centroids as fuzzy rules.	
13	Mundzir et al.	2023	Innovating Scholarship Design: a Comprehensive Approach Using Fuzzy Logic	Fuzzy logic, Analytical Hierarchical Process	The Fuzzy-AHP method systematically improves the flexibility, speed, and sensitivity of the system for evaluating biases in comparison to the traditional, inflexible method.	Fuzzy Logic, Analytical Hierarchy Process (AHP), Triangular Fuzzy Numbers, C++ programming language	The core of the framework in Demonstrate how fuzzy logic (using Analytic Hierarchy Process - AHP) can be fair and transparent in the distribution of resources
14	Mahbub et al.	2021	Implementing Fuzzy Analytical Hierarchy Process (FAHP) To Measure Malicious	Fuzzy Analytical Hierarchy Process (FAHP),	Malicious code behaviour in smart meters was successfully measured using FAHP, which concluded that the Fuzzy AHP	Fuzzy Analytical Hierarchy Process (FAHP), Malicious Rating System	Provide effective use of Fuzzy AHP with triangular fuzzy numbers and COA

No	Authors	Year	Title / Study Focus	Methodology	Key Findings	Tools / Tech	Relevance To My Project
			Behaviour of Codes In Smart Meter		method was efficient and effective. Among the code alternatives tested was the "R code" which was found to be the most malicious with a priority of 30%.	(MRS), Triangular Fuzzy Numbers, Center of Area (COA) Method.	defuzzification for structured decision making within a framework and supporting methods for assessing aid eligibility.
15	Kahraman et al.	(2003)	Multi-Criteria Supplier Selection Using Fuzzy AHP	Fuzzy Analytical Hierarchy Process (AHP), questionnaire, Chang level analysis method, triangular fuzzy numbers	Effective use of fuzzy AHP in multi-criteria supplier selection and addressing decision complexity and uncertainty inherent in human evaluation unlike traditional AHP. Includes numerical examples to identify the best supplier firms.	Fuzzy Analytical Hierarchy Process (AHP), Fuzzy Set Theory, Linguistic Variables, Triangular Fuzzy Numbers (TFN), Pairwise Comparisons, Chang's Reach Analysis Method and Questionnaires.	Implement the fuzzy AHP steps and its structural for determine the eligibility criteria.

2.10 Summary

In conclusion, this chapter has provided a comprehensive analysis of fuzzy logic and fuzzy rule-based systems in eGovernment based on previous researches in the areas of aid distribution and budgeting. The result will shows the extent to which fuzzy logic can handle ambiguity and uncertainty in decision-making and provides a more accurate and flexible method for determining eligibility than traditional methods. This realization will provides a solid foundation for the creation of the proposed fuzzy-based model in the next chapter

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

For this chapter, there are several comprehensive research methodologies that will be used throughout the development of an e-Government framework designed specifically for budget management and aid distribution through the use of logical rules. This can detail the appropriate approach by ensuring that all work can be done in a fully structured and orderly manner.

For this project, the methodological approach chosen is to use a systematic approach, namely the Software Development Life Cycle (SDLC) model using the Waterfall model where SDLC is used in software design, development and production of a software (S, 2017). SDLC is also reliable because it can explain the methodology in a structured way and improve the quality of the project development process. The Waterfall model is a non-overlapping sequential process model by implying that the next phase cannot start until the previous phase is completed S (2017). Figure 3.1 below shows the graphical representation of the waterfall model for this project.

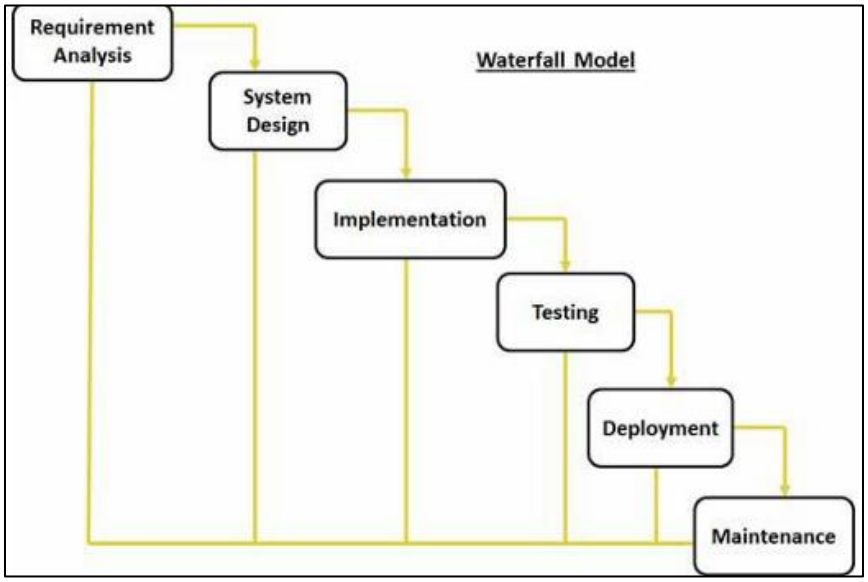


Figure 3.1 Waterfall model of this project (S, 2017)

3.2 Project Framework

Table 3.1

Project Framework

Objective	Phase	Activity	Outcome
Objective 1: To identify the suitable algorithms for the determination of the eligibility of aid recipients.	Requirement analysis	• Reading journals and articles related to fuzzy logic, Analytical Hierarchical Process (AHP), budgeting, software development life cycle (SDLC) and government aid distribution process. • Identification of hardware and software requirements for the system	• Problem statement, Objectives, Scope, significant of the project • Identification of relevant fuzzy algorithms and their potential use for eligibility determination that can use in eGovernment budgeting framework in terms of aid distribution • Complete list of hardware an software requirement for development and deployment.
	Data Collection	• Collect data from public dataset from DOSM (such as income, dependents, and employment) • Design synthetic data of aid recipient that reflect to aid applications • Data cleaning (Normalization date format	• Ready-to-use dataset for system development and testing • Realistic synthetic for simulation of eligibility logic.

Objective	Phase	Activity	Outcome
		and dropdown selection) for testing purpose	
	System Design	• Membership function design • IF-THEN fuzzy rules and AHP • Use Case Diagram and System flowchart	• Full design of fuzzy systems, including inputs, outputs, rules and inference.
Objective 2: To design and develop the application of fuzzy rules framework by using Analytical Hierarchical Process (AHP) techniques for the eligibility of applicants for aid in eGovernment.	Implementation	• The development of fuzzy rules systems using PHP-based web system with MySQL • Code fuzzy rules and AHP in PHP.	• Fuzzy model functioned by PHP and MySQL • Web forms for applicant registration login and data submission • Staff panel for management involving agency officer panel and ministry administrator panel
Objective 3: To evaluate the effectiveness of the algorithms in application of the eligibility of aid recipients.	Testing	• Validate fuzzy rules and AHP output • Test form input and security • Use synthetic data for testing • Ensure user interface are user-friendly	• Form validation • Security testing • Synthetic data for testing • Functionality testing
	Deployment	• Configure Apache server	• Apache/HTTPS

Objective	Phase	Activity	Outcome
		• Migrate MySQL database • Set up user rules (Agency officer, ministry administrator and applicant) • Provide applicant, agency officer and ministry administrator documentation • Set up version control and backups	• Documentation for applicant, agency officer and ministry administrator • Version control • Data backup schedule
	Maintenance	• Fix issues after deployment • Update fuzzy rules and AHP weights in PHP when needed • Ensure backups of applicant data securely • Document all system changes	• PHP code updates for rule changes • Version-controlled deployments • Database backup and recovery • Access control

3.3 Phase 1: Requirement Analysis

In this phase, requirement analysis is the critical part in understanding the functions and limitations of the eGovernment framework for the purpose of determining system specifications. This phase are including the preliminary study and the identification of hardware and software requirements.

3.3.1 Preliminary Study

In preliminary study, the initial study was conducted by using the document analysis method where journal articles and case studies were used to find information related to the government aid distribution process, eGovernment systems, fuzzy logic techniques in decision making and the application of Analytical Hierarchical Process (AHP) in determining eligibility (such as income and employment status) based on the criteria that have been set. The aim to focus on articles and journals is to ensure that the information collected is relevant and up to date to the research of this project. Throughout this study, research materials were obtained from online library databases subscribed by UiTM such as IEEE Xplore, ScienceDirect, Emerald and Scopus. Not only that, Google Scholar and ResearchGate also played a role in accessing research materials openly where there are articles, journals and reports relevant to this project. The results of the article research have already been explained in Chapter 2.

Through the analysis of this document, important information related to the eligibility criteria of aid recipients has been identified, including household income, number of dependents, employment status, education level, and health conditions. The study also involves documents related to existing systems such as e-Kasih, Living Aid (BSH) and various social policies by the Social Welfare Department (JKM). Not only that, other studies also show the diversity of their fuzzy techniques such as Fuzzy Logic, Fuzzy Rules Based System (FRBS), and Fuzzy Association Rules. Therefore, for this study, Fuzzy Rules Based System (FRBS) will be used in the context of determining eligibility for government aid for the eGovernment framework.

3.3.2 Hardware & Software Requirements

The requirement of software and hardware is very necessary in the successful implementation of this project which focuses on the eGovernment in budgeting framework to determine the eligibility of applicants in applications for government assistance. Table 3.2 shows the hardware requirements of this framework and Table 3.3 shows the software requirements of this framework.

Table 3.2
Hardware Requirements

No	Hardware	Specification
1.	Lenovo IdeaPad Slim 3	• Processor: AMD Rayzen 5 7430U • Memory: 16GB DDR4 • GPU: Graphics Integrated AMD Radeon Graphics

Table 3.3
Software Requirements

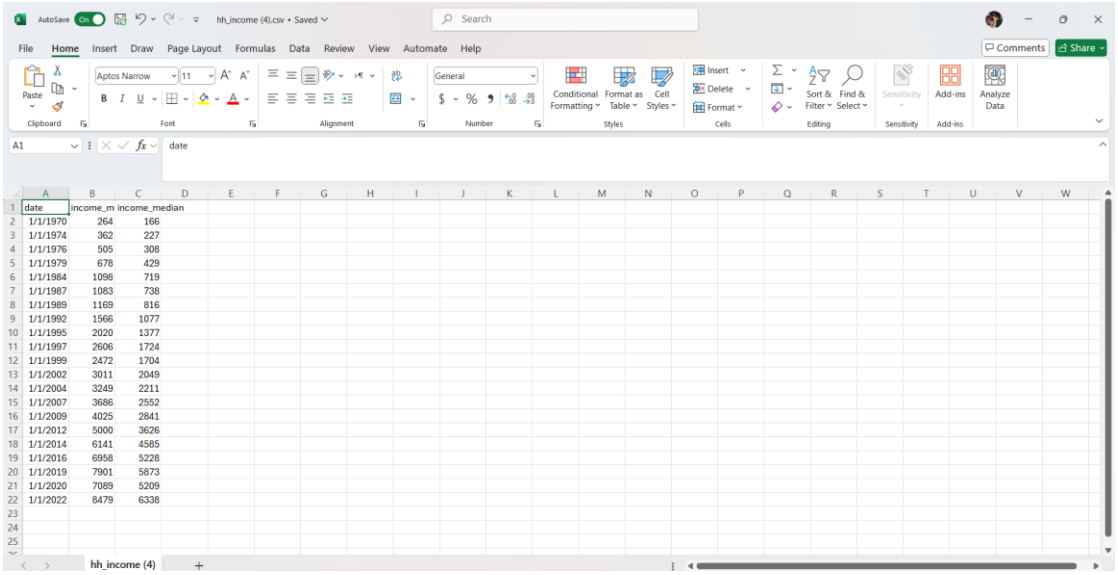
No	Software	Details
1.	Microsoft Word	Used for thesis report purposes.
2.	Mendeley	As reference management tool for organizing all reference that used in this thesis
3.	Draw.io	Used for drawing framework system diagrams
4.	Microsoft Edge	Used for browsing web to accessing references and others that related to the project
5.	Microsoft Excel	Used to create synthetic data for aid applicant data based on mySTR application form.
6.	Visual Studio Code (VS Code)	Used for system development
7.	MySQL	Used for database management
8.	XAMPP	Provides local web server for running and testing system

No	Software	Details
9.	GitHub	Used for version control by managing the track changes of the project codebase.

3.3.3 Data Collection

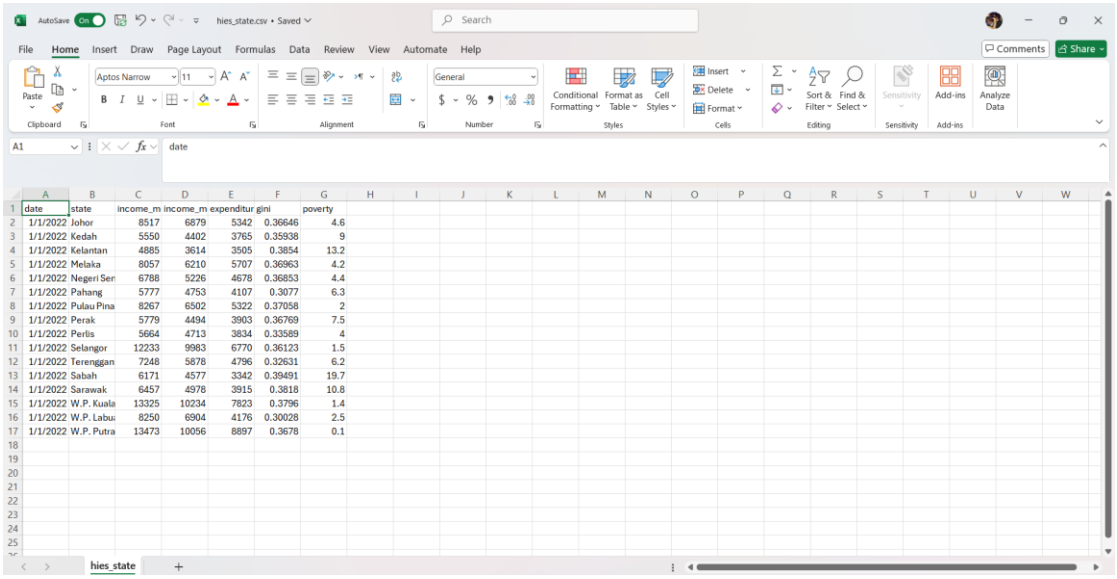
Data collection in this study involves two main sources, namely secondary data and synthetic data. The aim is to obtain relevant information to build a fuzzy logic model and conduct an analysis of the eligibility of aid recipients.

The main source of this study is secondary data obtained from open sources, namely from the Department of Statistics Malaysia (DOSM) website which this website includes statistics on household income distribution, household size and labour force. This data obtained can be used to understand the actual distribution of related variables in Malaysia and help in forming the fuzzy rules and Analytical Hierarchical Process (AHP) functions as well as eligibility criteria in this framework.



date	income_m	income_median
1/1/1970	264	166
1/1/1974	362	227
1/1/1976	505	308
1/1/1979	678	429
1/1/1984	1098	719
1/1/1987	1083	738
1/1/1989	1169	816
1/1/1992	1566	1077
1/1/1995	2020	1377
1/1/1997	2606	1724
1/1/1999	2472	1704
1/1/2002	3011	2049
1/1/2004	3249	2211
1/1/2007	3686	2552
1/1/2009	4025	2841
1/1/2012	5000	3626
1/1/2014	6141	4585
1/1/2016	6958	5228
1/1/2019	7901	5873
1/1/2020	7089	5209
1/1/2022	8479	6338

Figure 3.2 The data of income taken from DOSM.



date	state	income_m	income_m	expenditur	gini	poverty
1/1/2022	Johor	8517	6879	5342	0.36646	4.6
1/1/2022	Kedah	5550	4402	3765	0.35938	9
1/1/2022	Kelantan	4885	3614	3505	0.3854	13.2
1/1/2022	Melaka	8057	6210	5707	0.36963	4.2
1/1/2022	Negeri Sen	6788	5226	4678	0.36853	4.4
1/1/2022	Pahang	5777	4753	4107	0.3077	6.3
1/1/2022	Pulau Pina	8267	6502	5322	0.37058	2
1/1/2022	Perak	5779	4494	3903	0.36769	7.5
1/1/2022	Perlis	5664	4713	3834	0.33589	4
1/1/2022	Selangor	12233	9983	6770	0.36123	1.5
1/1/2022	Terengganu	7248	5878	4796	0.32631	6.2
1/1/2022	Sabah	6171	4577	3342	0.39491	19.7
1/1/2022	Sarawak	6457	4978	3915	0.3818	10.8
1/1/2022	W.P. Kuala	13325	10234	7823	0.3796	1.4
1/1/2022	W.P. Labua	8250	6904	4176	0.30028	2.5
1/1/2022	W.P. Putra	13473	10056	8897	0.3678	0.1

Figure 3.3 The data of income, expenditure and poverty based states taken from DOSM.

In addition, synthetic data is used through a dummy data set to simulate the profile of aid applicants. This synthetic dataset is designed to reflect realistic applicant attributes (such as income, number of dependents and age) by taking the range and distribution based on data from DOSM and the refences from the website of Bantuan Hasil LHDN (https://bantuantunai.hasil.gov.my/Default.aspx) that focuses on Sumbangan Tunai Rahmah (STR). It can also be used as input for this project framework for the logical rules process and also for testing and evaluation purposes.

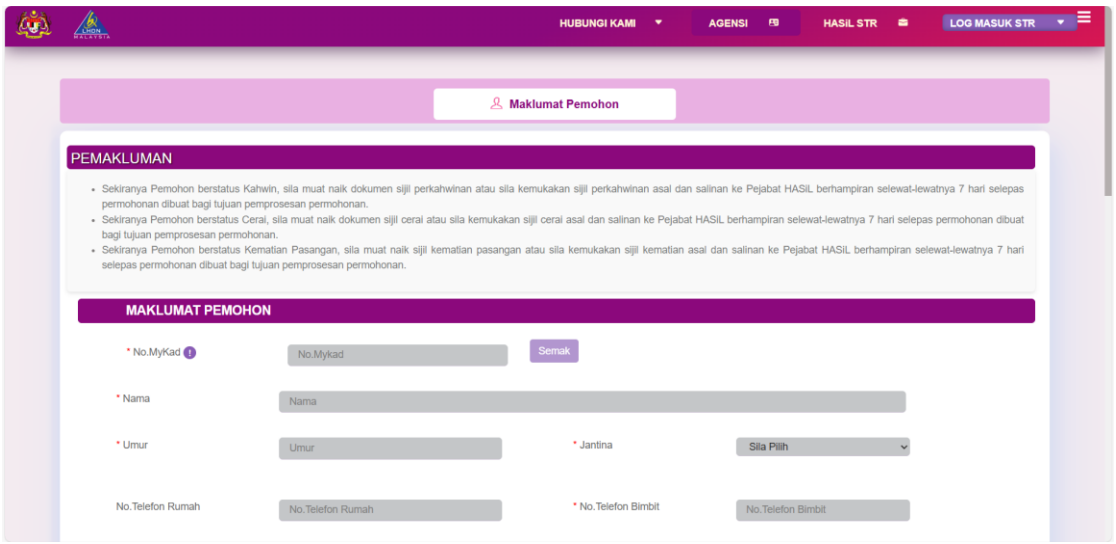


Figure 3.4 The application form of the applicant who didn't register with LHDN in

mySTR.

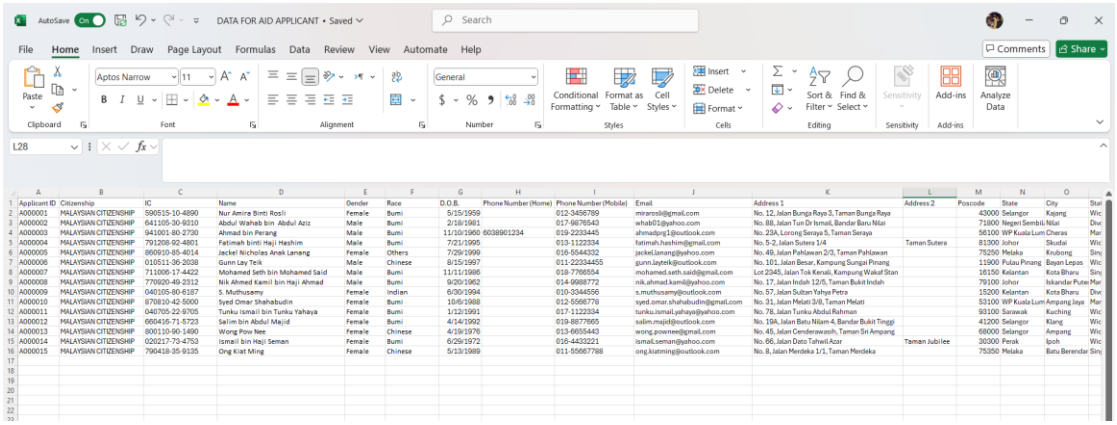


Figure 3.5 The synthetic data of the aid applicants based on the application form from mySTR

3.4 Phase 2: System Design

System Design is a phase where the entire requirements analysis phase is used as the basis for designing the general structure of the software product S (2017) It also plays a role in shaping the structure and process flow of the eligibility determination system using fuzzy rules and the Analytical Hierarchy Process (AHP).

3.4.1 System Architecture

The system architecture will operate as a decision support model where it will follow a set of eligibility criteria set by the government based on the type of government assistance. It is integrated with the use of fuzzy logic and Analytic Hierarchy Process (AHP). Starting with applicants as the target users of this system, for those who have not yet applied, they are basically required to submit their information through an application form as their registration in this system, while the staff who act as administrator is tasked with overseeing and managing the assistance distribution process.

From Figure 3.6, the operation of this system consists of 4 modules, starting with the input module which functions to enter applicant data where the applicant interacts with the User Interface by providing information through the application form. It plays a role in receiving input from the user for the purpose of implementing data validation and cleaning. And this module also uses data from the MySQL database

for the purpose of updating information from the applicant. Next, is the fuzzy rule module, this module runs after receiving applicant data from the input module where it functions in processing fuzzy rules by translating the correct input value into fuzzy linguistics using predefined membership functions and fuzzy rules. It will also be combined with the Analytical Hierarchical process where it will store weighted results and managed by staff through ministry administrator. Third module of this system are Analytical Hierarchical Process (AHP) Module where is responsible for generating weighted results by taking fuzzy outputs and using the weights given to various criteria through the AHP methodology which ensures critical factors that have a greater impact in making the final decision. And finally, the Eligibility Result module which acts as a result of the decision to determine the decision in determining the eligibility for aid distribution by taking weighted decisions from the AHP module and issuing a final eligibility result with scores for each applicant. This result will be stored in the MySQL database for recording and reporting purposes. And the result of this result will be published through the applicant application details to allow them to see the results of their aid application with the amount that they will receive based on the application.

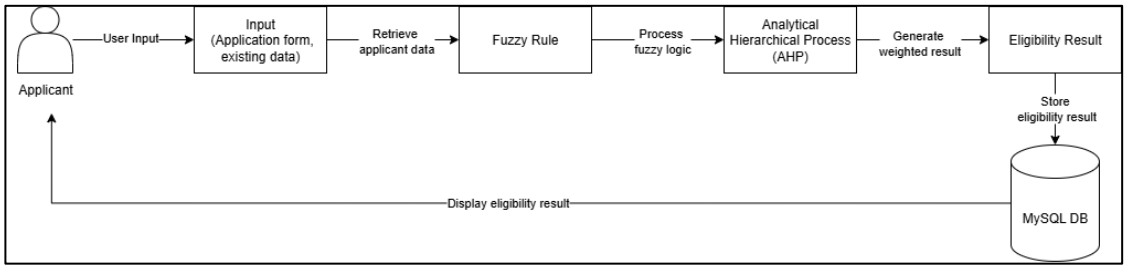


Figure 3.6 System architecture design of this project.

Figure 3.7 shows a representation of the hierarchical structure of this project. In this structure, the basic components of the Analytical Hierarchical Process (AHP) are used in determining the eligibility of applicants as in the previous paragraph. At the peak of this structure, the goal of this project is to determine the eligibility of applicants for assistance distribution followed by 3 main criteria, namely income, number of dependents and employment status which are critical factors in influencing the eligibility decision of assistance applications, each of which will be assessed based on criteria set by the Government. This structured hierarchy aims to ensure that the assessment process can be managed well and allows the use of pairwise comparisons in obtaining weighted criteria which ultimately generates fair eligibility results for all applicants.

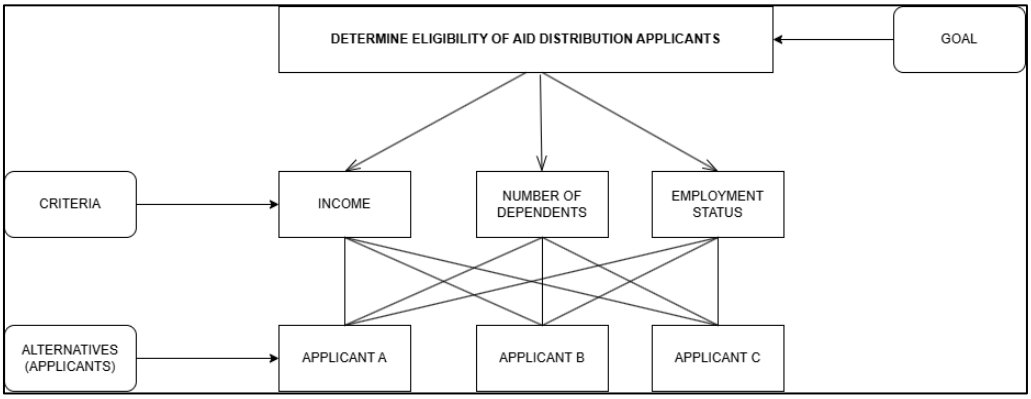


Figure 3.7 The hierarchical structure of the project.

3.4.1.1 Fuzzy Rule Module Design

The example of fuzzy rule condition that will be used in this project are shown in Table 3.4.

Table 3.4
The Example of fuzzy rules condition to determine the applicant's eligibility

No	Fuzzy Rules
1	"If income is LOW AND dependent is HIGH AND employment is UNEMPLOYED, Then eligibility are HIGH"
2	"If income is MEDIUM AND dependent is LOW AND employment is UNEMPLOYED, Then eligibility are MEDIUM"
3	"If income is HIGH AND dependent is LOW AND employment is EMPLOYED, Then eligibility are LOW"

3.4.1.2 Analytical Hierarchical Process (AHP) Module Design

The AHP approach in this system is to provide a structure for the decision-making process by breaking the problem down into a hierarchy of smaller, more manageable criteria and sub-criteria (Mundzir et al., 2023). This is intended to make it easier for the decision-maker to determine the priority in each of the available eligibility criteria. The hybrid steps to perform the AHP process (can refer to Figure 2.2) with fuzzy rule base (can refer to subtopic 2.4 of Chapter 2) in this system:

1. Breaking Down The Complex Problem into A Number Of Small Constituent Elements.

In this process, it functions to break down the problem of uncertainty in the decision-making process into hierarchical forms (small elements), namely the applicant's eligibility criteria such as Eligibility (Eligible/Not Eligible), Criteria (Income, Number of Dependents, Employment) and alternatives (Applicant).

2. Creating A Hierarchical Structure Of Elements For Solution Of The Problem

The hierarchical structure is very necessary in finding solutions to uncertainty problems because according to Mahbub et al. (2021), there are three levels in structuring a hierarchical framework where the objective of the issue will be the top node of the hierarchical structure, then, the second and subsequent levels are criteria and alternatives. The following is the hierarchical structure of the eGovernment in budgeting in terms of aid distribution framework:

1. Level 1: Goal Framework (Eligibility Determination)
2. Level 2: Eligibility criteria such as income, number of dependents and employment status.
3. Level 3: List of alternatives (Applicants)

3. Comparing The Criteria By Using Linguistic Variable And Establishing The Triangular Fuzzy Number

Each criterion will be compared in pairs using a linguistic scale such as:

Table 3.5
The criterion of aid distribution rating

Linguistic Variables	**Linguistic Scale**	**Triangular Fuzzy Numbering Scale**
Equally Important	1	(1,1,1)
Slightly More Important	2	(1,2,3)
Moderately More Important	3	(2,3,4)
Important	4	(3,4,5)
Strongly More Important	5	(4,5,6)
Very Strongly More Important	6	(5,6,7)
Extremely Important	7	(6,7,8)
Absolutely More Important	8	(7,8,9)
Not Important	9	(9,9,9)

4. Constructing Fuzzy Pairwise Comparison Matrix

In this step, fuzzy pairwise comparison matrix are developed to capture the relative between criteria by using linguistic variables and triangular fuzzy numbers (TFNs). Here, each entry in the matrix represents its subjective judgement of criterion's importance. For example, if income are considered as "Strongly important" than employment, it could be represented as (4,5,6). The matrix are reciprocal where the inverse fuzzy value are used to the reverse comparison. The matrix become the foundation for calculating the fuzzy weights for next phase.

Table 3.6

The example of fuzzy pairwise comparison matrix

Criteria	Income	Dependents	Employment
Income	(1,1,1)	(1,1,1)	(3,4,5)
Dependents	(1/4, 1/3, ½)	(1,2,3)	(2,3,4)
Employment	(1/4, 1/6, 1/3)	(2,3,4)	(1,1,1)

5. Calculating The Geometric Means Of Fuzzy Comparison Values And Fuzzy Weights

After the fuzzy pairwise comparison matrix has been created, the next step is to calculate the geometric mean for the criteria, which can help in aggregating the comparison values in a mathematically consistent manner. The fuzzy geometric mean $\widetilde{J_i}$ are calculated for each criterion (n) as follows in Equation 3.1:

$$\widetilde{J_i} = [\, \widetilde{f}_{i_1} \bigotimes \dots \bigotimes \widetilde{f}_{i_n} \,]^{\frac{1}{n}} \tag{3.1}$$

In this equation 3.1, $\widetilde{J_i}$ are used as fuzzy geometric mean value of criterion i. The fuzzy value represented as $\widetilde{f}_{i_n}$ in the pairwise comparison of criteria element between criterion i and criterion j. The $\otimes$ used for fuzzy multiplication operator. This equation produces a triangular fuzzy number (TFN) for each criterion.

After all geometric means that has been calculated, next step are to compute the fuzzy weights for each criterion by using Equation 3.2:

$$\widetilde{w_i} = \widetilde{J_i} \bigotimes (\widetilde{J_1} \bigoplus \widetilde{J_2} \bigoplus \dots \bigoplus \widetilde{J_n})^{-1} \tag{3.2}$$

The equation shows that $\widetilde{w_i}$ are fuzzy weight of criterion i where the denominator is the inverse of the fuzzy sum of all geomteric means. $(\widetilde{J_1} \oplus \widetilde{J_2} \oplus \dots \oplus \widetilde{J_n})^{-1}$ are the fuzzy reciprocal of the total geometic means in all geometric means.

6. Defuzzying The Fuzzy Weights

Defuzzification is done by transforming the fuzzy weights into sharp values which can be used in the system. The Center of Area Approach (COA) is used in this framework:

$$w_i = \frac{l + m + u}{3} \tag{3.3}$$

In this equation, l are used as lower value, m are modal value and u used as upper value of the triangular fuzzy number where represents as each criterion's weight.

7. Normalizing the Defuzzified Values

After the fuzzy weight did the defuzzified phase by using the Center of Area (COA) into crisp values. The defuzziefied values need to normalize to ensure the sum of all fuzzy weights equals to 1. It is because to ensure that consistency and make the fuzzy weights suitable for any evaluation. The normalization process can be process by using the following formula:

$$w_i{}^{norm} = \frac{w_i}{\sum_{i=1}^{n} w_i} \tag{3.4}$$

In this equation, $w_i{}^{norm}$ are represented as normalized crisp weight for criterion i. w_i are the defuzzified weight of criterion of i and $\sum_{i=1}^{n} w_i$ represent as total sum of all defuzzified weights.

3.4.2 Use Case Diagram

Figure 3.8 shows the use case of the proposed of eGovernment for budgeting that focusing on aid distribution eligibility status.

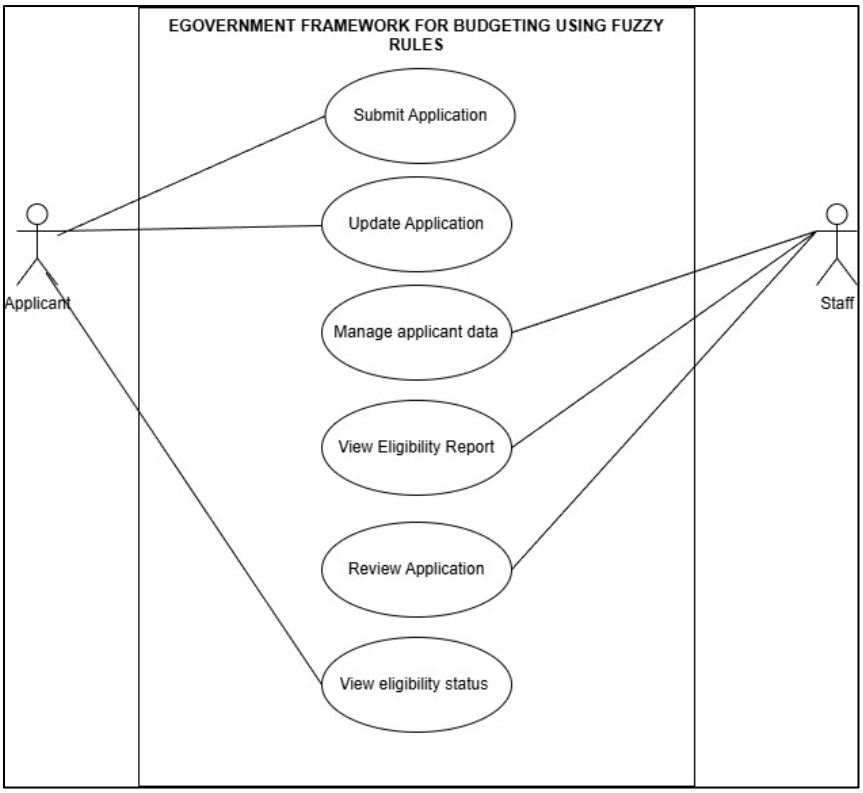


Figure 3.8 Use Case Diagram of this project

Table 3.7
Use Case Submit Application

1a. ID No.	UC001	**1b. Title**	UC1 – Submit Application
2. Actor	Applicant		
3. Brief Description	The use case allows the applicant to submit a new application by entering their personal details and socioeconomic information (such as their job and gross income) into the system.		
4. Precondition	• Applicant has access to the website, • Application forms are available online as registration of the system until due date.		
5. Normal Flow	1. The applicant accesses the website. 2. If the applicant's IC are not registered in the system, they need to submit their application form as registration of the system. 3. Applicants click "HANTAR" button (Submit) 4. The system will validate input data from applicants 5. The system stores data and assign a unique application ID		

	6. The system confirms successful submission to the applicant.
6. Extension – Alternate Flow	4a. Incomplete Data: If the applicant leaves the required fields bank, the system will highlight the missing fields and ask the applicant to complete it before submission. 4b. Invalid Data Format: If the applicant enters in an incorrect data format such as text in numeric field, the system will display the error message and ask to applicant to insert correct input.
7. Extension – Exception Flow	3a. System Error during Submission: If the system error occur during save the applicant data, the system displays an error message with logs the error and tell the applicant to try again. 3b. Session Timeout: If the applicant remains inactive to filling the form, it shows the session was times out and the applicant input disappear automatically. The need to refresh the session.

Table 3.8
Use Case Manage Update Application

1a. ID No.	UC002	**1b. Title**	UC2 – Update Application
2. Actor	Applicant		
3. Brief Description	The applicant update their information in existing submitted application that typically if they have a correct information of their details.		
4. Precondition	• The applicant has access to the system. • An application that has been previously submitted by the applicant • The application status that allows for update such as “MAKLUMAT DIPERLUKAN” (Information Required) or “DALAM PROSES” (In Process)		
5. Normal Flow	1. The applicant must login the system if their account exist after doing the registration for application. 2. Next, after login the system, the applicant can update by click “Permohonan” to access all application that applicant made. 2. The system retrieves and display the applicants previously submitted application data. 3. The applicant can update the application by choose the latest application and click “Kemaskini” (Update) for modify the previous application fields. 4. The applicant reviews the updated application before submit the updated application. 5. The applicant click “Simpan Kemaskini" (Save Update) button. 6. The system validates the updated data. 7. The system save the updated application data and shows the successful message update to the applicant.		
6. Extension – Alternate Flow	2a. Application Not Found: If the applicant didn’t find any application, the system informs the applicant that the applicant didn’t apply application.		

	4a. Incomplete Data: If the applicant leaves any required fields such as blank or insert incorrect format, the system will highlight the errors by display message and force user for correction.
7. Extension – Exception Flow	5a. System Error during Update: If the system facing error during data saving, the system will displays an error message and force the applicant to try again later. 5b. Concurrent Modification: If another process or staff through ministry administrator simultaneously modifying the same application, the system handles the conflict by warns the users.

Table 3.9
Use Case Manage Applicant Data

1a. ID No.	UC003	**1b. Title**	UC2 – Manage Applicant Data
2. Actor	Staff		
3. Brief Description	The staff who role as ministry administrator or agency officer used to manages the applicant data where viewing, editing or deleting the existing applicant record in the system.		
4. Precondition	• The staff who role as ministry administrator or agency officer is logged into the system in the role panel of the system. • Applicant data already exists in the system.		
5. Normal Flow	For ministry administrator: 1. For staff who role as ministry administrator, they need to login their account in login page for ministry administrator as Admin. 2. Next, after they success login to the system, they can access the applicant data by "Pengurusan Akaun" section. There, ministry administrator can view the list of applicants who register to the system. 3. The administrator can add staff as user by insert the necessarily data such as ID staff number. They also can import the existing applicant data and staff data using .csv file for user registration to the system 4. The system will display a list of applicant and staff's data 5. For deletion, administrator can click delete button for remove staff, while for applicant accounts, administrator are not allowed to remove applicant, they only can block applicant account from the system. 6. For edit, administrator can edit the details of staff data such as name, ID staff number and staff roles. 7. The system display confirmation of the administrator's action. For agency officer: 1. For staff who role as agency officer, they need to login their account in login page for agency officer as agency. 2. The agency officer can view applicant data by select "Pengurusan		

	Permohonan" to see the list of application made by applicants. In this section. Agency officer can review the application made by applicant.
6. Extension – Alternate Flow	3a. No Matching Applicant Found: If the admin search yield no results, the system will inform the admin. 6a. Invalid Data during Edit: If the admin insert invalid data during editing, the system highlighting the errors and force for correction.
7. Extension – Exception Flow	5a. Data Corruption: If an attempt to retrieve or save data results facing corruption, the system display error message and logs the incident. 5b. Database Unreachable: If the system cannot connect to the database to retrieve or save applicant data, it display an error message.

Table 3.10
Use Case View Eligibility Report

1a. ID No.	UC004	**1b. Title**	UC4 – View Eligibility Report
2. Actor	Staff		
3. Brief Description	Staff who role as agency staff and ministry administrator views generated eligibility application report and providing overall insights into aid distribution including display statistics.		
4. Precondition	• Staff (ministry administrator and agency officer) is logged into the system in the admin panel of the system. • Application have been process processed include after fuzzy rules and Analytical Hierarchical Process (AHP) process and eligibility determined by the system.		
5. Normal Flow	For ministry administrator: 1. The administrator require to login their account by insert their staff ID number and password. 2. For viewing applicant eligibility report, the administrator need choose "Laporan Permohonan" (Application Report) section. This sections provides statistical summaries, list of applicant with fuzzy eligibility score result, graph and application result made by agency officer. 3. The administrator can print the application eligibility report as pdf. For agency officer: 1. The agency officer require to login their account into system by insert their staff ID number and password. 2. Then, they need to click "Pengurusan Bantuan" (Financial Aid Management) where contains applications that made by applicants. There was contains list of financial aid that available in the system. 3. For viewing applicant eligibility report, the agency officer chooses any financial aid then choose any application made by applicants by click "Lihat" button. Next, the system will navigate to the applicant details that included the		

	eligibility report contains fuzzy score and eligibility status by using Fuzzy Rules and Analytical Hierarchical Process (AHP). 4. For viewing overview applicant eligibility report, the agency officer choose "Laporan Permohonan" where there the system show the overview report of the application based on statistics that consists of list of application and graphs.
6. Extension – Alternate Flow	3a. No Data for Report: If the selected report parameters yield no data, the system informs the admin that no record match the criteria. 5a. Interactive Report: The report may include the interactive elements such as sorting columns where admin can use to explore the data.
7. Extension – Exception Flow	4a. Report Generation Error: If system facing problem during complex report generation such as database query timeout, the system will display an error message. 4b. Performance Issue: If the report involves a very large dataset, it will suggest running as background process or narrowing the parameters

Table 3.11
Use Cse Review Application

1a. ID No.	UC005	**1b. Title**	UC5 – Review Application
2. Actor	Staff		
3. Brief Description	Staff who role as agency officer are responsible to manually reviews submitted application based processed eligibility result by fuzzy rules and AHP that required verification from admin before the result display to the applicants		
4. Precondition	• Staff who role as agency officer is logged into the system in the admin panel of the system. • Application have been submitted (UC001) and already processed through fuzzy rules and AHP process that generate eligibility (UC004)		
5. Normal Flow	1. In agency officer panel, agency officer accesses the "PENGURUSAN PERMOHONAN" (Application Management) section. 2. The system display a list of application that consists of financial aid name, total application of the financial aid, duration of the financial aid that applicant can apply and action. For action column, it consists of "Senarai Permohonan" button that navigate agency officer to the list of application. 3. Agency officer selection financial aid to review. 4. Agency officer review applications and the eligibility result of the applications. 5. Agency officer make a final decision and record it on the application by approve, reject, defer or they can write the notes as the information of the decision. 6. The system updates the application status and store to database. 7. The system confirm the updated application status to the staff who role as		

	administrator.
6. Extension – Alternate Flow	3a. No Application for Review: If there are no application currently pending review, the system will inform to admin. 6a. Request More Information: Agency officer can choose to request additional information by write the notes where the applicant will see the attached notes by admin.
7. Extension – Exception Flow	5a. System Error During Record Decision: If the system error occurs during record agency officer's decision, the system display the error message and log the incident by ensuring no data loss.

Table 3.12
Use Case View Eligibility Status

1a. ID No.	UC006	**1b. Title**	UC6 – View Eligibility Status
2. Actor	Applicant		
3. Brief Description	The use case allow the applicant to check their latest status of their financial aid application.		
4. Precondition	• Applicant has previously submitted application (UC001) • The application has been processed and eligibility status that been determined by staff who role as agency officer (UC005)		
5. Normal Flow	1. The applicant accesses to the system by login their details such as IC number and password. 2. The applicant selects the "Permohonan" section which the system displays the list of financial aid applications made by the applicant (including the application date, current status and actions). For action, if application is still under review, the "Butiran" (Details) button only will be shown. If the application is approved, the action column will display the "Butiran" (Details) and "Cetak" (Print) buttons. In the case of a rejected application, the system display a "Semak" (Review) button that opens a modal containing the reasons for rejection along with the agency officer's remarks. 2. The system will query the database to retrieve the application status 3. The system display the current application eligibility status.		
6. Extension – Alternate Flow	2a. No Application Found: If the system cannot find application that associated to logged-in applicant, the system will display alert message 3a. Application Status is Pending: The application status are "DALAM PROSES" (In Process) , the system display the status that review is still progress. 3b. Information Required form Applicant: If the application status is "Information Required", the system will display the status and may provide the information needed where the applicants need to update their application details.		
7. Extension –	1a. System Unavailable: If the "SEMAK STATUS PERMOHONAN" face the		

Exception Flow	problem of unavailable dure to maintenance, the system displays “SISTEM TIDAK TERSEDIA” (System Unavailable) message. 2a. Database Connection Error” If the system fails to connect to the database to retrieve the application status, the system display error message and logs the error. 2b. Data Corruption: If the retrieved application data found corrupted, the system display a generic error message.

3.4.3 System Flowchart

Figure 3.9 shows a flowchart for the conceptual step-by-step process of the proposed framework of eGovernment for budgeting in the context of aid distribution. This flowchart serves as blueprint that outlining the logical sequence of the activities and crucial decision point that rule to the entire system. For this project, it starts from an applicant’s initial engagement to the final that precise on determination of their eligibility status.

The process begins with the applicant who are the main user who apply for the aid distribution application. The system will check the applicant’s data if the applicant already have an application by checking the IC number. If the applicant is new, the system will guide the new applicant to create a new application and in the same time, create new account for the system by fill out their personal details. If the applicant is existing applicant, they just log in to access the system by insert their IC number.

After the applicant successfully login, the system bring to the system’s dashboard. Here, the applicant can choose to update their application if they provide new information. The system then retrieves all applicant’s application data. Then, the data will put through an assessment where the system will check the basic eligibility then applies the fuzzy rules and AHP weight calculations. It can help the system to figure out the final score of eligibility status by considering all application data that system provided.

Finally, the system will display the eligibility status by showing “LAYAK” (Eligible) or “TIDAK LAYAK” (Not Eligible) where it clearly displayed. Once the

applicant seen the eligibility status, they can simply logout from the system as the end of the interaction session.

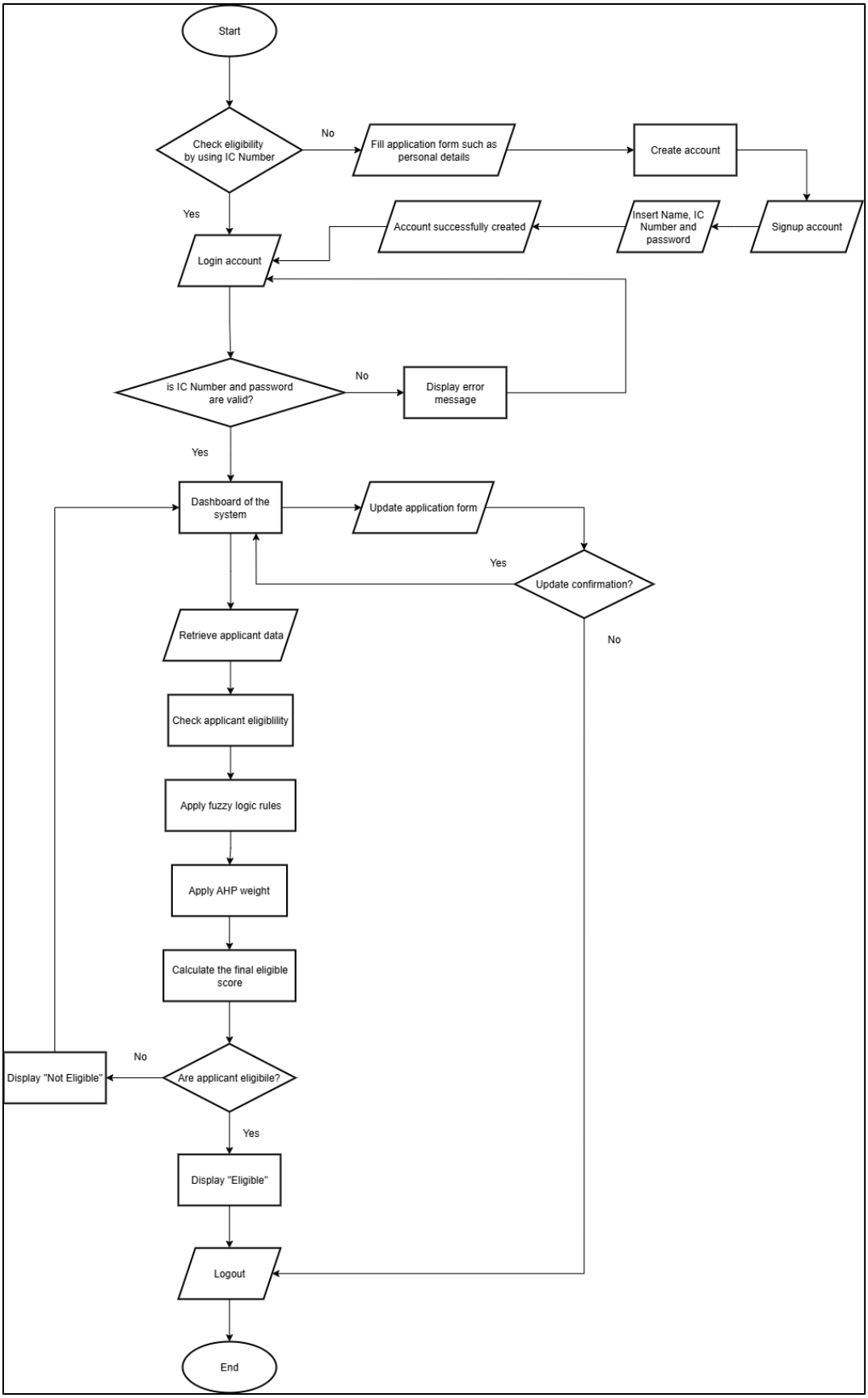


Figure 3.9 The flowchart of the project.

3.4.4 ERD Diagram

Entity Relationship Diagram (ERD) is a visual representation of how different entities can relate to each other and at the same time it is a blueprint for building a database for a system. It is used in designing and understanding the structure of a system's database and identifying each relationship between different data. It also facilitates communication between developers, database administrators and stakeholders.

In this project, the ERD diagram in Figure 3.10 clearly illustrates the foundation of the system database by includes the number of important entities and its relationship where it consist 16 main entities such as Applicant, Children, Spouse, Heir, Security Question, Ticket, Staff, Content, Unit, Agency, Application, Application Appeal, Supporting Document, Financial Aid, Fuzzy Rules and Fuzzy Configuration. Here, the Applicant entity is linked to the Children, Spouse, Heir, Security Question, Ticket and Application entities that act as foreign keys to ensure that all relevant applicant data is properly stored and accessible. For the Staff entity, it is responsible for managing and processing applications through the Application entity that linked to the Financial Aid entity that handles active financial aid records. Regarding to the eligibility result, the eligibility criteria are processed through the Financial Aid entity after the applicant data evaluated by the Fuzzy Rules entity to determine the applicant's eligibility based on the parameters made by the staff who role as ministry administrator. Once the fuzzy analysis done, the Fuzzy Config entity manage the processing by using the Analytical Hierarchical Process (AHP) before producing the final eligibility result to the staff who role as agency officer and applicants.

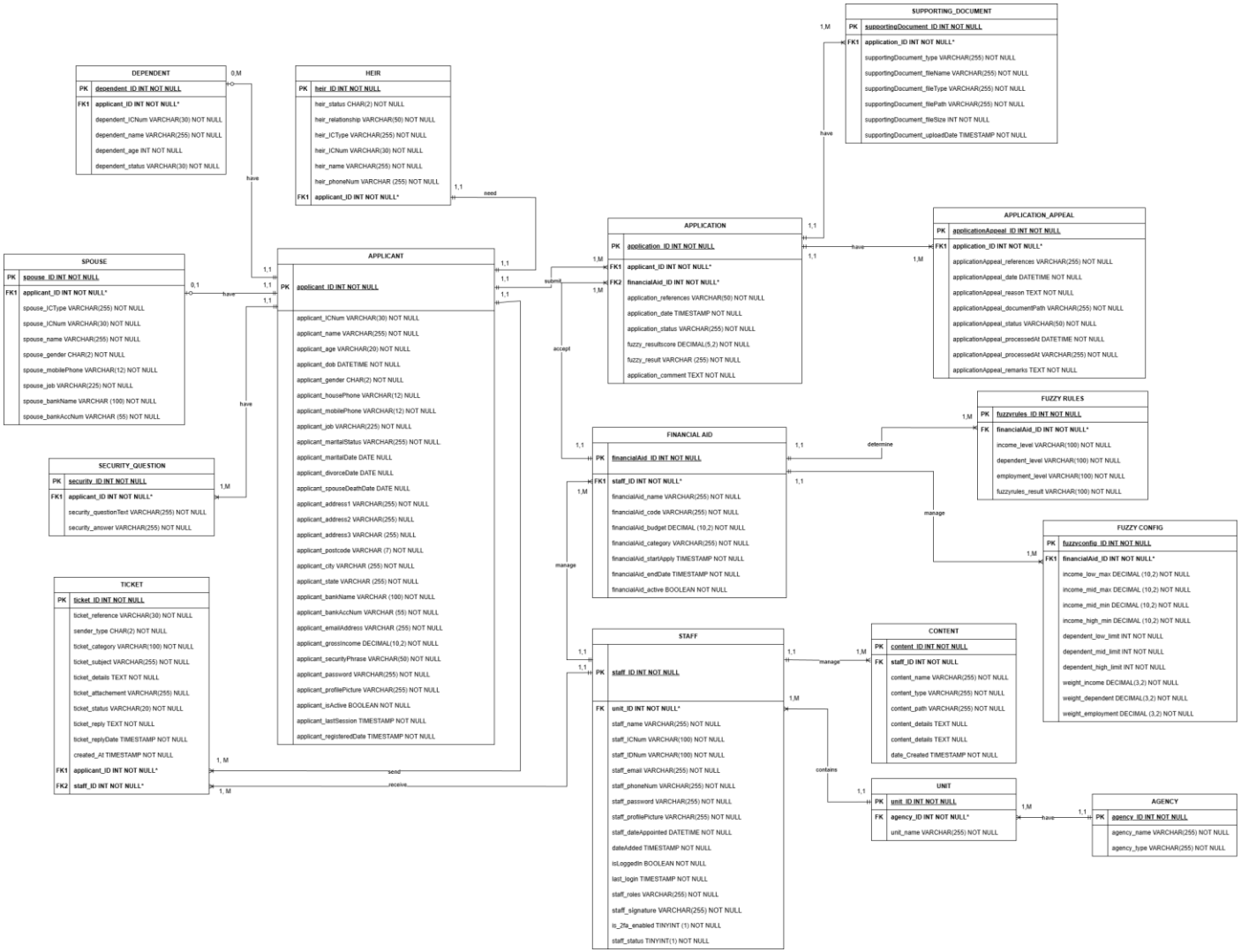


Figure 3.10 The ERD Diagram for the system for displaying the eligibility result of applicant.

3.4.5 User Interface

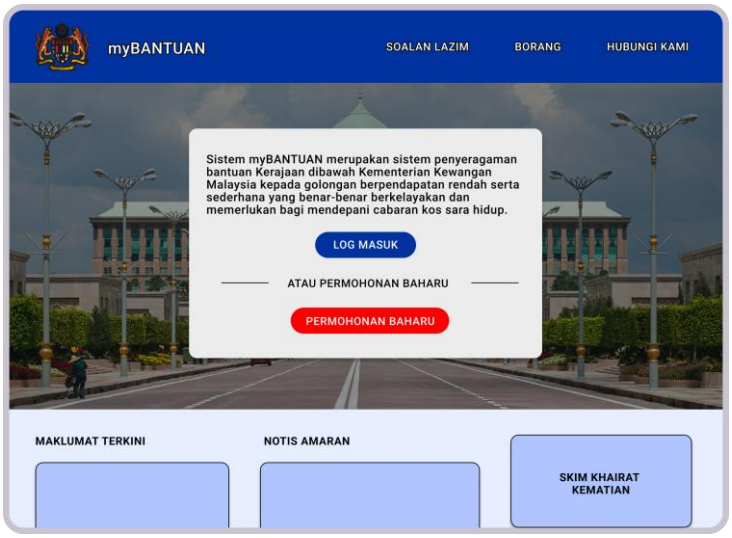


Figure 3.11 The homepage of the aid distribution application system, myBANTUAN.

Figure 3.11 shows the homepage of the aid distribution application, myBANTUAN system that focuses on aid distribution applications system. Here, it shows login button that navigate applicant to the login page where it required applicant to insert their IC number for status checking purposes. If the applicant didn't register into the system or didn't apply financial aid application, they need to apply applicant by click "PERMOHOHAN BAHARU" (New Application) button.

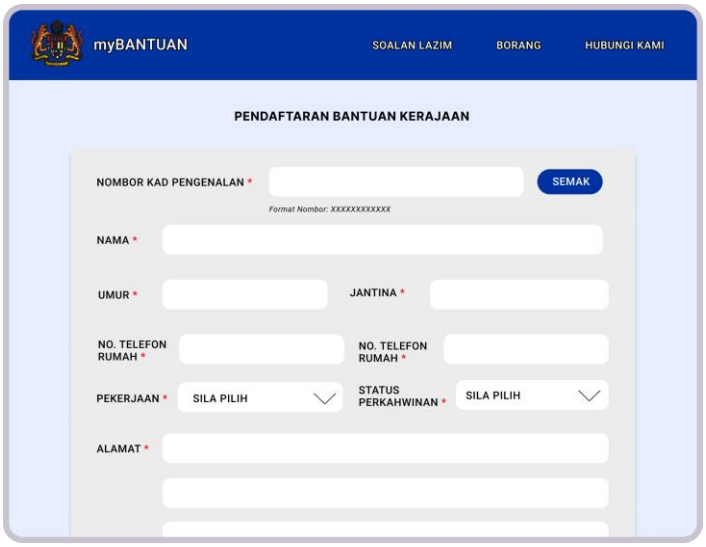


Figure 3.12 The application form of myBANTUAN.

After the applicant who didn't apply any application choose "PERMOHONAN BAHARU" button, the system will redirect to the application form as shown in Figure 3.12 where there it shows the details that applicant needs to fill out such as IC Number, Name and other details that required.

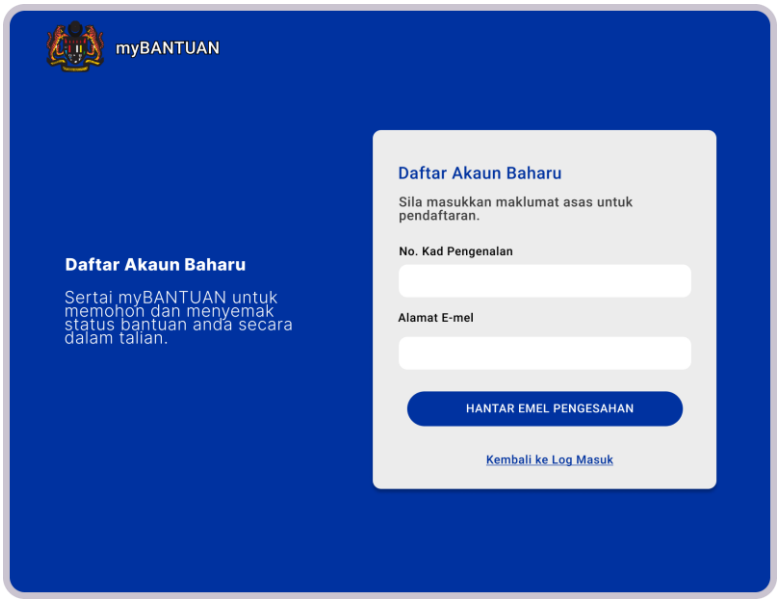


Figure 3.13 The signup page of myBANTUAN.

Next, Figure 3.13 shows the signup account of the myBANTUAN. In this page, applicant needs to fill out the details such as their IC Number, E-Mail address where here, the system will send a code as verification then the system require applicant to register the system account by insert security phrase, security question and password.

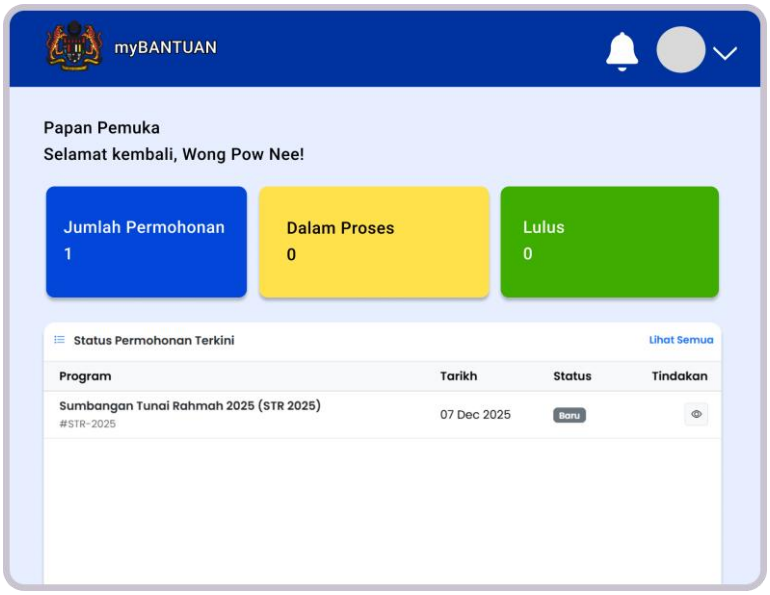


Figure 3.14 The dashboard of myBANTUAN.

Figure 3.14 shows the dashboard of myBANTUAN that act as central navigation hub for the applicant. Here, applicants can easily access various functionalities such as their application details where they can correspond their goals within the system.

Figure 3.15 The update of application form page.

Figure 3.15 shows the updating of application form page where applicant can update their latest details such as phone number, age and other details they provided. In this page, the system will show the detailed view of information that the actual data modification takes place.

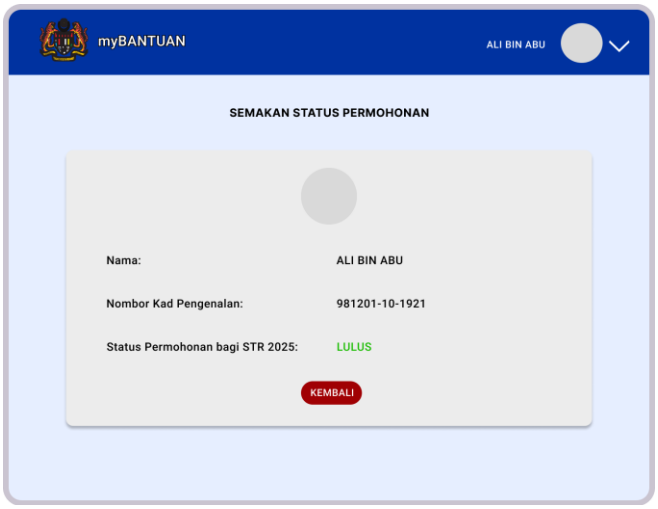


Figure 3.16 The eligiblity result status of myBANTUAN.

Figure 3.16 shows the eligibility result status page which this page is one of the crucial outcomes of the applicant's interaction with the system. Here, this page will display the details of the applicant with eligibility status for the financial aid application.

3.5 Phase 3: Implementation

According to the Waterfall model, the implementation process is the development of software starts. In this project, this system implemented by using PHP-based web application with MySQL database to ensure the data handling. A responsible web form used for allowing applicants to register, login, insert their data that used for processing the automated eligibility evaluation through fuzzy rules and AHP algorithm that built into the system itself by suing PHP scripts.

For fuzzy rules, the fuzzy membership functions and IF-THEN rules statement implemented programmatically where it can eliminate the manual calculations consistently. Same with AHP, the AHP also coded to handling the pairwise comparison matrices and calculate geometric mean, normalize weights and defuzzied results to produce clear eligibility scores. All applicant data, application submissions and its result are stored in database by ensuring the data integrity and secure user access control.

For staff, the system includes a staff panel with two different roles: agency officer and ministry administrator. For agency officer, they allow to view submitted applications, eligibility reports and detailed analysis of fuzzy AHP scoring result. Meanwhile for ministry administrator, they allow to view toe overview of the reviewed application made by agency officer who made decision on application after they review the fuzzy score and triangular fuzzy graph that generate using Analytical Hierarchical Process (AHP). This can ensure that the decision-making processes became transparent and accessible.

The development of the myBANTUAN, a system of aid distribution by implementing fuzzy and AHP was carried out by using the following tools and platforms below.

Table 3.13
Platform and Tools Used for the system

Category	Tool / Platform	Description / Purpose
Code Editor	VS Code	Writing and editing PHP, HTML, CSS, JavaScript
Programming Language	PHP	Server-side scripting to implement business logic an algorithm
Database	MySQL	Data storage for applicants, eligibility results and user account
Database Management	phpMyAdmin	GUI for managing database tables and queries
Testing Tool	Microsoft Edge browser	Debugging, testing UI and forms APIs
Version Control	GitHub	To tracking changes and backup of the system
Web Server	Apache	Serving the PHP-based web application

3.6 Phase 4: Testing

To ensure the accuracy, reliability and usability of the framework, the testing phase is essential in the development of a system by guaranteeing the system's precision and ensure each function accurately and reliably before deployment. This project is involved thorough functioning testing of all system modules that including the application of fuzzy rules and AHP to ensure the eligibility scores can calculated accurately for a variety input.

3.6.1 Testing Strategies

For testing strategies, there are three strategies that involved to validate the functionalities of the system. Firstly, Unit Testing focuses on individual components such as user registration, login validation, fuzzy rule and AHP calculation and database operations are tested by using test input data to ensure the functionality. The PHP functions for membership evaluation, IF-THEN rules and AHP weight calculations are verified for correctness and accuracy.

Second, Integration Testing such as User authentication, application submission, eligibility score computation and database storage are tested together to ensure seamless data flow. Communication between PHP scripts, MySQL database and web forms are checked to verify the data correctly passed and stored.

Finally, System Testing by ensure the complete web-based system is tested end-to-end by using test cases that includes full workflow scenarios such as applicant registration using fuzzy rules and AHP and admin panel. Section 3.7.2 Functional Testing shown the detailed test cases and expected outcomes during this phase.

3.6.2 Functional Testing

Table 3.14
Functional Testing

Test Case ID	Functionality	Expected Outcome	Actual Outcome	Status (Pass / Fail)
TC001	User Registration	User (Applicant and Staff) successfully register with valid data		
TC002	User login	User (Applicant and Staff) can login with correct IC Number (Applicant), Staff ID number (Staff) and password		
TC003	Submit Application Form	Application data and eligibility score saved into database		
TC004	Eligibility Calculation	Fuzzy rules and AHP calculate the eligibility correctly		
TC005	View Application	Staff can view submitted applications		
TC006	View eligibility report	Staff can access eligibility reports with scoring details		
TC007	Input validation	Application form prevents submission of invalid or incomplete data		
TC008	SQL Injection Protection	System blocks SQL injection attempts		
TC009	Session management	User (Applicant and Staff) session expired after logout		

3.7 Summary

In conclusion, this chapter has explained the research methodology in developing an eGovernment framework for budgeting using fuzzy rules and Hierarchical Process (AHP) in focusing on the eligibility of government aid recipients. This approach is carried out using the Waterfall model to carry out the development of this project into sequential and structured phases by ensuring that the completion of the development can be done systematically before proceeding to the next stage that help in achieving a reliable and robust system.

The research methodology began with Requirement Analysis phase which involved preliminary literature review related to fuzzy logic, Analytical Hierarchical Process (AHP), budgeting, and work assistance processes in addition to data collection from the Department of Statistics Malaysia (DOSM) and design of synthetic applicant data to run simulation data which essential for testing and validating the project's effectiveness under diverse conditions. The System Design Phase included the development of membership functions, IF-THEN fuzzy rules, AHP pairwise comparison matrices, system architecture design, use case diagrams, flowchart, ERD diagram and User Interface to clearly translate the qualification determination process by ensuring the project is transparent, traceable and aligned to the project objectives.

For the implementation of this framework, the framework built in PHP-based system with MySQL to define implementing fuzzy rules and AHP matrices, defuzzification and eligibility scoring for each application that made by applicants. Testing is conducted that involves sensitivity tests, boundary condition tests and repeatability checks to ensure consistent and precise fuzzy rules and AHP calculations. Although maintenance is designed to updating PHP code to modify fuzzy rules and AHP weight when government change the aid eligibility or policies.

With this methodology, it can be applied systematically which can ensure that this system can be created in a transparent, easy-to-use and maintainable manner while supporting the determination of eligibility for the government assistance distribution process.

CHAPTER 4
RESULTS AND FINDINGS

In this chapter, the results and findings of the development of the system, the determination of aid eligibility using the Fuzzy Rules and Analytical Hierarchical Process (AHP) methods, which include the development of a fuzzy rules module, the generation of Analytical Hierarchical Process (AHP) weighted values, the implementation of the system in processing applications, the results of the application process and the analysis of the application eligibility results. All findings are presented in this chapter to show the effectiveness of the model in producing fairer and more consistent eligibility assessment results based on mathematical justification and fuzzy rules.

4.1 Fuzzy AHP Development Framework

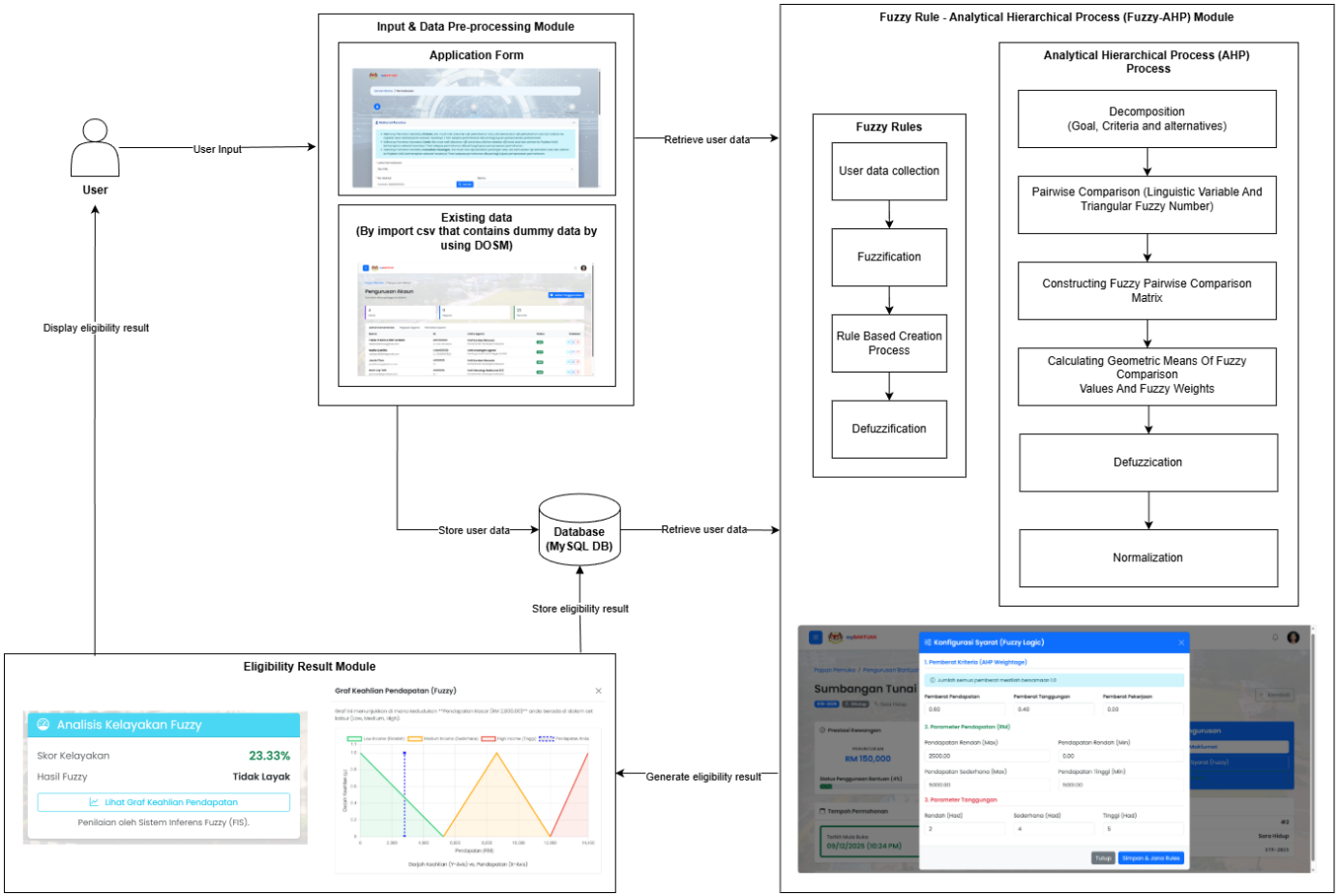


Figure 4.1 Fuzzy AHP development framework architectural flow diagram

Figure 4.1 shows the Fuzzy AHP Development framework flow for the development of a financial aid eligibility determination system based on fuzzy AHP to integrate fuzzy rules and Analytical Hierarchical Process (AHP) in a comprehensive, consistent and efficient work process. It starts with the data input module and data pre-processing module where the user will enter information into the system, namely the applicant using the application form while the ministry admin enters existing data by importing a csv file or entering user data manually. The information provided by both users is necessary for the use of the system, especially in assessing the applicant's eligibility status. The provision of the function to import information via CSV format files is intended to facilitate the process of migrating existing data into the system systematically. This step is in line with standard procedures in the public sector which prioritizes the use of authentic data from various government agencies or departments to ensure the integrity of information and the efficiency of government system management being developed. All data will go through a data cleaning process such as number format correction, identity card format correction and category coding, all of which will be stored in the MySQL database.

Then, the cleaned data will be sent to the fuzzy rules module to carry out the initial data interpretation process by setting a fuzzy set definition for each input variable through the determination of a membership function. In this module, linguistic variables such as Low, Medium and High will be used to enable the system to interpret information without relying on rigid engineering values. The fuzzy membership values will then be processed through a rule-based inference method using the If-Then rule which will be explained in subtopic 4.1.1, namely Fuzzy Rule Module Development. All rules made are dynamic and can be updated by the ministry administrator who acts as the system administrator by making this system more flexible and able to improve policies in the future.

Next, the initial fuzzy score that has been generated will then be sent to the Analytical Hierarchical Process (AHP) Module process for the purpose of weighting and prioritizing criteria in determining the applicant's qualifications. In this module, AHP is applied by breaking the decision structure into three layers, namely Goals, Criteria, Sub-Criteria and Alternatives of the applicant. The pairwise comparison evaluation process will be carried out using linguistic variables based on fuzzy scales

which are detailed in subtopic 4.1.2., namely the Analytical Hierarchical Process (AHP) Module. All of this will be translated into Triangular Fuzzy Number and then form a Fuzzy Pairwise Comparison Matrix and will be calculated using the Geometric Mean method to produce a fuzzy value. Then, this fuzzy value will go through a defuzzification process where the fuzzy value will be converted to a crisp value to obtain the final weight value. This final weight will be normalized to ensure that the total is 1.0 and then becomes the basis for calculating the final qualification score.

The result of the integration of the fuzzy rules module with the AHP weights will produce an overall qualification score in the form of a percentage and qualification status. This value to determine the status of eligibility to receive assistance is ≥50% (Eligible) and <50% (Not Eligible). Once these results are obtained, the system will produce an analysis report that displays a triangular graph using a fuzzy membership graph using income as an indicator. This report will be displayed through the applicant panel and staff panel with the aim of supporting transparency and audit activities in determining the eligibility of the application.

4.1.1 Fuzzy Rule Module Development

The Fuzzy Rules module is a core component for determining the initial eligibility decision of an applicant based on three main criteria, namely income, number of dependents, and employment status. Each of these variables is represented using linguistic terms such as LOW, MEDIUM, and HIGH to describe the actual situation of the applicant based on a range that has been set in accordance with the conditions of a government assistance application. Therefore, the use of these linguistic terms is in line with the objective of fuzzy logic with the aim of translating numerical inputs into values that can be interpreted and unambiguous according to real-world conditions.

After the membership function has been determined, a set of fuzzy rules is formed based on the logical relationship between the three criteria. Table 4.1 shows a list of fuzzy rules condition used in this framework to determine the initial decision of the applicant's eligibility. Each rule is built to mimic the typical decision pattern made by government officials. For example, an applicant who has a low income (LOW), a

high number of dependents (HIGH) and is unemployed (UMEMPLOYED), then the applicant's eligibility is high (HIGH) because he belongs to the critical category facing financial problems. If an applicant has a high income (HIGH), works full time (EMPLOYED) and has no dependents (LOW), then the applicant's eligibility is low (LOW) because the applicant is in a group where the economic situation is stable and is not eligible to apply for financial assistance.

Table 4.1
The Fuzzy Rules condition to determine the applicant's eligibility

No	Fuzzy Rules
1	If income is LOW AND dependent is LOW AND employment is UNEMPLOYED, Then eligibility are HIGH.
2	If income is LOW AND dependent is MEDIUM AND employment is UNEMPLOYED, Then eligibility are HIGH.
3	If income is LOW AND dependent is HIGH AND employment is UNEMPLOYED, Then eligibility are HIGH.
4	If income is MEDIUM AND dependent is LOW AND employment is UNEMPLOYED, Then eligibility are MEDIUM.
5	If income is MEDIUM AND dependent is MEDIUM AND employment is UNEMPLOYED, Then eligibility are MEDIUM.
6	If income is MEDIUM AND dependent is HIGH AND employment is UNEMPLOYED, Then eligibility are MEDIUM.
7	If income is HIGH AND dependent is LOW AND employment is UNEMPLOYED, Then eligibility are LOW.
8	If income is HIGH AND dependent is MEDIUM AND employment is UNEMPLOYED, Then eligibility are LOW.
9	If income is HIGH AND dependent is HIGH AND employment is UNEMPLOYED, Then eligibility are LOW.
10	If income is LOW AND dependent is LOW AND employment is EMPLOYED, Then eligibility are HIGH.
11	If income is LOW AND dependent is MEDIUM AND employment is EMPLOYED, Then eligibility are HIGH.
12	If income is LOW AND dependent is HIGH AND employment is EMPLOYED, Then eligibility are HIGH.
13	If income is MEDIUM AND dependent is LOW AND employment is EMPLOYED, Then eligibility are MEDIUM.
14	If income is MEDIUM AND dependent is MEDIUM AND employment is EMPLOYED, Then eligibility are MEDIUM.
15	If income is MEDIUM AND dependent is HIGH AND employment is EMPLOYED,

	Then eligibility are MEDIUM
16	If income is HIGH (L) AND dependent is LOW AND employment is EMPLOYED, Then eligibility are LOW
17	If income is HIGH (L) AND dependent is MEDIUM AND employment is EMPLOYED, Then eligibility are LOW
18	If income is HIGH (L) AND dependent is HIGH AND employment is EMPLOYED, Then eligibility are LOW

This fuzzy rule also functions as an inference machine that will be used to produce initial qualification results. Then, this result will be taken to the Analytical Hierarchical Process (AHP) module to calculate the final score for the applicant's qualification results in depth and holistically. The development of this fuzzy rule module can reduce the mass of inconsistencies in the results and can increase transparency in the process of interpreting and evaluating aid applications.

4.1.2 Analytical Hierarchical Process (AHP) Module Development

The Analytical Hierarchical Process (AHP) module is an important module in this framework after the fuzzy rules module where it is used to determine the priority (priority weighting) of the criteria involved in assessing the eligibility of the application. Each criterion set does not have the same importance where each criterion has its own significance in determining the actual ability of the applicant. Weighting or weightage is needed in calculating the final score of the applicant's eligibility in an aid application with the aim of being able to coordinate the policies of the ministry and its agency.

First, the development of AHP begins by defining the data range for each criterion. For this framework, there are three main criteria, namely Income, Number of dependents and employment. Table 4.2, Table 4.3 and Table 4.4 show the linguistic data division table for the three criteria based on the usual eligibility conditions for assistance applications and through literature review. This is very important because it can ensure that the system can categorize the input from the fuzzy rules module consistently and avoid any problems of overlapping ranges that can thwart the fuzzy calculation process.

Table 4.2

Income Criteria

Variable	Income Data Range
Low	[0 – 5250]
Medium	[5251 – 12000]
High	[12001 – 20000]

Table 4.3

Number of Dependent Criteria

Variable	Number of Dependent Data Range
Low	0
Medium	1-4
High	≥ 5

Table 4.4

Employment Criteria

Variable	Employment Data Range
Low	Unemployed
Medium	Self-Employed, Retired
High	Full-Employed (Government, Private)

Next, these criteria will be compared using the pairwise comparison method to determine the relative importance of each other. Table 4.5 shows the linguistic scale matched with a triangular fuzzy numbering scale to facilitate the mathematical processing process. This can help in the subjective assessment of officers by using indicators such as Equally important and Important. In addition, it can also act as a numerical model that can be calculated systematically and efficiently.

Table 4.5

The criterion of aid distribution rating

Linguistic Variables	Linguistic Scale	Triangular Fuzzy Numbering Scale
Equally Important	1	(1,1,1)
Slightly More Important	2	(1,2,3)
Moderately More Important	3	(2,3,4)
Important	4	(3,4,5)
Strongly More Important	5	(4,5,6)
Very Strongly More Important	6	(5,6,7)
Extremely Important	7	(6,7,8)

Absolutely More Important	8	(7,8,9)
Not Important	9	(9,9,9)

Table 4.6 shows the pairwise comparison matrix for this study where the fuzzy values in this matrix are used in the geometric mean calculation process, normalization and defuzzification before it produces a weight value for each criterion. This weight value will be used in the calculation of the final score of the applicant's qualifications together with the fuzzy inference value that has been generated by the fuzzy rules' module.

Table 4.6

The fuzzy pairwise comparison matrix

Criteria	Income	Dependents	Employment
Income	(1,1,1)	(1,1,1)	(3,4,5)
Dependents	(1/4, 1/3, ½)	(1,2,3)	(2,3,4)
Employment	(1/4, 1/6, 1/3)	(2,3,4)	(1,1,1)

The Analytical Hierarchical Process (AHP) module provides a detailed structure in the applicant qualification assessment system by ensuring that each resulting decision can be justified through a strong and clear mathematical basis. The combination of fuzzy rules and AHP can allow the system to more accurately imitate the thinking of officers in assessing applications and it can also minimize the risk of injustice if the decision is made entirely manually.

4.2 Analysis of Fuzzy AHP Development Framework on Applicant Eligibility Result

This section details the evaluation of the effectiveness of the budgeting system of managing aid distribution through the application of fuzzy logic and the integration of AHP techniques. This hybrid approach serves as the main mechanism in identifying the eligibility level of applicants to receive financial assistance based on the established parameters. This analysis will focus on comparing the results between applicants who are eligible to receive assistance and those who are not eligible to receive assistance using two applicant data sets as examples. By examining the process from fuzzy inference to the calculation of the final score, this section will show how the integration

of fuzzy rules with the Analytical Hierarchical Process (AHP) in assessing the eligibility status of applicants.

To demonstrate the process of evaluating eligibility decisions, two applicants were selected as sample based on different socioeconomic profiles by using Sumbangan Tunai Rahmah 2026 (STR2026) dataset that extracted from the system.. The two selected applicants were taken from dummy data that was cleaned when imported from a .csv file. into the system by the ministry admin. Table 4.7 shows the data of two applicants who applied with different socioeconomic characteristics.

Table 4.7
Sample of two applicants with different socioeconomic characteristics

Applicant Name	Income	No. of Dependent	Employment Type	Eligibility Score	Eligibility Score Status
Ahmad Bin Perang (IC Number: 941001802730)	RM 3100.00	1	Government (Employed)	20.5%	Tidak Layak (Failed)
Tunku Ismail bin Tunku Yahaya (IC Number: 040705229705)	RM 1000.00	4	Self-Employed (Employed)	65.5%	Layak (Passed)

The first applicant, Ahmad Bin Perang, represents a high-income household category of RM3,100.00 with a small number of dependents and has a stable career as a government employee. Meanwhile, the second applicant, Tunku Ismail bin Tunku Yahya, represents a low-income household of RM1,000.00 with a burden of 4 dependents and is only self-employed.

For the fuzzy rules module, both samples will be translated from quantitative input variables to fuzzy linguistic terms. Each applicant data will be interpreted according to the membership function based on the main criteria (Income, Dependent and Employment) from the applicant data based on Table 4.2, Table 4.3 and Table 4.4. The linguistic variables will be defined into three, namely LOW, MEDIUM and HIGH representing the applicant's qualification level.

For the first applicant, Ahmad Bin Perang, his income is RM 3100.00 where the criteria variable for the first applicant's income is Low. The number of dependents is 1 and the criteria variable for dependents is Medium. Finally, for employment status, the first applicant works as a government employee and the criteria variable is Med. When these three are combined as a fuzzy rules membership condition, then the probability of qualifying for assistance is Ineligible, indicating that the first applicant has a stable economy and is not considered to need to apply for assistance.

The second applicant, Tunku Ismail bin Tunku Yahya, has an income of RM1000.00 where the criteria variable shows the Low range. Next, for dependents, he has 4 dependents who are potentially eligible to receive assistance. For government, he is self-employed with the criteria variable which is Medium. Therefore, according to the fuzzy rules membership condition, the second applicant is eligible by reflecting the need to apply for assistance with the aim of temporarily stabilizing finances.

Next, after both applicants have the initial results of the application eligibility status, the Analytical Hierarchical Process (AHP) module is used to calculate the final eligibility score for the applicant's eligibility to apply for financial assistance by using weights for each criterion. The pairwise comparison process and the fuzzy AHP process that have been detailed in subtopic 4.1.2 where can produce weights that reflect relative importance. The weights for each aid will be determined by the ministry admin by entering the weights they determine to ensure that the Fuzzy AHP algorithm produces a score that is in line with the objectives of the aid as shown in Figure 4.2.

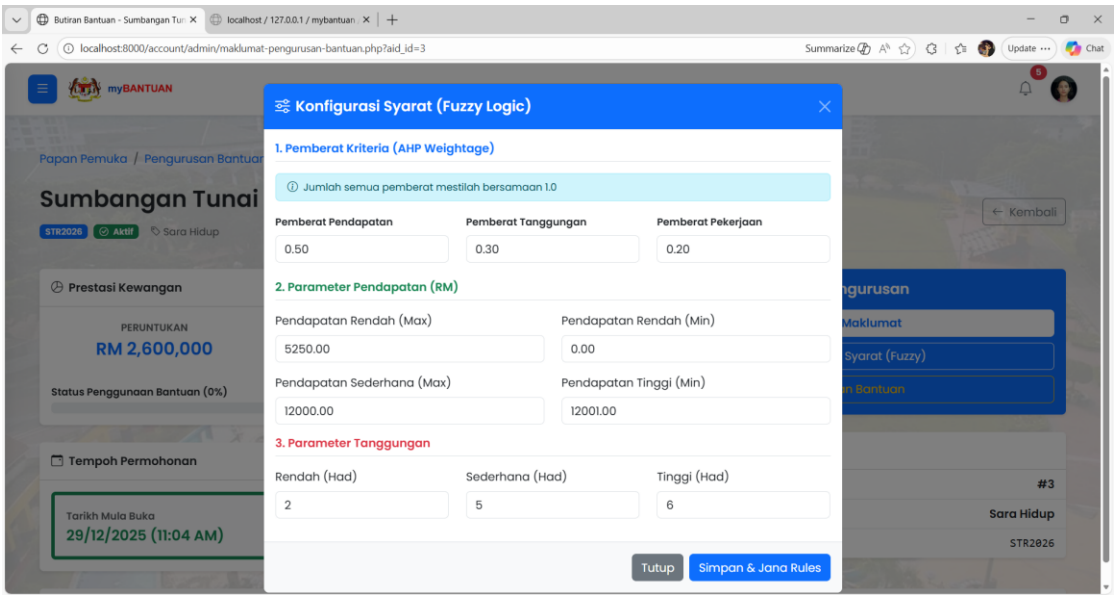


Figure 4.2 Weights set for each financial assistance application that made by the ministry admin for fuzzy logic configuration.

The eligibility score will be calculated using the defuzzified fuzzy rule weightings as follows:

$$\textit{Eligibility Score} = (\textit{Income Score} \times 0.50) + (\textit{Dependents} \times 0.30) + (\textit{Employment Score} \times 0.20) \quad (4.1)$$

For the first applicant, Ahmad Bin Perang, the calculation produced an eligibility score of 20.5%, which is below the 50% eligibility threshold leading to a classification of Not Eligible (Not Eligible). Meanwhile, for the second applicant, Tunku Ismail bin Tunku Yahaya, the weighted calculation produced an eligibility score of 65.5%, which exceeded the 50% threshold and resulted in a classification of Eligible (Eligible).

4.3 User Interface

For the user interface, it consists of three interfaces, namely the main section, applicant section and staff section. For the staff section, it is divided into two roles, namely agency officers and ministry administrators. This framework is implemented in this web system as the basis for the process of determining eligibility and distributing financial assistance dynamically.

4.3.1 Main Section

This section describes the user interface of the main section of the system that accessible to users. Each page has its own function with the aim of helping users get information related to assistance, make assistance applications online, manage assistance applications and know the status of their application eligibility. Therefore, responsive design is very necessary to make it easy for users to access the site easily and can be used on any platform such as tablets and computers.

For the user interface of the main module, it focuses on a user-centered design approach where it plays the function of clear navigation, the use of appropriate colors and can facilitate the understanding of users from various backgrounds. Figure 4.1 to Figure 4.15 show the pages for the main section of the system.

4.3.1.1 Main Page

The main page is used as the main interface of the users to access the system where users are introduced to the system functions and navigations that related to financial aid eligibility such as navigation links related to assistance and navigation for assistance applications for those who have not yet applied. The design of this main page emphasizes simple and informative design elements by creating several access sections related to assistance such as the latest information and frequently asked questions with the aim of making it easier for users to understand the latest information related to assistance made by the ministry administrator.

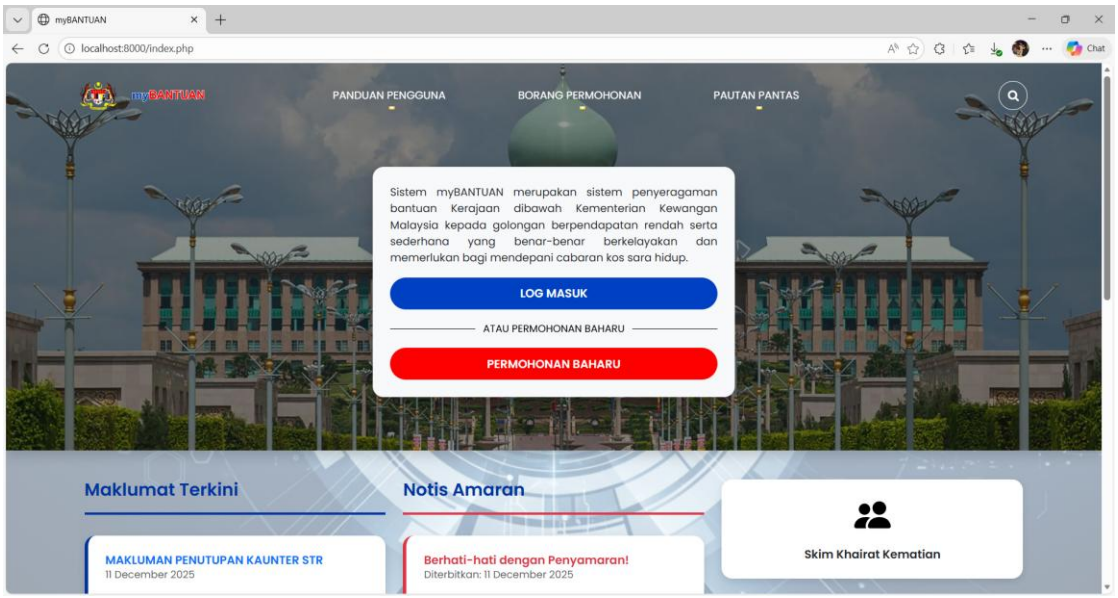


Figure 4.3 The main page of myBANTUAN.

4.3.1.2 Maklumat Terkini page

For the Maklumat Terkini (Latest Information) page, it displays the latest information on current assistance including the assistance payment schedule and official notifications from the Ministry of Finance Malaysia which is managed by the ministry administrator. This page is used to make it easier for users to access accurate information on current assistance without referring to any party other than the Ministry of Finance Malaysia and its agencies.

Figure 4.4 Maklumat Terkini page

4.3.1.3 Notis Amaran page

The Notis Amaran (Warning Notice) page is used to notify users of notices related to applications such as fraud warnings, application deadlines, and technical issues. The notices displayed are intended to ensure that users are aware of important information that can affect the assistance application process.

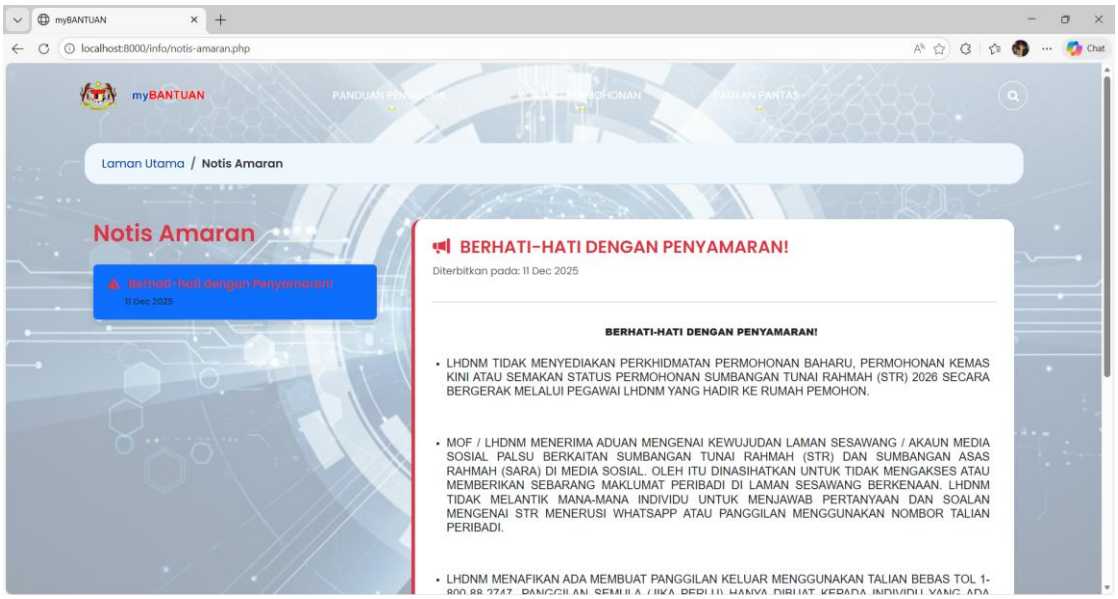


Figure 4.5 Notis Amaran page

4.3.1.4 Skim Khairat Kematian page

The Skim Khairat Kematian (Death Benefit Scheme) page also displays information related to this scheme such as the claim process with the aim of being a reference for users (heirs) who need emergency financial support. This page also allows users to access the application form through the links provided on this page.

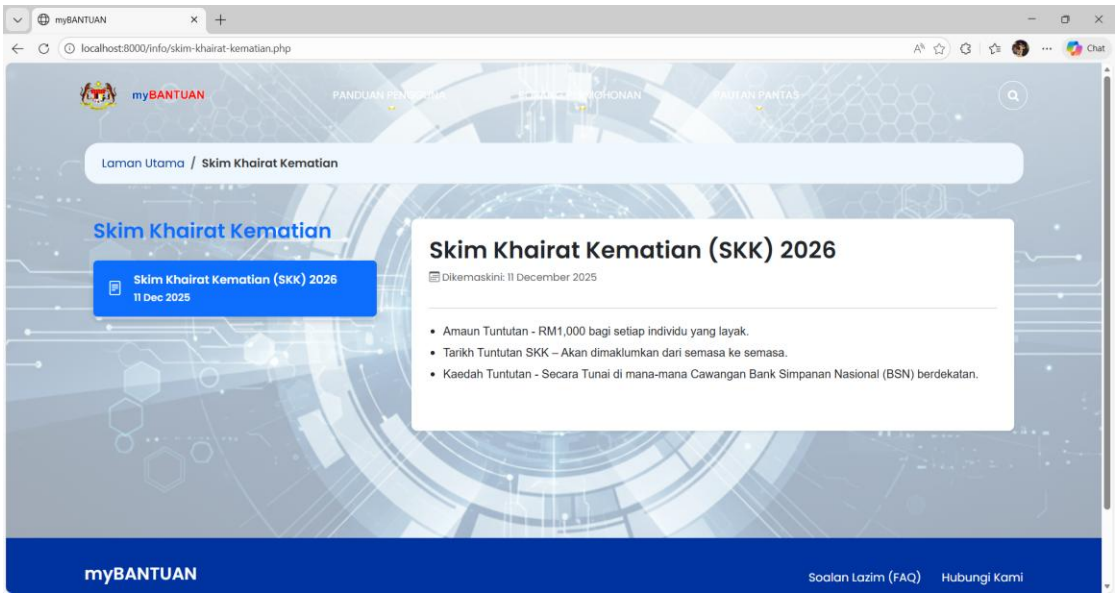


Figure 4.6 Skim Khairat Kematian page

4.3.1.5 Sumbangan Asas Rahmah (SARA) page

For Sumbangan Asas Rahmah (SARA) page, it focuses on information related to the Sumbangan Asas Rahmah (SARA) assistance program where it displays information related to the assistance program with the aim of making it easier for users to follow information about the SARA assistance program.

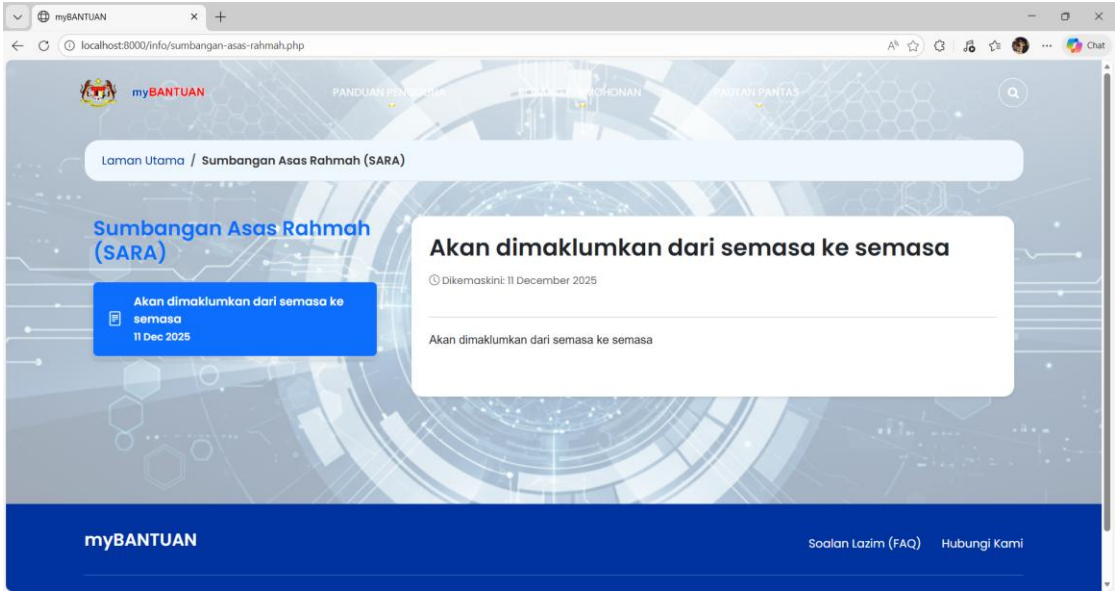


Figure 4.7 Sumbangan Asas Rahmah (SARA) page

4.3.1.6 Hebahan Infografik page

The Hebahan Infografik (Infographic Announcement) page displays interactive infographics that include information related to current aid applications, aid statistics, and information related to aid. This page was developed to create visual literacy for users regarding current information related to this aid system. The visual display featured on this page is in the form of images with the aim of making it easier for users to understand the data easily.

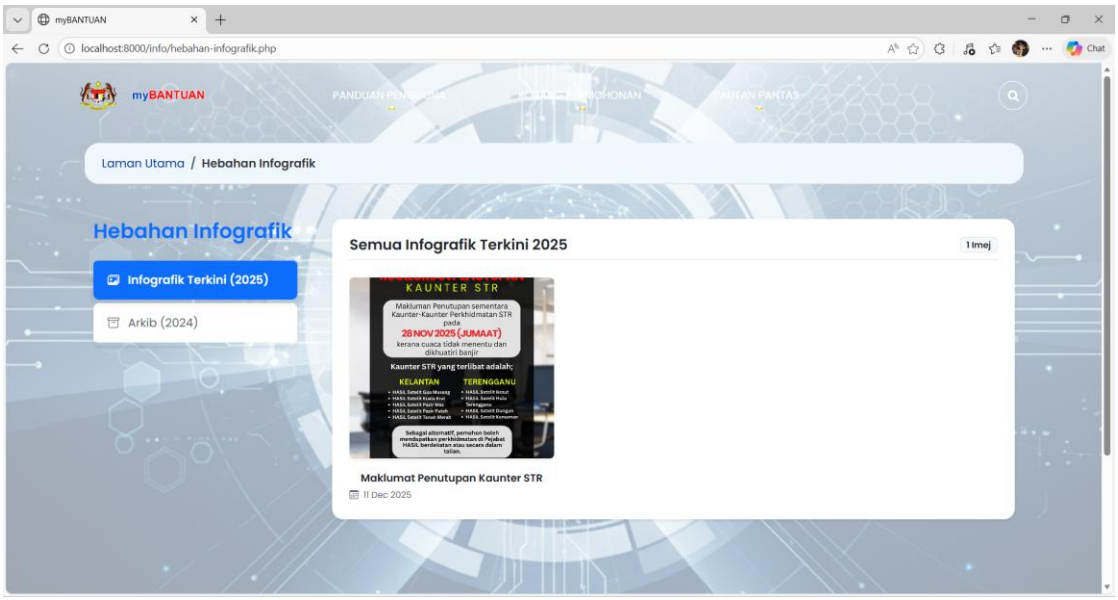


Figure 4.8 Hebahan Infografik page

4.3.1.7 Soalan Lazim page

The Soalan Lazim (Frequently Asked Questions) (FAQ) page collects common questions related to assistance and the assistance system that are frequently asked by users. Each question will be matched with a document provided by the Ministry of Finance Malaysia with an easy-to-understand answer and reducing reliance on technical support.

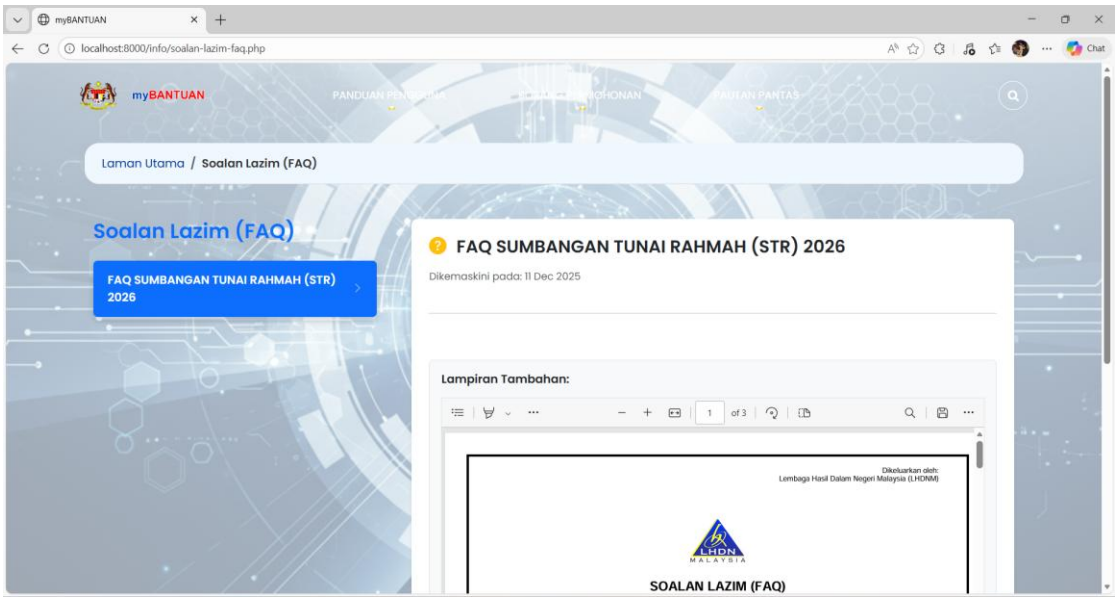


Figure 4.9 Soalan Lazim page

4.3.1.8 Hubungi Kami page

This page contains official contact information for the ministry that manages this system such as phone numbers, email addresses, and office locations. This is to make it easier for users to get more in-depth help-related information if there is a problem related to the system.

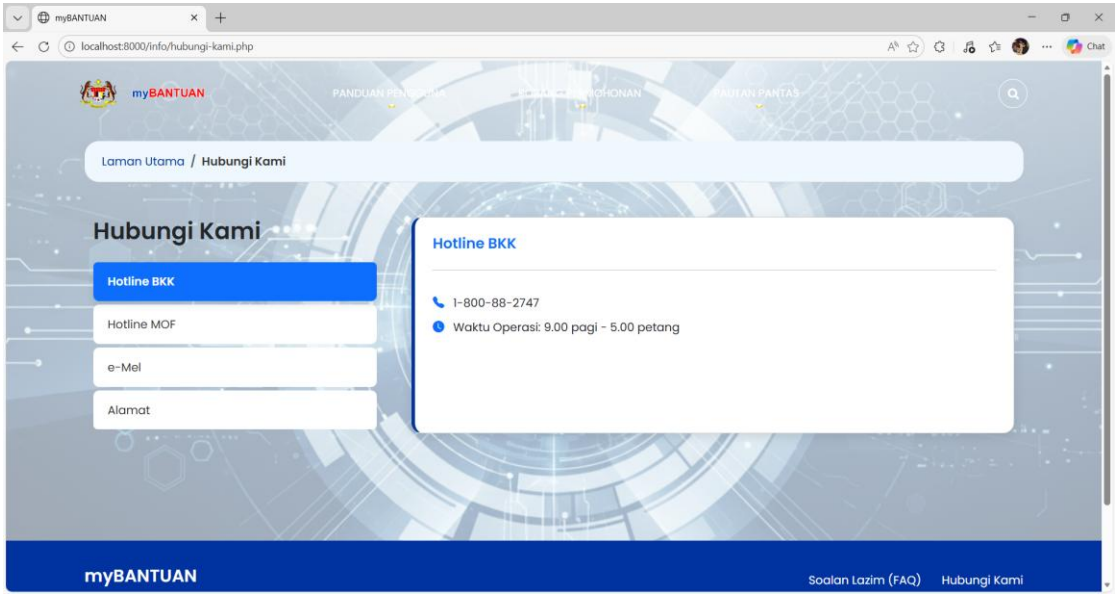


Figure 4.10 Hubungi Kami page

4.3.1.9 Search Result page

The Search Results page will display the search results made by the user when the user enters a search related to assistance information in the search button. The output of this page will show a list of search results available in this main section.

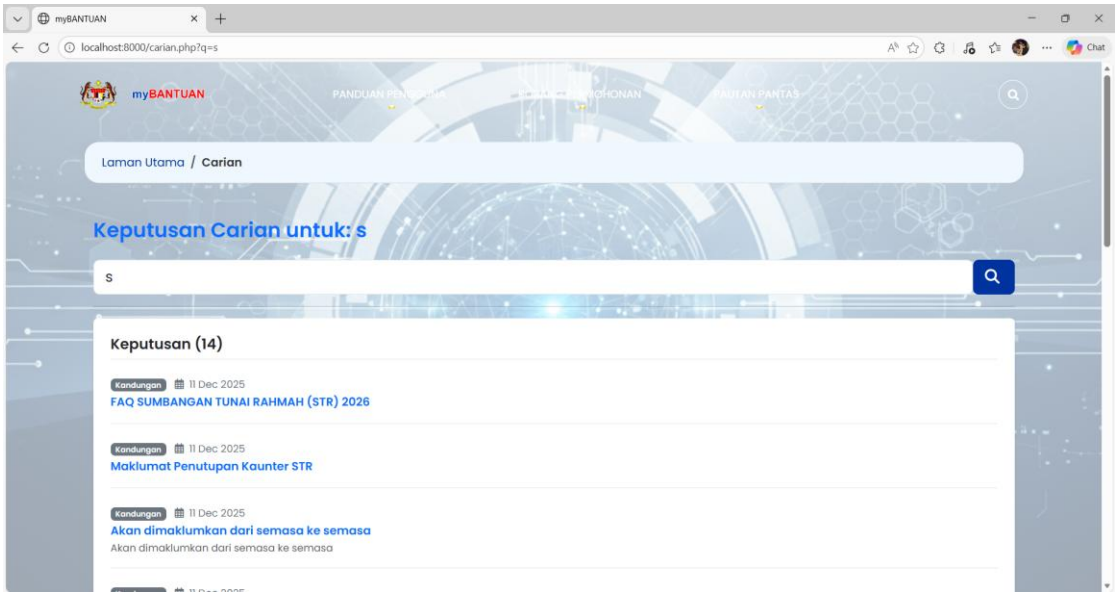


Figure 4.11 Search result page

4.3.1.10 Login Page

For login page, it used to authorize users registered with this system for the purpose of accessing their accounts. This mechanism is developed to ensure that authorized users can change their information and manage assistance request information.

This page is divided into 3 parts, namely applicant, agency officer and ministry administrator. For applicants, they need to enter their identity card number and then they need to confirm their security phrase as shown in Figure 4.11. If they confirm, they can fill in their password before being given access to the system.

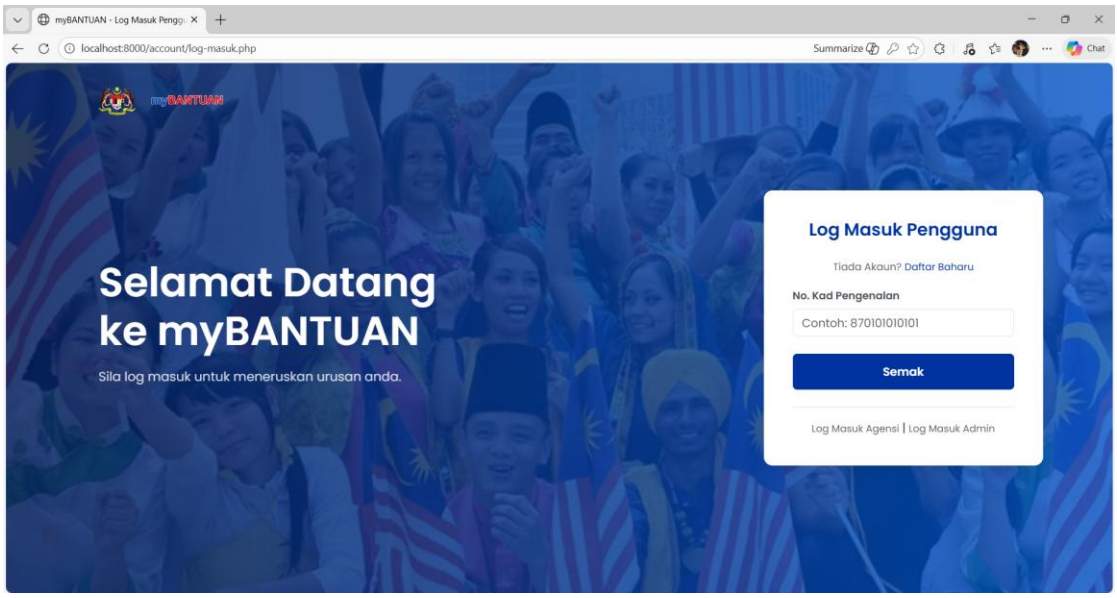


Figure 4.12 Applicant login page

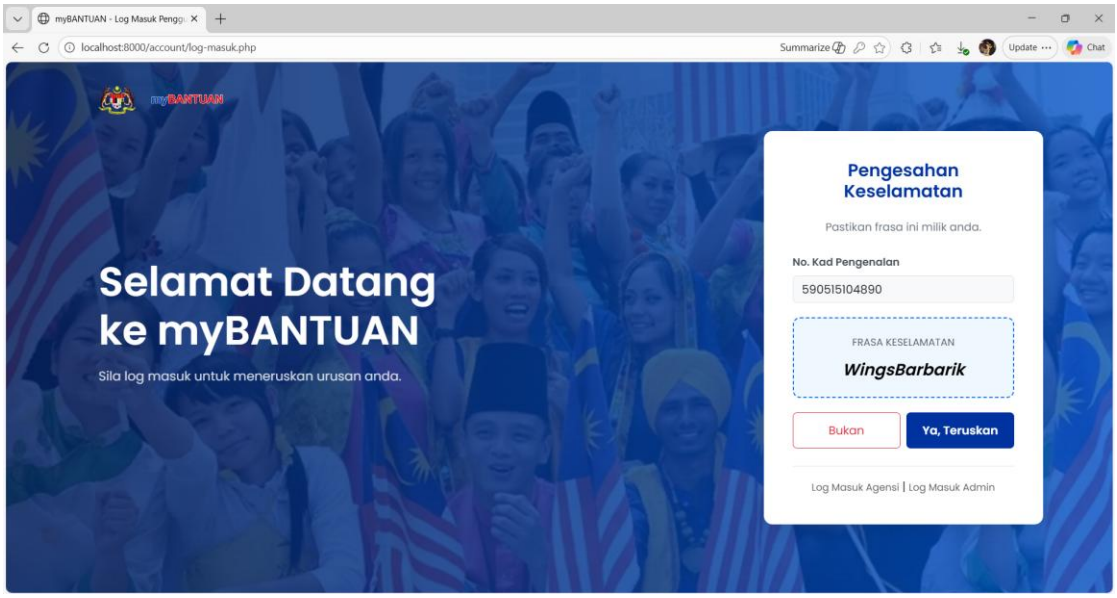


Figure 4.13 Applicant's security phrase confirmation

For agency officer and ministry administrator, they need to enter their ID number and password before they can access the system as shown in Figure 4.12 and Figure 4.13.

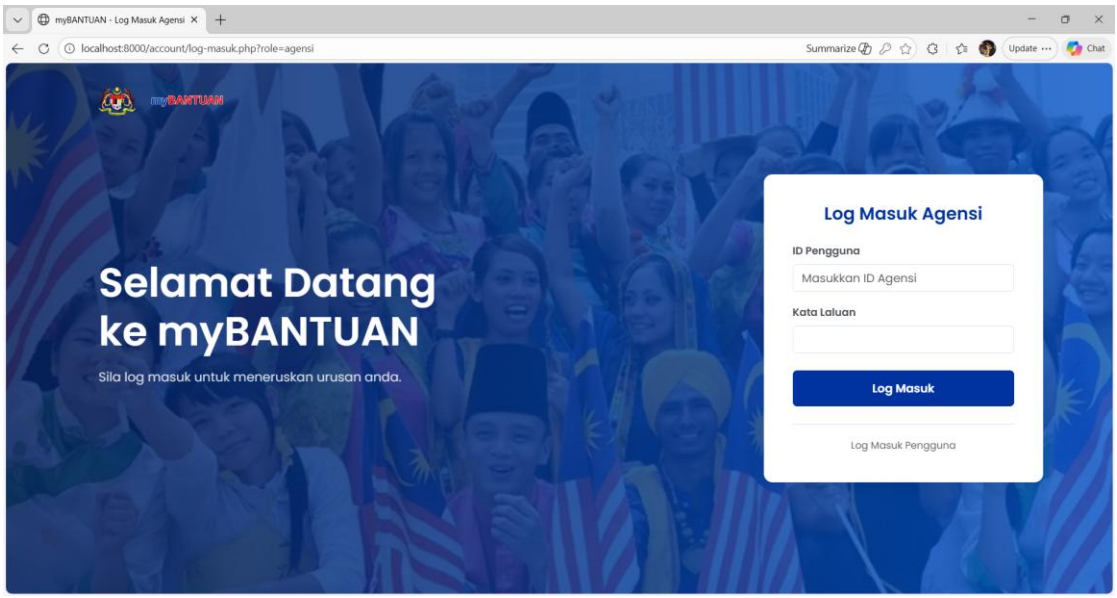


Figure 4.14 Agency officer login page

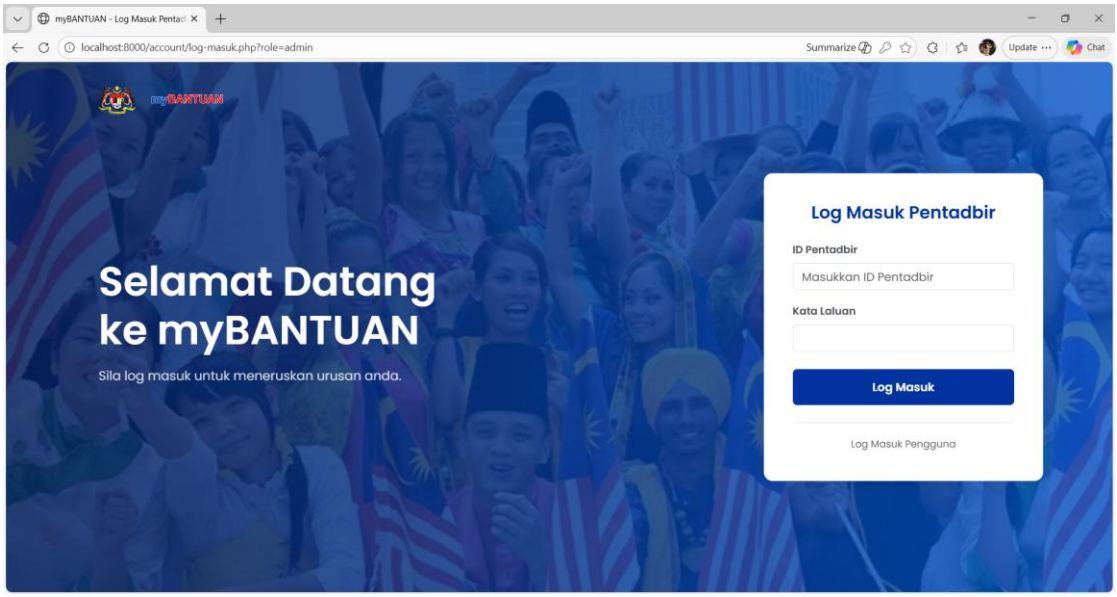


Figure 4.15 Ministry Administrator login page

4.3.1.11 Registration page

The registration page used to create an applicant account in the system after making an application on the application page with the aim that they can check the eligibility status of their application and make other assistance applications. To register an applicant account, they need their identity card number and email address as shown in Figure 4.14. Then, the system will send an OTP code to the applicant's email based on the applicant. Applicants are required to set a question and a security phrase to increase the level of account security and prevent any data leakage. Next, applicants are also required to set a password for the purpose of accessing the system.

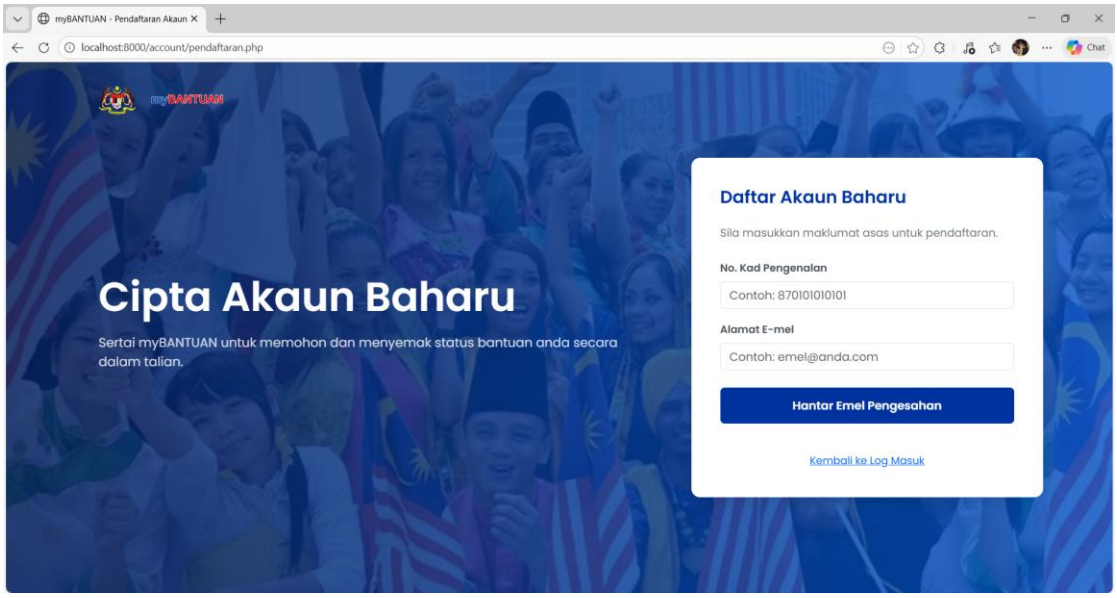


Figure 4.16 Applicant account registration page

4.3.1.12 Application page

For the application page, it is one of the pages that is the focus because applicants need to enter their personal information in the application form on this page by entering their identity card number with the aim of ensuring that their identity card number exists in the system. If not, they need to contact the Ministry of Finance Malaysia or related agencies to manage data that is not in the system. Through this page, the input entered by the applicant is used in processing fuzzy rules and Analytical Hierarchical Process (AHP) which is the core of this framework project for the purpose of determining the applicant's eligibility.

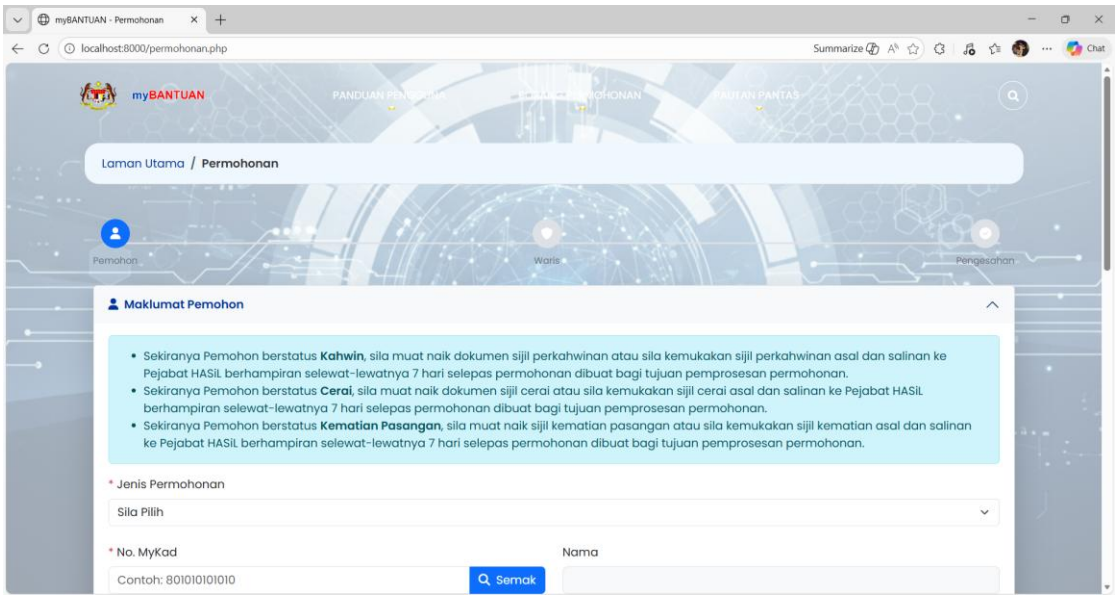


Figure 4.17 Application page of myBANTUAN.

4.3.2 Applicant Panel

For this panel, applicants need to log in to the system by ensuring their identity card number and correct password before accessing the system. This panel provides several specific functions for applicant actions including updating assistance application information, making a new application and checking the eligibility status of assistance applications. Each view is developed to ensure that applicants can navigate the system easily through the features available in the system which can be found in the sidebar of the panel.

4.3.2.1 Dashboard Page

The dashboard page is the first page that will be displayed in the applicant panel after an applicant logs in. This page displays a summary of information related to the application made by the applicant and the applicant's profile information. The design of this page can help applicants to find out brief information about the application details they have made.

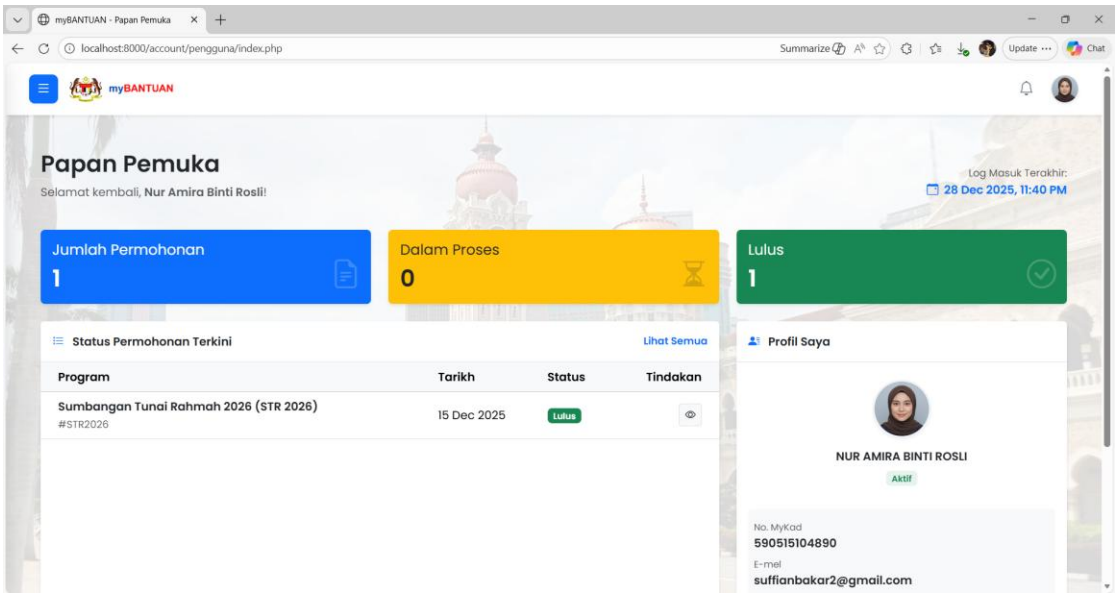


Figure 4.18 Dashboard page of applicant panel.

4.3.2.2 Permohonan Section

The Application section of the page displays a list of applications made by applicants, allowing applicants to make a new application or update details of applications that have been made as long as the application has not been evaluated by an agency officer. Therefore, applicants can update information as if they were applying for the first time. For processing, the applicant's application data will be used in processing fuzzy rules and the Analytical Hierarchical Process (AHP) which acts as the core framework to determine the eligibility of assistance applications. Applicants can also see the eligibility status of their applications which will be highlighted in the application list shown in Figure.

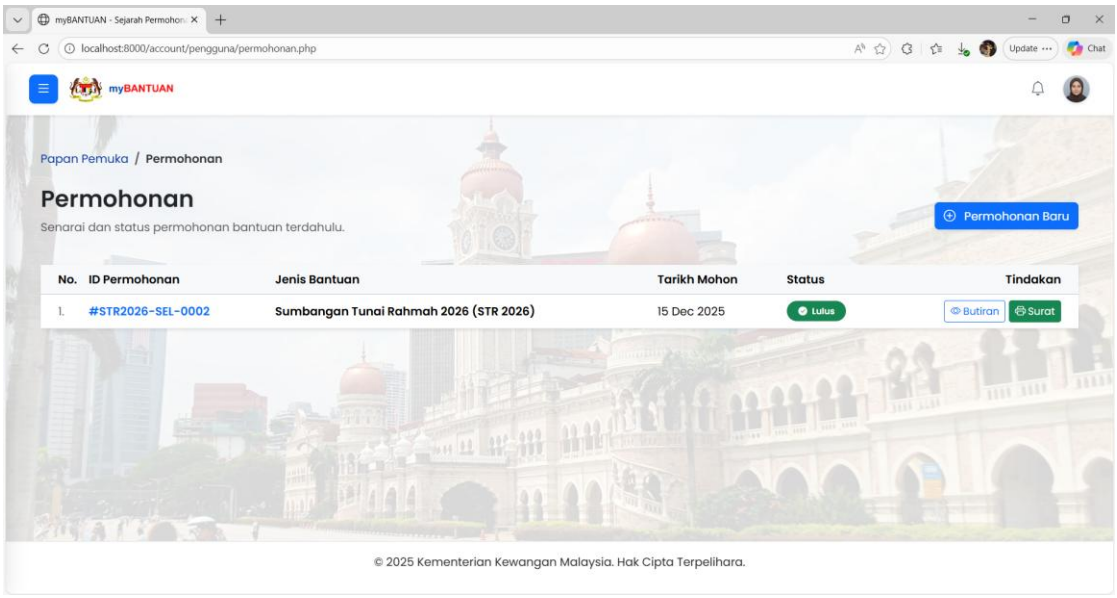


Figure 4.19 List of application made by applicant in Permohonan page.

4.3.2.3 Butiran Permohonan page

The Application Details page displays detailed information for applications made by applicants where applicants can review the information that has been entered in the system including personal information and heir information. In this page, it also has an application status where this status consists of 3 statuses namely "In Process", "Passed" and "Failed". Not only that, but this page also has a fuzzy eligibility score where it will inform the applicant of their current qualification status based on the calculated criteria including a triangular graph (see Figure 4.15) as a visual support.

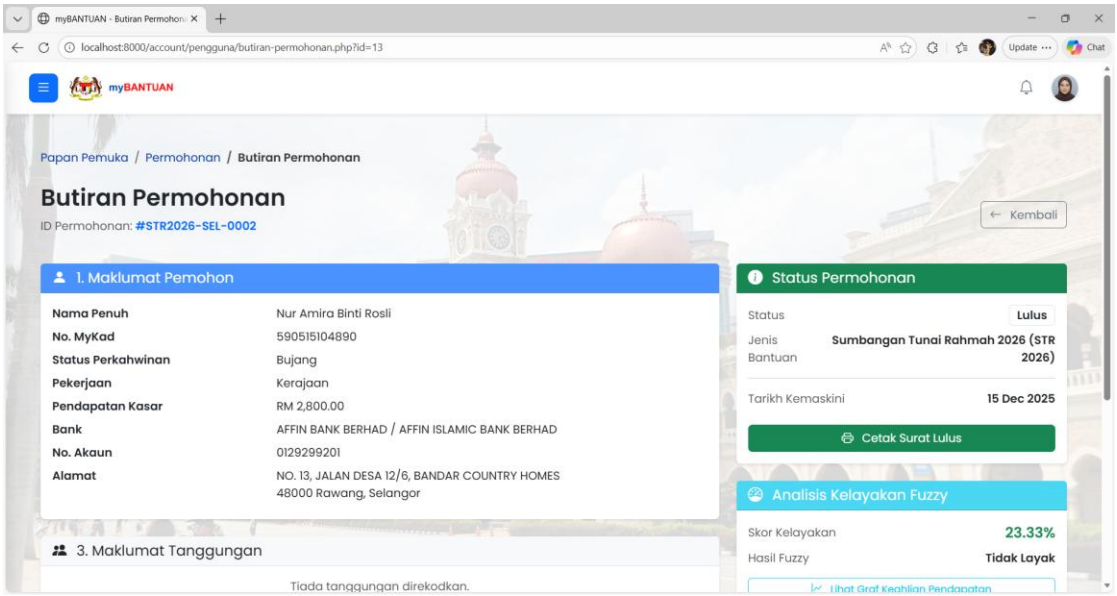


Figure 4.20 Butiran Permohonan page.

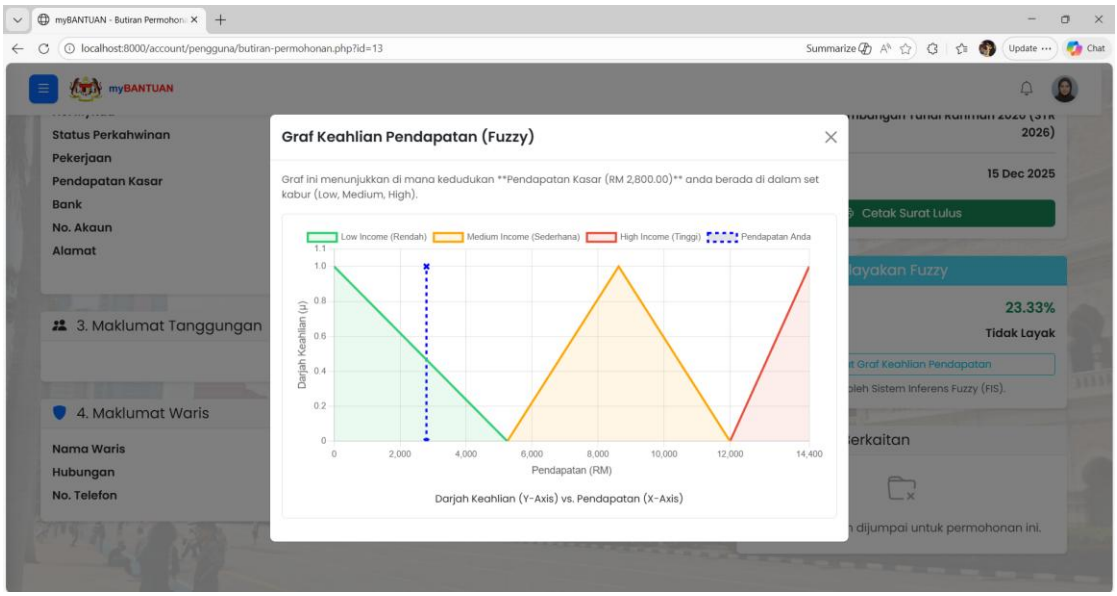


Figure 4.21 Triagular graph of fuzzy eligibility analysis for application made by applicants.

4.3.2.4 Cetak Permohonan page

For this page, it provides a function to generate and download an application confirmation letter which acts as an application slip for each application that has been made by the applicant after they click the "Cetak" (Print) button. The purpose is to ensure that applicants have an official copy for application reference and can be used if system have unexpected problems in the future. The information displayed is based on the information submitted by the applicant based on the application they made before.

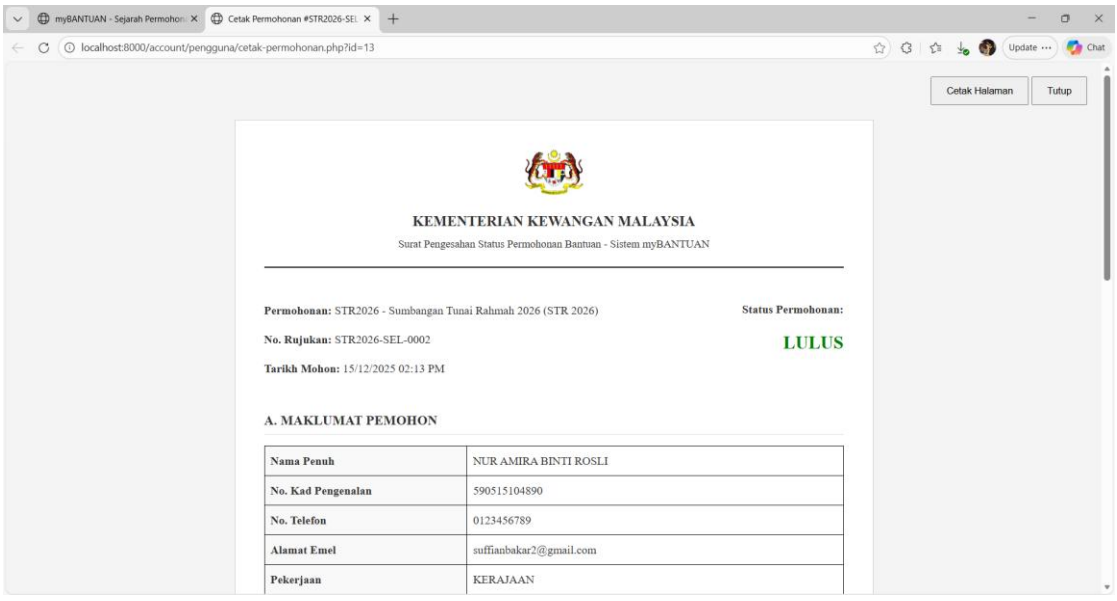


Figure 4.22 Cetak Permohonan page

4.3.2.5 Maklum Balas page

For the Maklum Balas (feedback) page, it allows applicants to send feedback and complaints related to the system and additional information to the staff either agency staff or ministry administrator. Each feedback and complaint made will be stored in a database for the staff's reference to ensure data integrity of the system. It also displays the response status to make it easier for applicants to monitor their response.

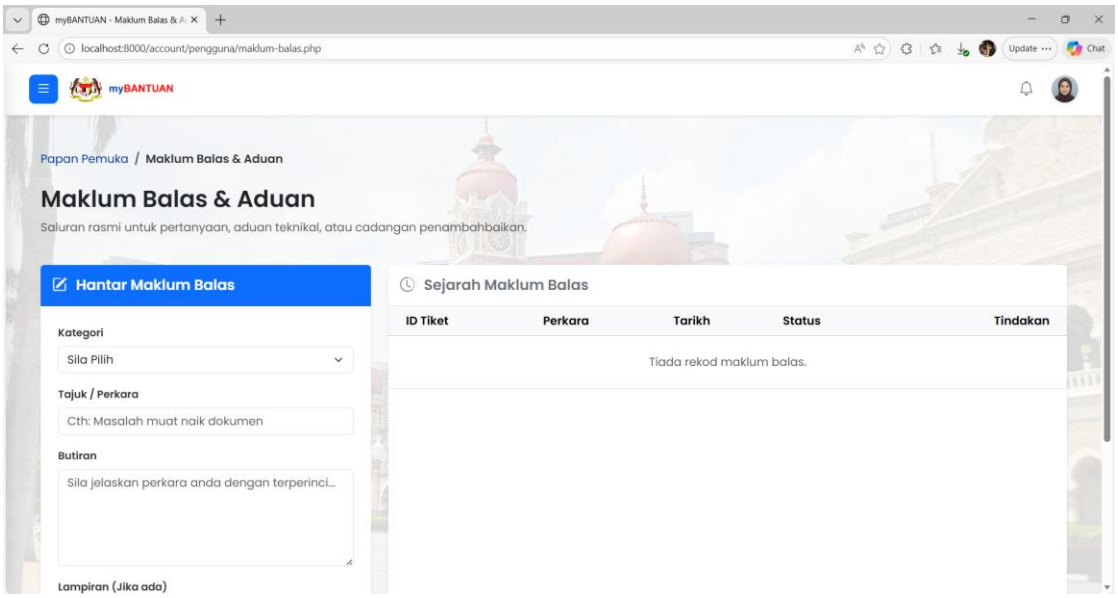


Figure 4.23 Maklum Balas page

4.3.2.6 Profil page

The Profil (profile) page allows applicants to update their information such as phone number, email address, profile picture and password (for password reset purposes). This is because it can prevent any misuse of the applicant's account in the system.

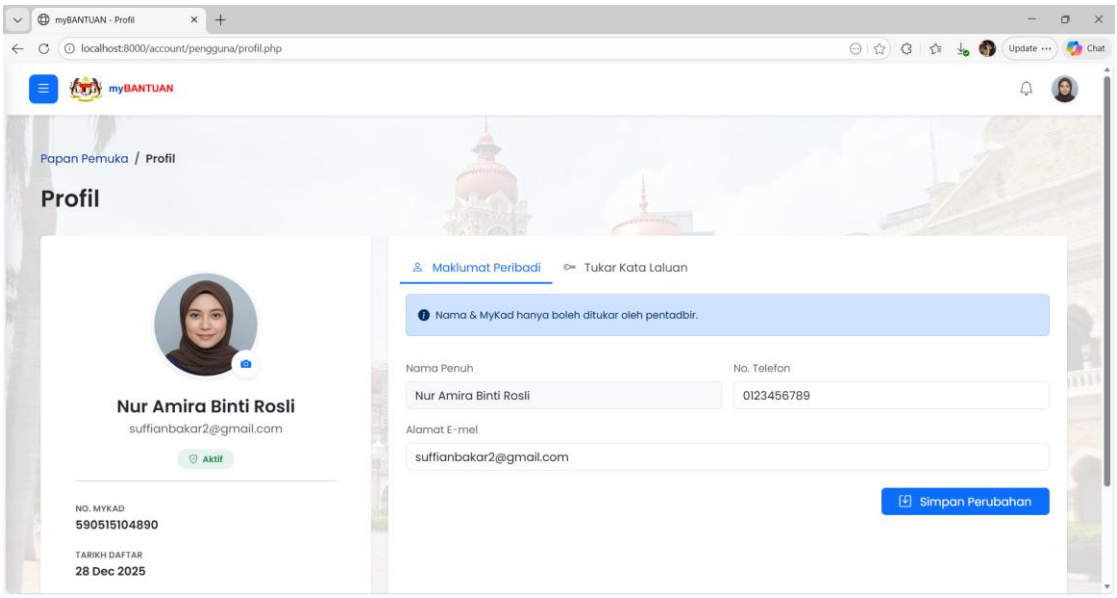


Figure 4.24 Profile page

4.3.2.7 Notifikasi page

The Notifikasi (notification) page used in the system by displaying all notifications related to the system including application status. Not only that, but this page also ensures that applicants do not miss any important information from the system. Notifications on this page have a "Mark All Read" button if the applicant has read the notification.

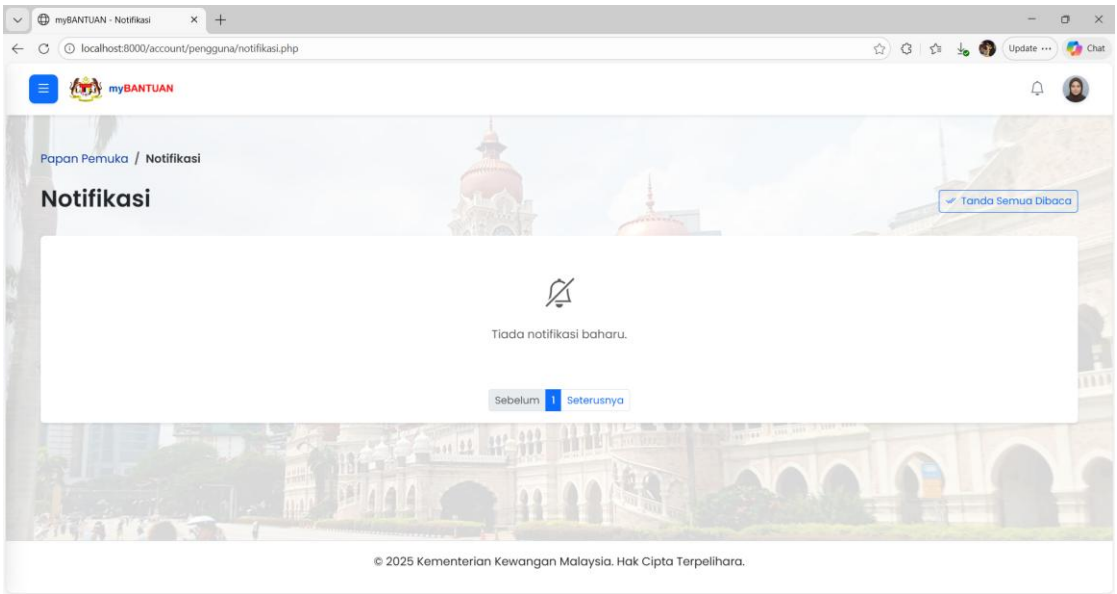


Figure 4.25 Notification page

4.3.3 Staff Panel

For the staff panel, it is a panel that can only be accessed by staff who act as agency officers and ministry administrators with the purpose of managing application data, coordinating assistance, monitoring assistance eligibility status, and overall system management. For this panel, it is divided into two roles, namely the agency officer panel and the ministry administrator panel, both of which have their own functions based on different access levels. This panel also supports the system's objectives to ensure that the aid distribution process is transparent, responsive and in line with ministry policies.

4.3.3.1 Agency officer panel

For the agency officer panel, it allows officers to carry out their duties in processing applications and appeals for assistance, both of which have been sent by applicants. The function of this panel is to check applicant applications, verify applicant eligibility, update application status, and generate application reports in the system. This panel also includes eligibility result analysis using fuzzy rules and Analytical Hierarchical Process (AHP) and triangular graphs used to illustrate applicant salary indicators for the purpose of visualizing eligibility results more clearly and in detail.

a) Dashboard page

The dashboard page displays a summary of application statistics that are being processed, such as approval trends, applications that require officer action, and the total for the fuzzy eligibility score category, which displays the number of eligible and ineligible applicants based on scores generated by fuzzy rules and the Analytical Hierarchical Process (AHP). This page is intended to help officers identify their tasks by priority.

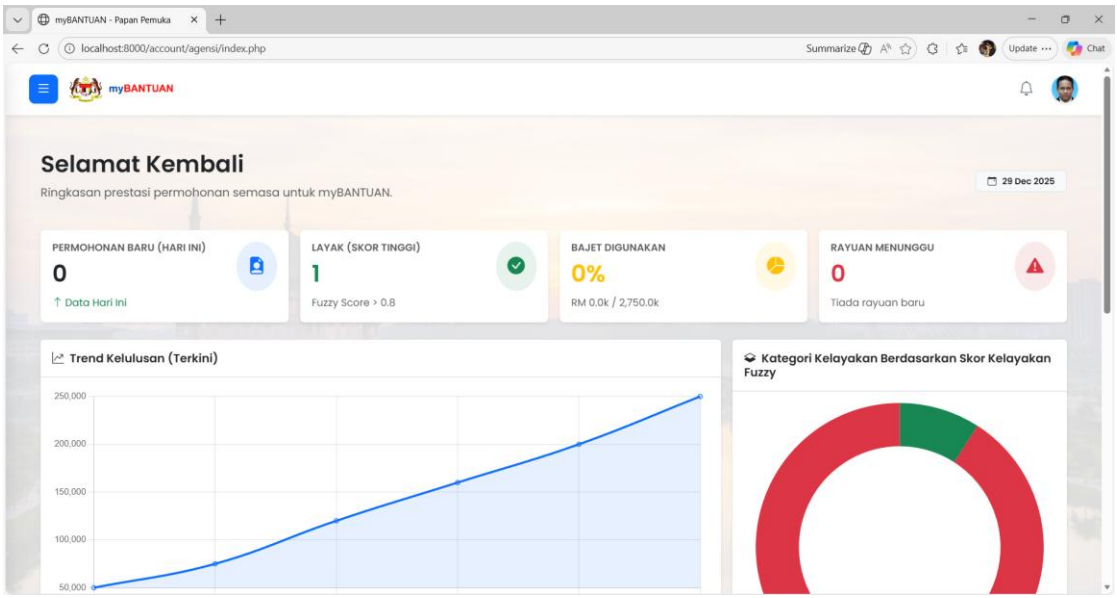


Figure 4.26 Agency officer dashboard page

b) Pengurusan Permohonan page

This page lists the list of applications that have been submitted by applicants where officers can evaluate the information entered by the applicant, determine the status of the application according to the fuzzy eligibility score. Notes are also created to allow officers to make notes as justification of the decision before the application status is confirmed and updated in the system.

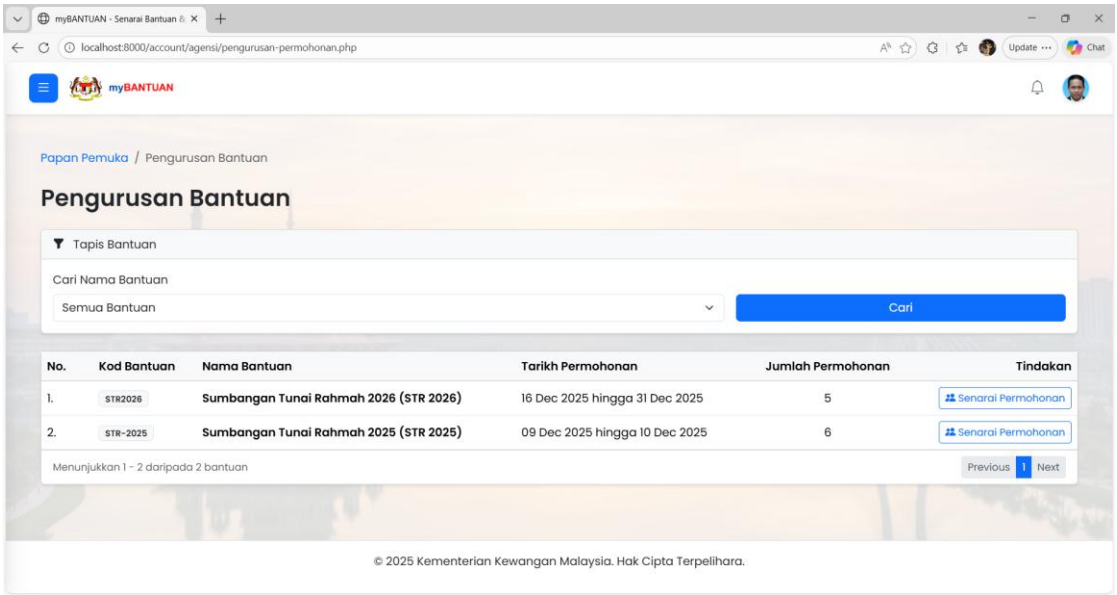


Figure 4.27 Pengurusan Bantuan page

c) Senarai Permohonan page

This page lists all application records made by applicants, with each application including applicant information and current application status. The display can be

filtered by name, identity card number, reference and application type to facilitate the search process.

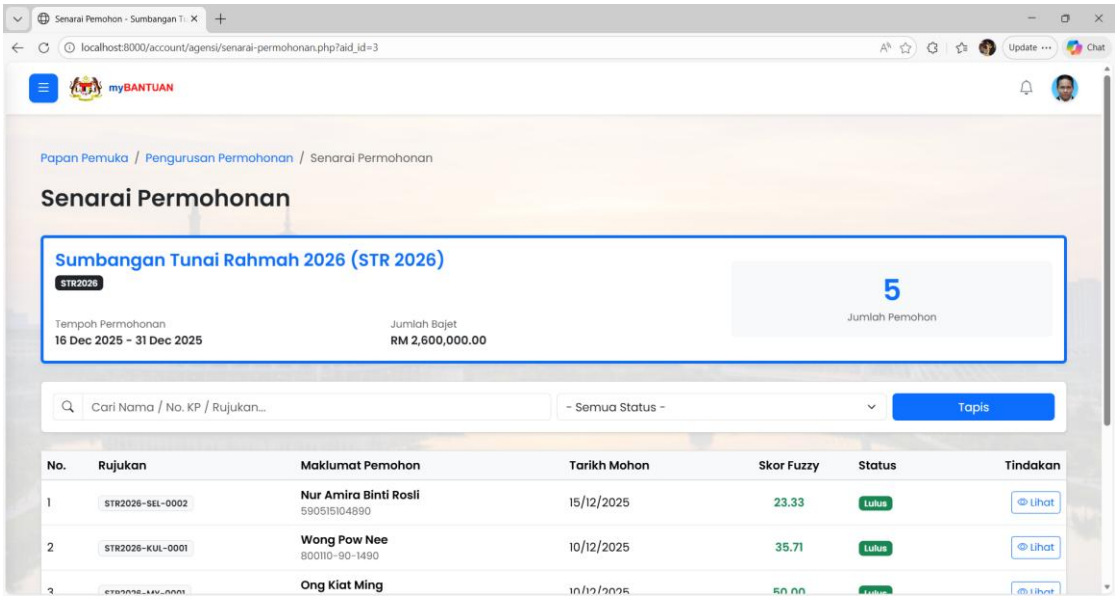


Figure 4.28 Senarai Permohonan page

d) Butiran Permohonan page

The Butiran Permohonan (Application Details) page allows officers to view the applicant's full information including personal information details, beneficiary information, and supporting documents. Each applicant's application will be accompanied by an eligibility result based on a fuzzy eligibility score that allows officers to assess the eligibility status of the applicant's application. Officers can also view a triangular graph as a visual representation of the analysis related to the applicant's eligibility that affects the eligibility score as shown in Figure.

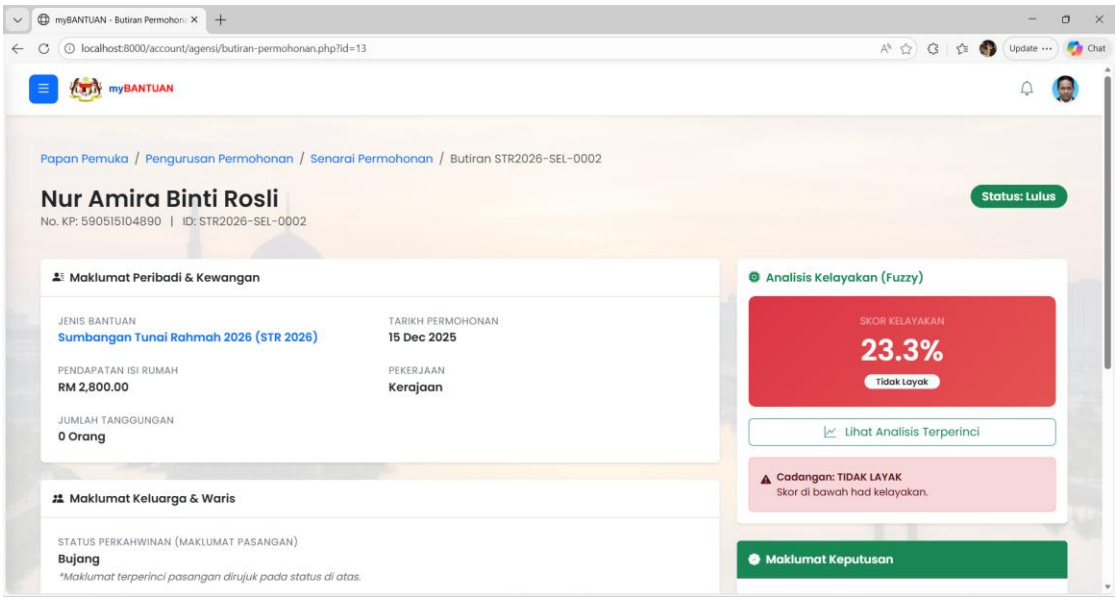


Figure 4.29 The details of applicant in Butiran Permohonan page

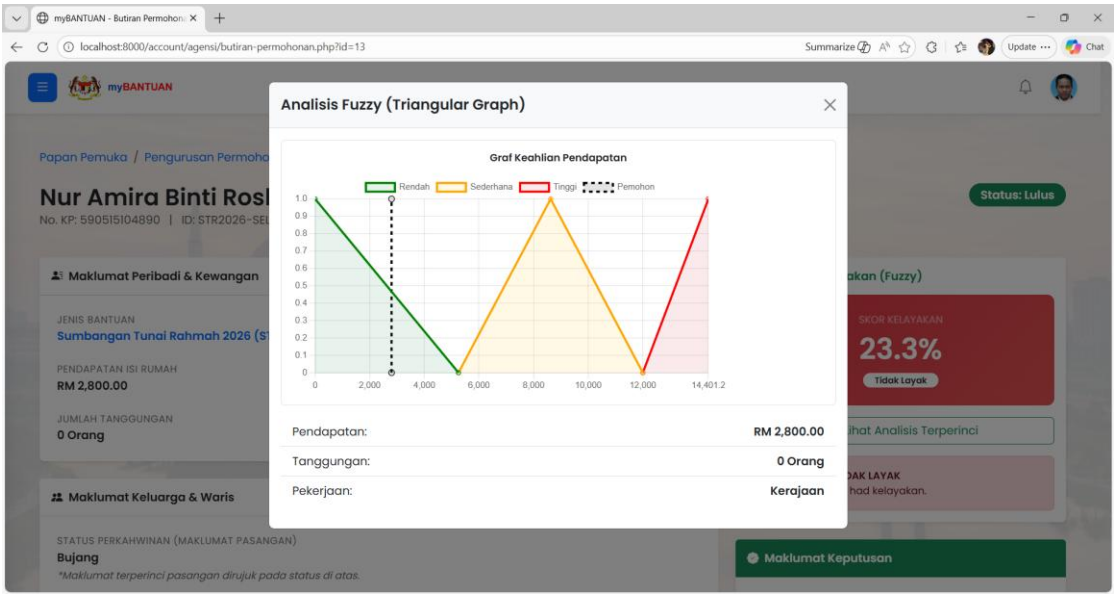


Figure 4.30 Analysis of triangular graph based on the result of eligibility score of applicant's application

e) Pengurusan Rayuan page

The Penguurusan Permohonan (Application Appeals) page is used to review appeals from applications made by ineligible applicants and submit additional justifications. Officers can assess appeals for applications by determining whether to uphold the existing decision by dismissing the appeal or to approve them by stating reasonable grounds.

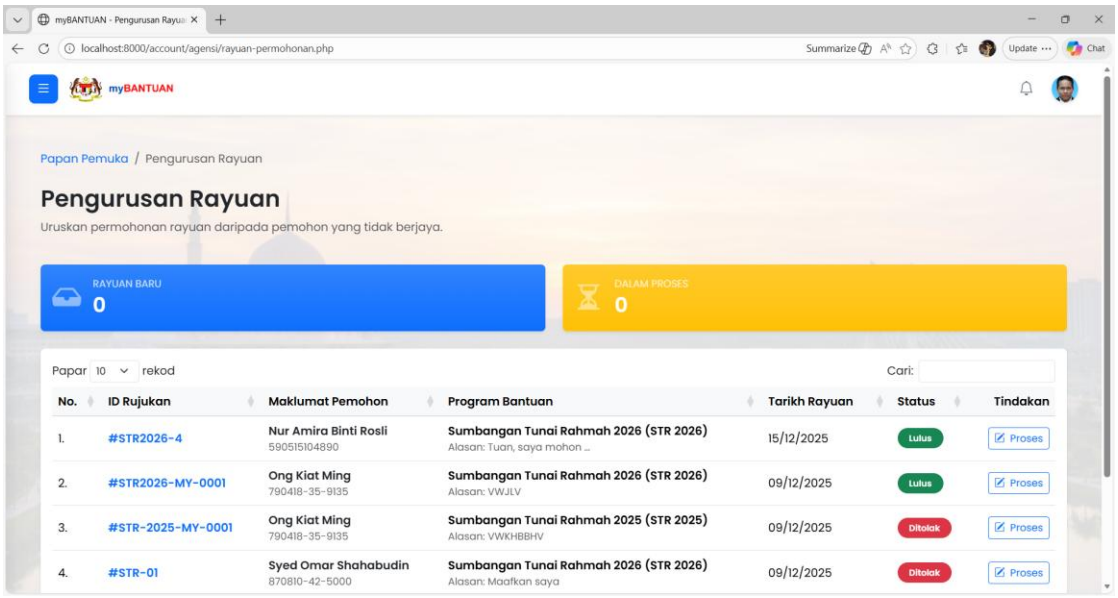


Figure 4.31 Pengurusan Rayuan page

f) Butiran Rayuan page

The display on this page displays detailed information including the grounds for appeal and supporting documents submitted by the applicant. Here the officer needs to make an appeal decision and can provide reasons for each appeal application made by the applicant.

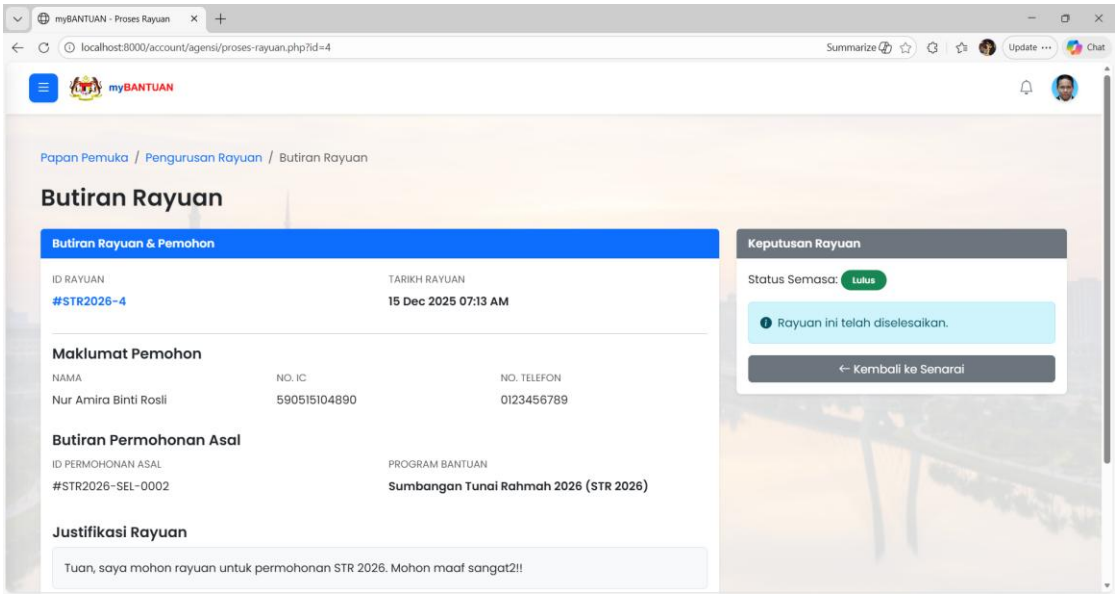


Figure 4.32 Butiran Rayuan page

g) Laporan Permohonan page

This page shows several brief and detailed reports that have been generated in the system. In this page also, it has a print function for reference purposes for officers where it will generate in the form of a pdf file.

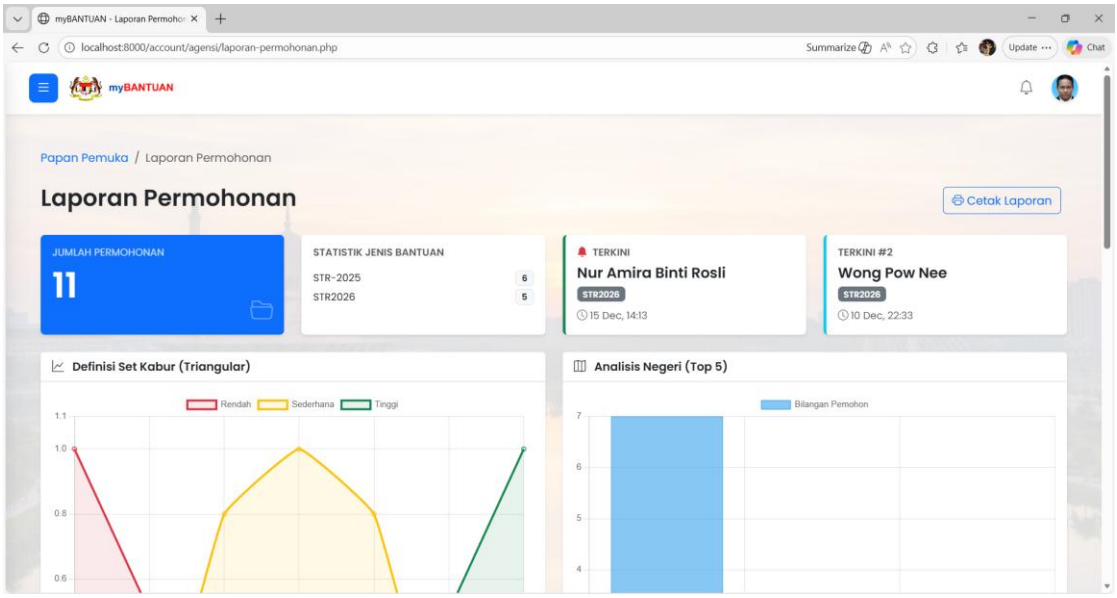


Figure 4.33 Laporan Permohonan page

h) Maklum Balas page

This page collects feedback made by applicants. Agency officer can answer feedback or escalate feedback to ministry administrators if the feedback raised is outside their jurisdiction.

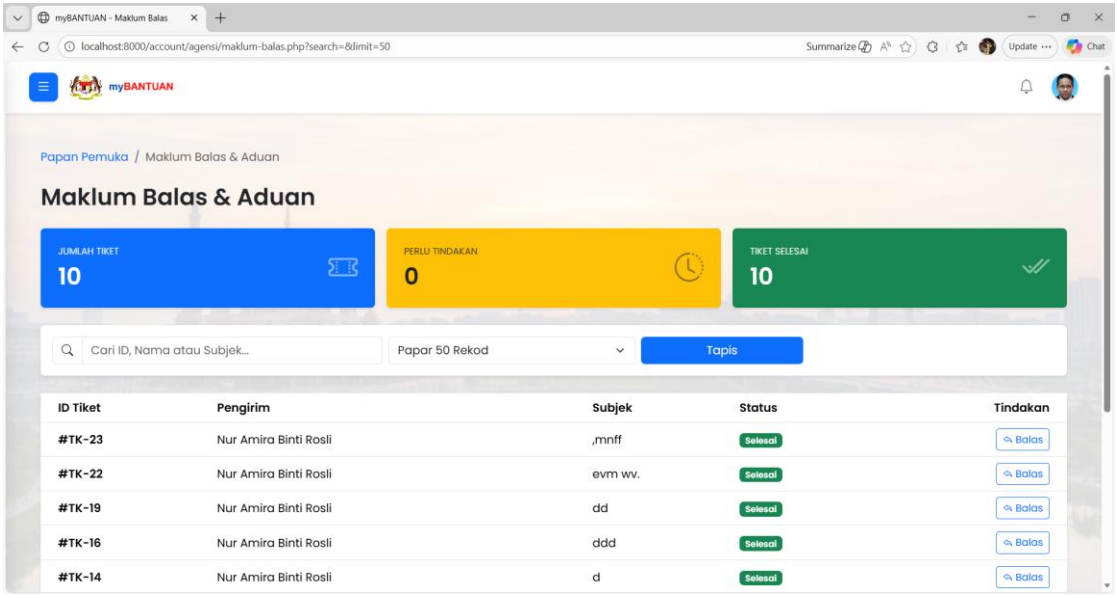


Figure 4.34 Maklum balas page for agency officer panel

i) Profil page

The Profil (profile) page allows officers to update their information such as email address, phone number and profile picture. They can also update their password.

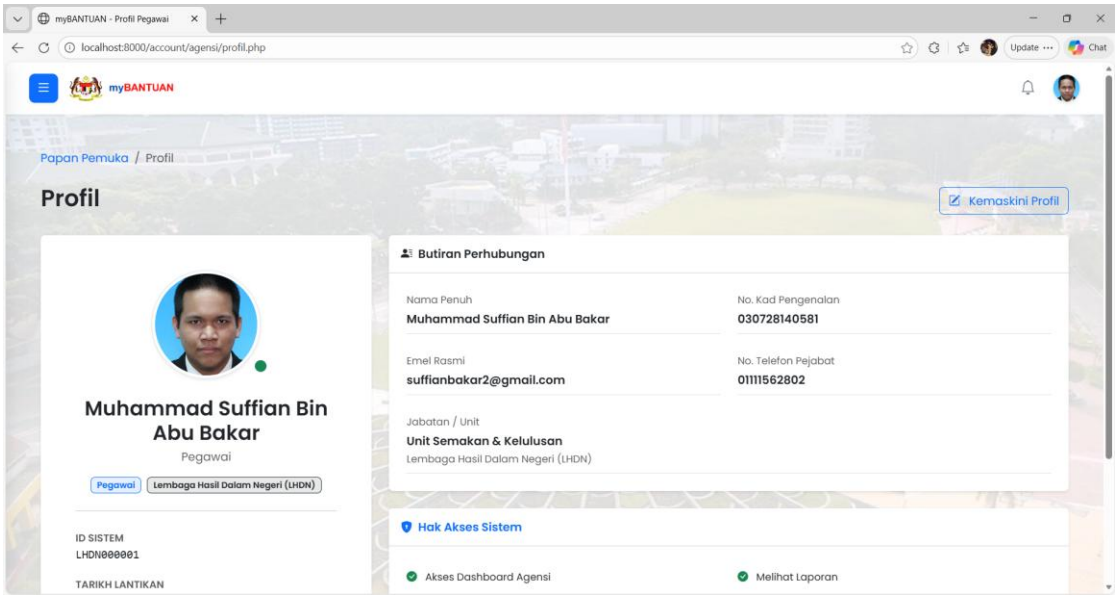


Figure 4.35 Profil page for agency officer

j) Notifikasi page

For the Notifikasi (notification) page, it displays system messages including new applications and notifications for application reviews.

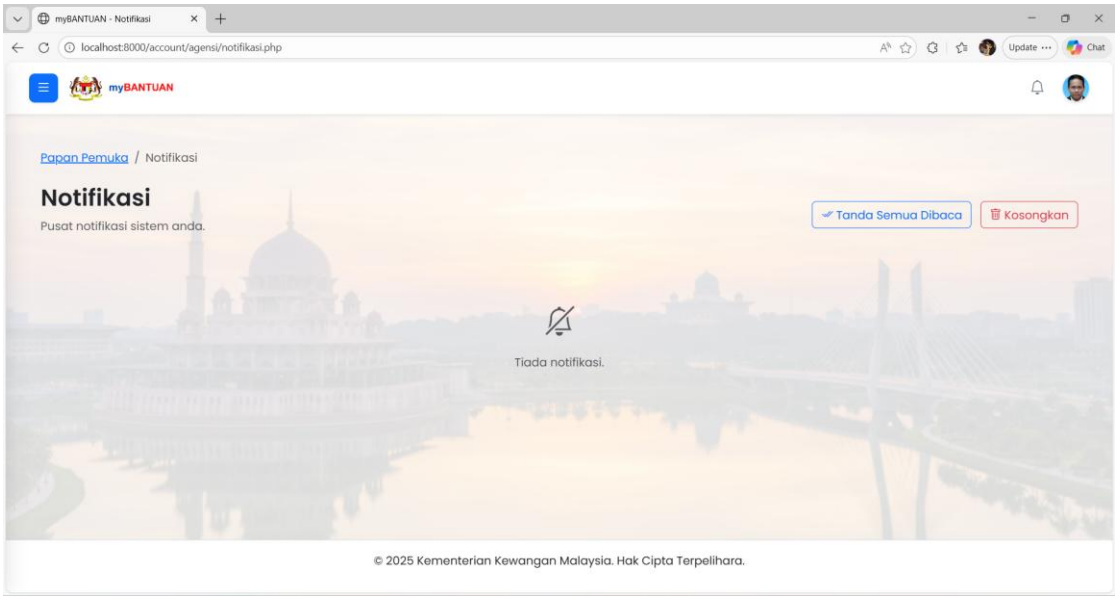


Figure 4.36 Notification page for agency officer

4.3.3.2 Ministry Administrator panel

For the ministry administrator panel, this panel is the highest management module in the system compared to agency officers. This is because this panel plays a

role in controlling the administrative structure of the entire system by managing user accounts in the system, setting fuzzy parameters in assistance applications, and reviewing the effectiveness of the application process. This ensures that each existing process can increase transparency in decision-making and improve the system's ability in the government assistance distribution process.

a) Dashboard page

This page displays a summary of overall applications centrally. It includes information related to applications, application appeals, feedback and the number of users in the system. Application statistics are also integrated to enable monitoring of the number of approvals.

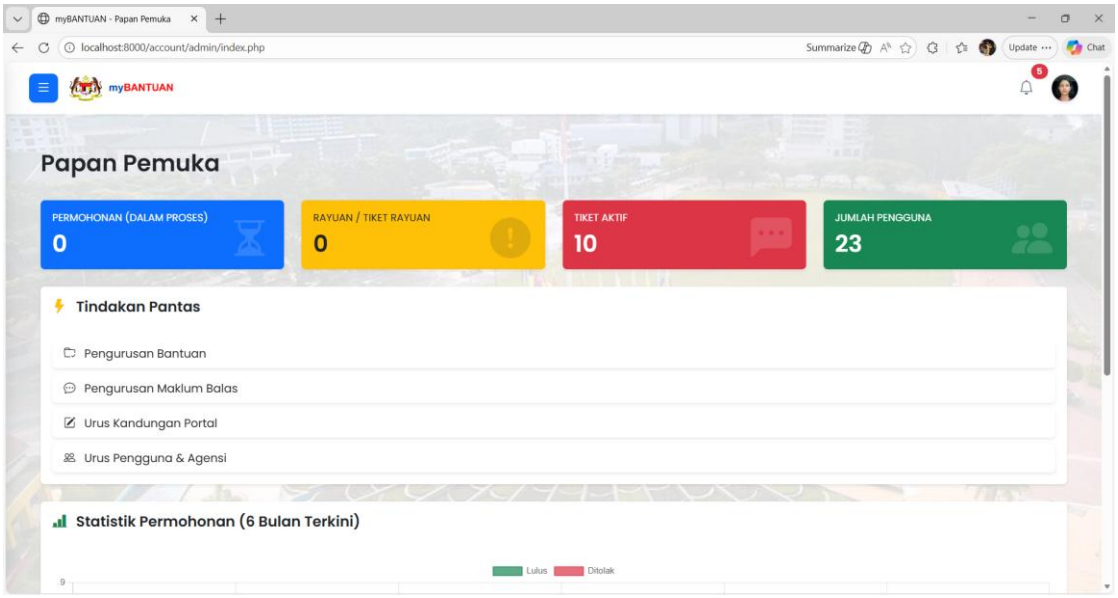


Figure 4.37 Dashboard page for ministry administrator

b) Pengurusan Akaun page

The Pengurusan Akaun (Account Management) page is used to register new users into the system by entering user data manually or can import user data using a csv file. This page also allows ministry administrators to deactivate user accounts, change user roles, and reset staff passwords if needed.

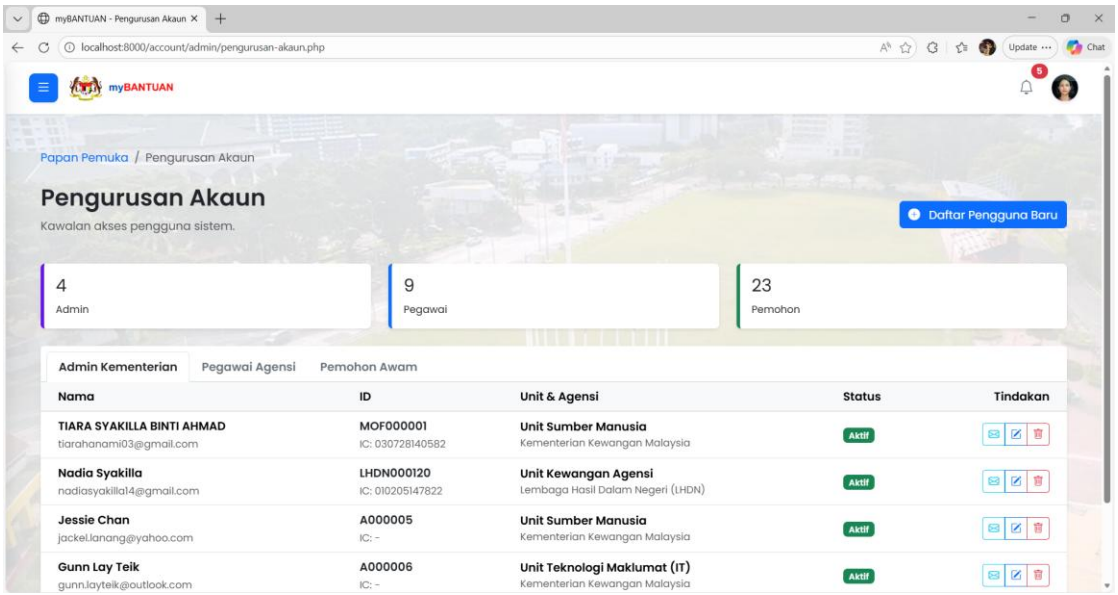


Figure 4.38 Pengurusan Akaun page

c) Pengurusan Bantuan page

Ministry administrators can add, update the list of assistance applications where on this page, ministry administrators can deactivate assistance and view full details of the applications in the list.

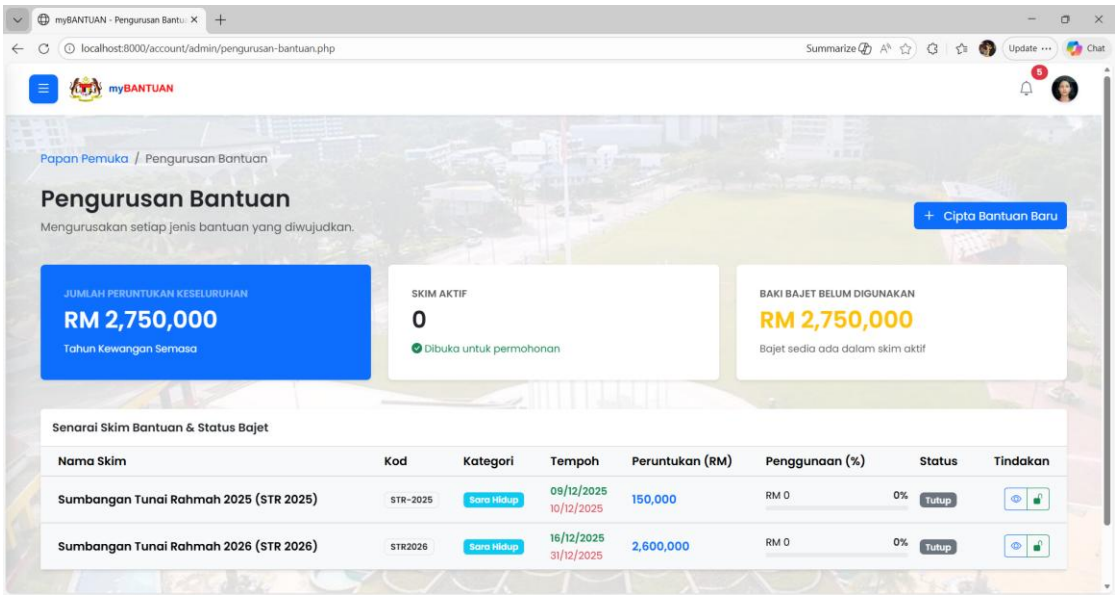


Figure 4.39 Pengurusan Bantuan page

d) Maklumat Bantuan page

This page displays detailed assistance information where assistance made by ministry administrators can be seen on the portal main section, user panel and agency officer panel. Administrators can update assistance information which includes

updating fuzzy configuration conditions and deactivating assistance if needed. The list on this page shows the list of applicants who have applied for assistance.

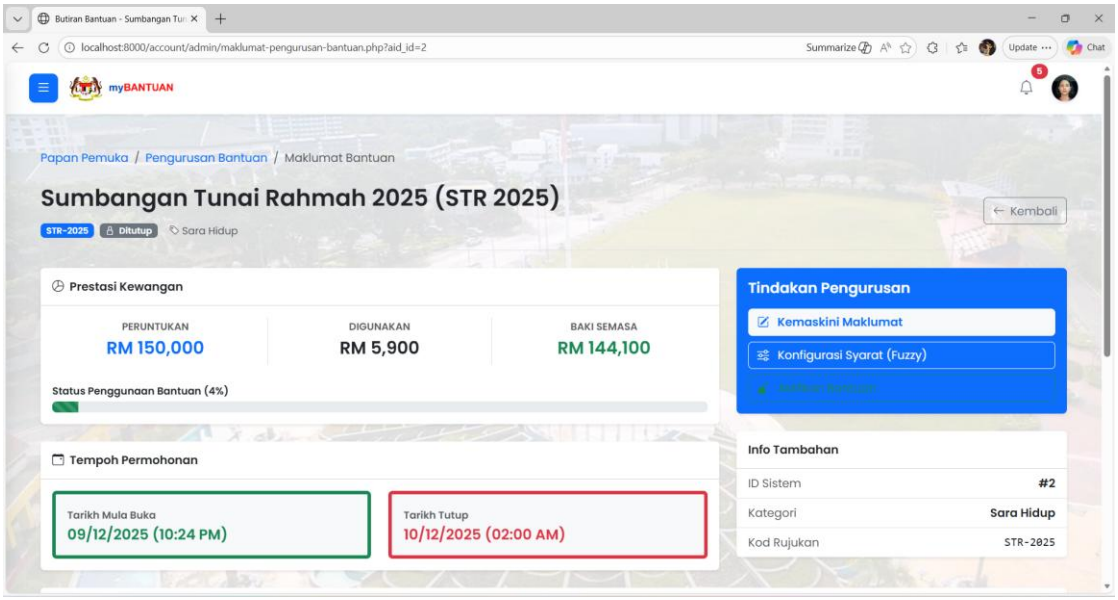


Figure 4.40 Maklumat Bantuan page

e) Semakan Permohonan page

This page is developed to display comprehensive application details to allow administrators to review the decisions made by agency officers. In addition, the analysis of the eligibility score (including the triangular graph) is also integrated as a technical reference in case of any dispute or need for review.

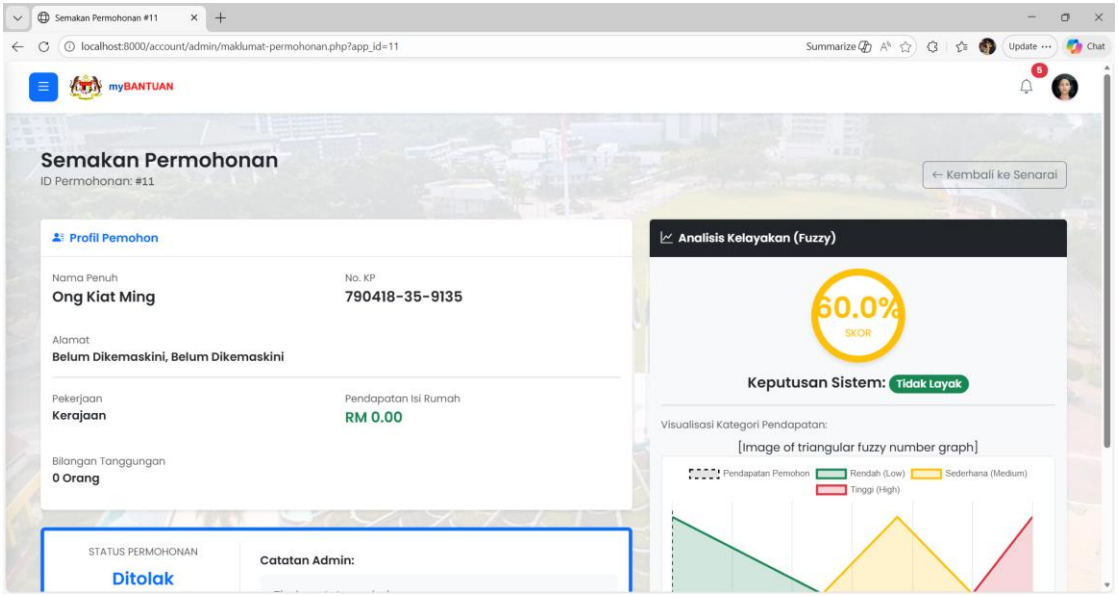


Figure 4.41 Semakan Permohonan page for the details of applicant's application

f) Laporan Permohonan page

For this page, ministry administrators can generate reports for ministry monitoring purposes and can be used as a reference in government policy formulation and policy presentation. This report includes statistics on the number of applications and income profiles by state based on applicant data.

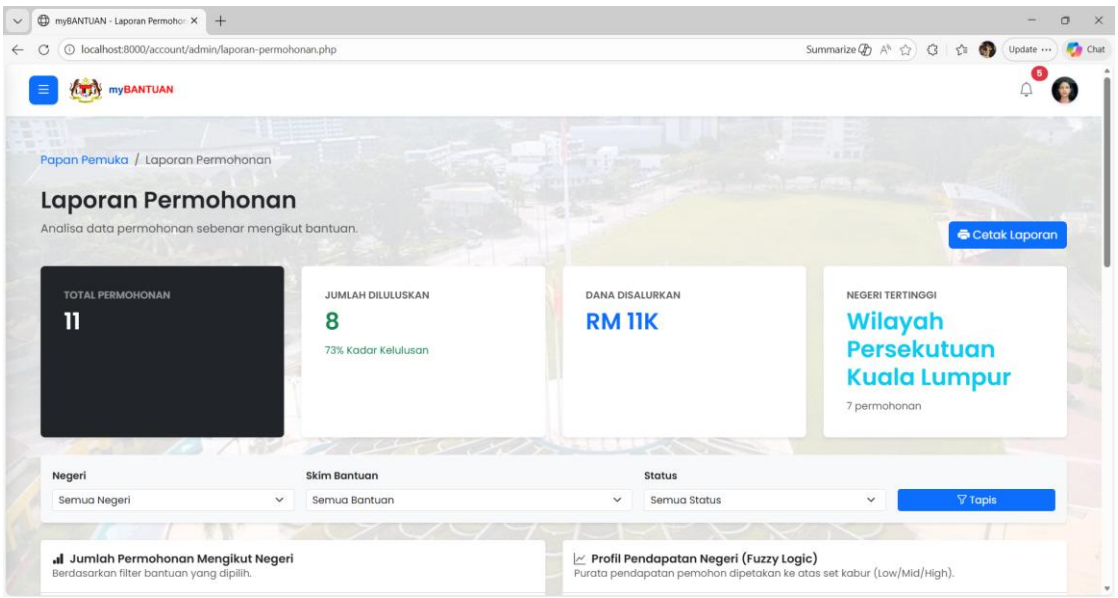


Figure 4.42 Laporan Permohonan page

g) Maklum Balas page

In Maklum Balas (feedback) page, administrators can monitor all feedback received centrally in the system and record all feedback for more effective follow-up actions.

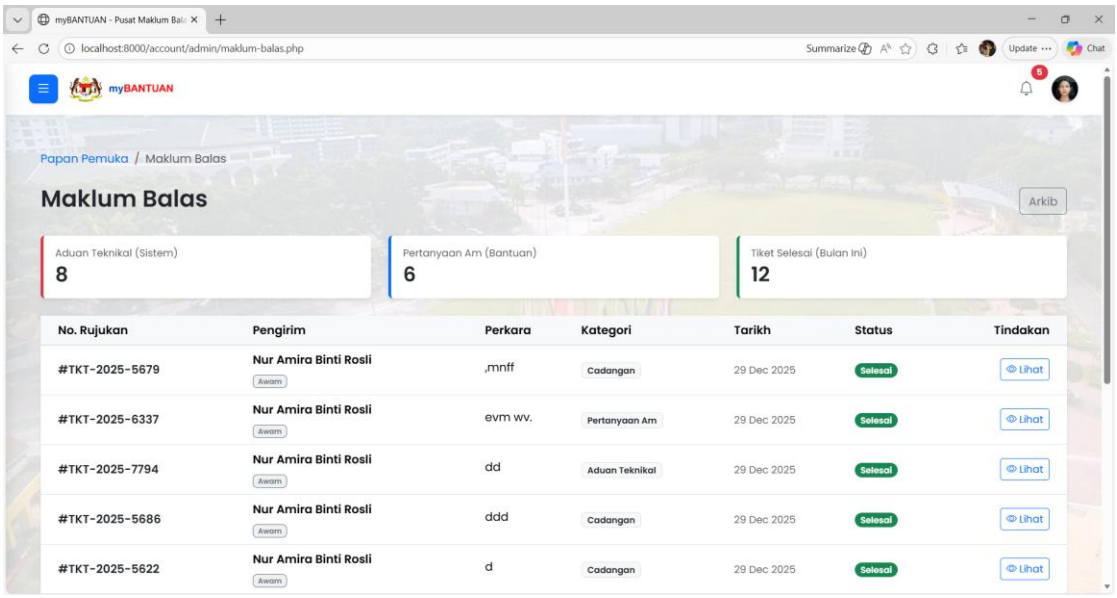


Figure 4.43 Maklum Balas page for ministry administrators

h) Maklum Balas Details page

The display highlighted on this page is the detailed feedback information made by the applicant and the ministry administrator is allowed to respond to the feedback if the agency officer is unable to respond to the feedback.

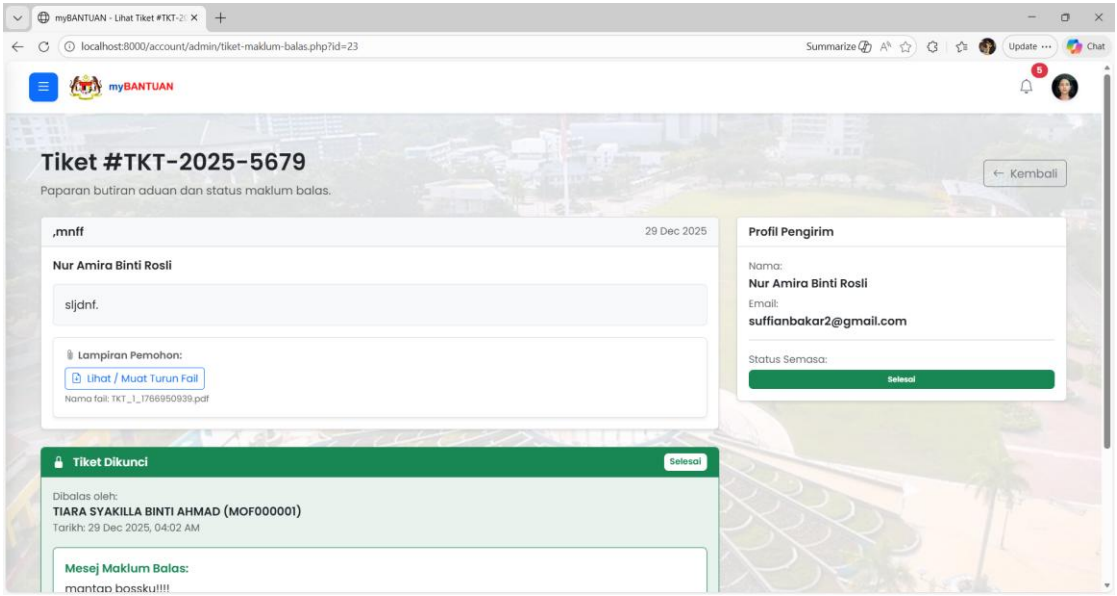


Figure 4.44 Maklum Balas (feedback) Details page

i) Pengurusan Kandungan Portal page

This page is used to control the content displayed in the system to users such as infographics, latest information and documents related to assistance applications.

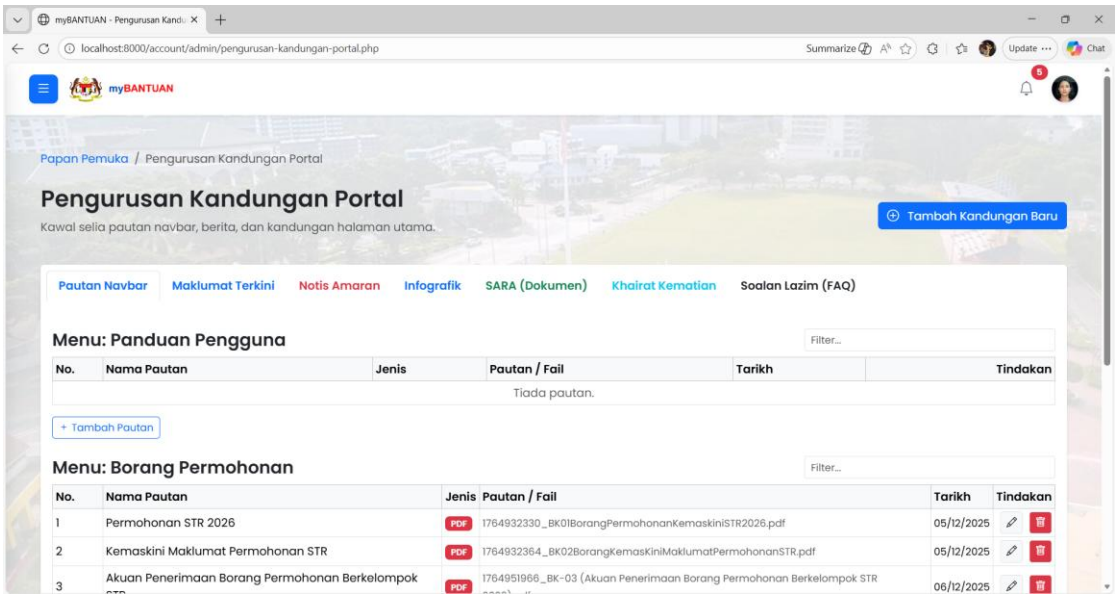


Figure 4.45 Pengurusan Kandungan Portal (Portal Content Management) page

j) Tetapan Sistem page

For the Tetapan Sistem (System Settings) page, it acts as a technical and security control center for this system where it displays critical configurations such as Mod Penyelenggaraan (Maintenance Mode) status, system display name management with the aim of ensuring that the integrity of system data is always maintained.

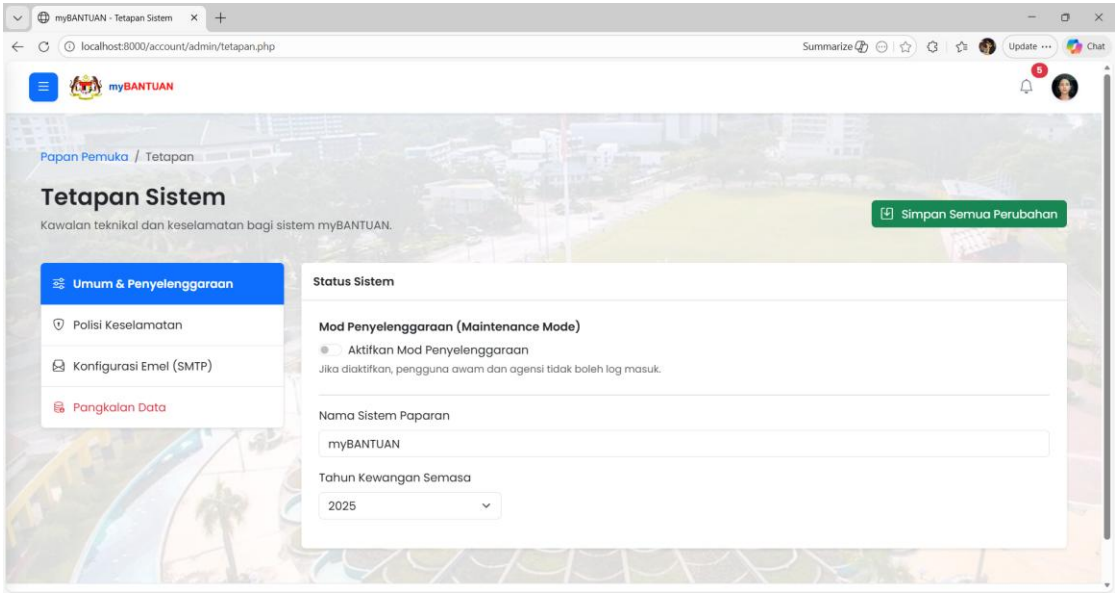


Figure 4.46 Notification page

k) Log Aktiviti page

The Log Aktiviti (Activity Log) page is used to record all user actions in the system to ensure accountability. In addition, it is used for comprehensive security and auditing purposes.

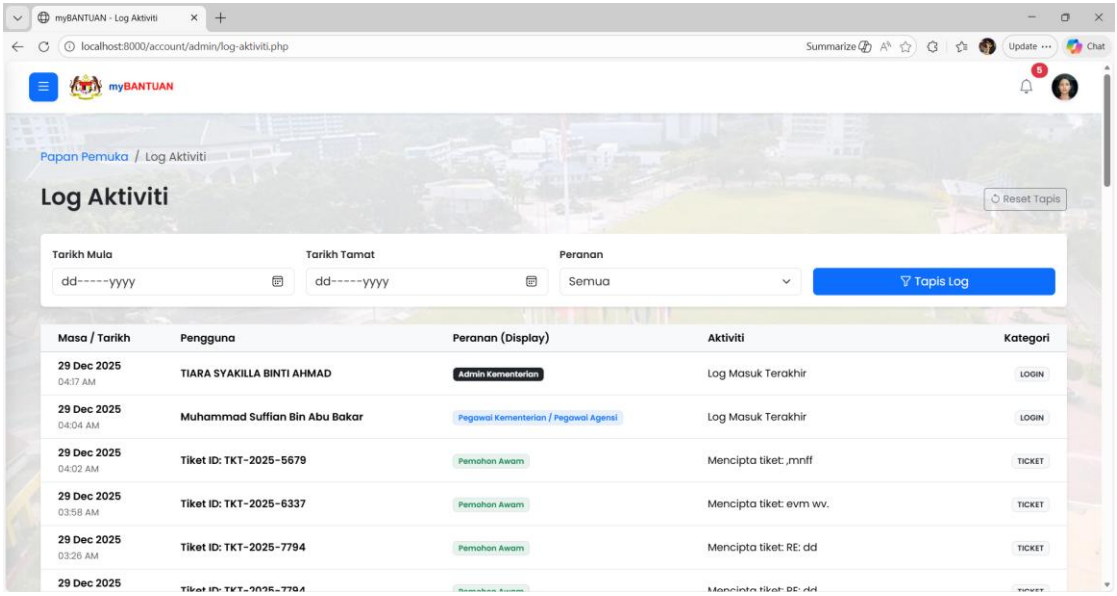


Figure 4.47 Log Aktiviti (Activity Log) page

l) Profil page

The Profil (profile) page displays details of ministry administrators where they can update their information (including profile picture) and passwords for the purpose of their account security and system integrity.

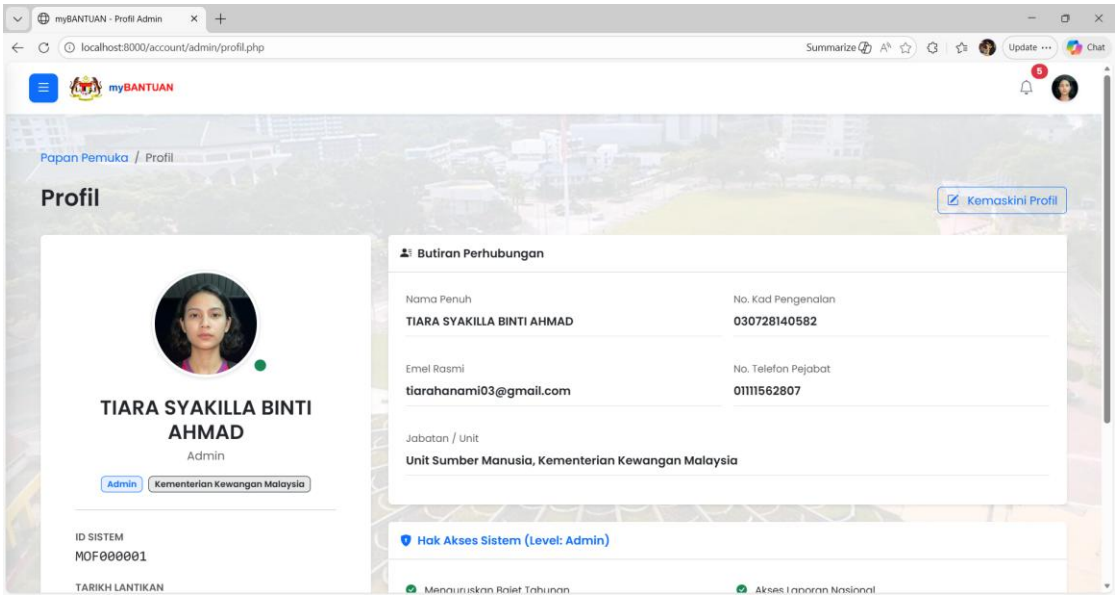


Figure 4.48 Profil (profile) page of ministry administrator

m) Notifikasi page

This page displays a list of important notifications regarding the status of the entire system's application.

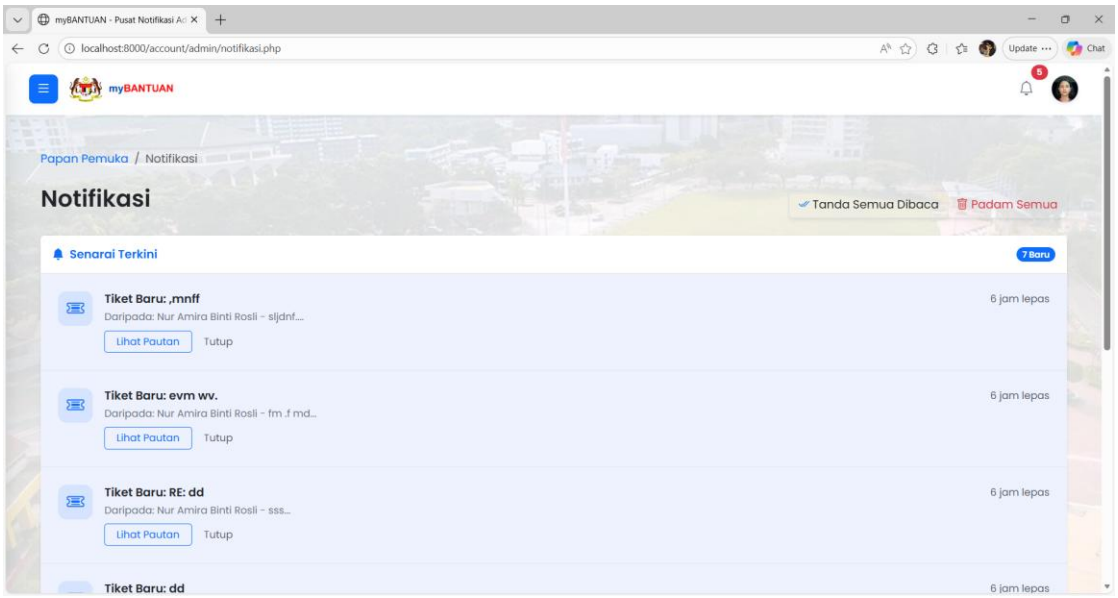


Figure 4.49 Notification page in ministry administrator panel

4.4 Functional Testing

To ensure that the system operates as designed, functionality testing is essential to verify the functionality and performance of the system, where each test case needs to be tested thoroughly to avoid any problems when users use the system. Table 4.7 shows the functionality testing schedule that contains test cases with expected outcomes and actual outcomes to make sure all these test cases can run smoothly and achieve the project objectives.

Table 4.8
Functional Testing

Test Case ID	Functionality	Expected Outcome	Actual Outcome	Status (Pass / Fail)
TC001	User Registration	User (Applicant and Staff) successfully register with valid data	User (Applicant and Staff) successfully register with valid data: 1. Applicant successfully register their account in the system by insert their email, password, security question and security phrase. 2. Staff successfully registered by the ministry administrator by adding the user by import the existing data using .csv file or they can add user by insert manual data.	Pass
TC002	User login	User (Applicant and Staff) can login with correct IC Number (Applicant), Staff ID number (Staff) and password	User can login their account successfully. 1. Applicant login their account by insert their IC Number and password. Next, they need to authentication their account by recognize their security phrase before they can access to the system. 2. Staff (for ministry administrator and agency officer) insert their ID Number and password before access to the system.	Pass

TC003	Submit Application Form	Application data and eligibility score saved into database	For submission application form, applicant successfully submitted their application and save into the database. Upon completion of the eligibility score calculation, the system automatically updates and saves the eligibility score into the database.	Pass
TC004	Eligibility Calculation	Fuzzy rules and AHP calculate the eligibility correctly	Fuzzy rules and AHP successfully calculate eligibility correctly by make a code for the calculation of the eligibility score. Next the eligibility score will store into database as references of the application eligibility score.	Pass
TC005	View Application	Staff can view submitted applications	Staff can view submitted application in Pengurusan Permohonan (Application Management) page where it displays list of application that exists in the system (include the past application that act as reference to the staff for audit)	Pass
TC006	View eligibility report	Staff can access eligibility reports with scoring details	Staff can access the eligibility report with scoring details by review each application that submitted by applicants where there appear the eligibility score with display the triangular graph.	Pass
TC007	Input validation	Application form prevents submission of invalid or incomplete data	Application form successfully prevent submission of invalid or incomplete data during data insertion by applicant.	Pass
TC008	SQL Injection Protection	System blocks SQL injection attempts	The system successfully blocks the SQL injection attempts.	Pass
TC009	Session management	User (Applicant and Staff) session expired after logout	User session successfully expired automatically after logout.	Pass

4.5 Summary

This chapter presents the results of the implementation of the Fuzzy AHP eligibility framework in making applicant eligibility decisions starting with the development of the fuzzy rules module that enables the process of translating applicant data into linguistic variables using the main criteria of income, dependents and employment. Next, the initial results of the fuzzy rules will be brought to the Analytical Hierarchical Process (AHP) module to carry out the structural priority selection process using the pairwise comparison method, geometric mean calculation and defuzzification to obtain the final weight value. Next, the final results will be displayed when the officer makes an assessment before the status is posted to the applicant. Therefore, this framework can minimize the problem of inconsistency and increase the accuracy of the assessment of assistance eligibility compared to the time-consuming manual assessment process.

CHAPTER 5
CONCLUSION AND FUTURE WORK

In this chapter, it will summarize the overall development process of the project which includes summary of project objectives, project contribution, project limitations and recommendation and future work.

5.1 Summary of Project Objectives

This section will discuss the project objectives that have been achieved throughout the project development by providing a summary of the objective achievements as follows.

5.1.1 Project Objective 1

The first research objective of this project is to identify the appropriate algorithm to determine the eligibility of aid recipients. In the objective of this study, a literature review was conducted by conducting a comparative analysis of several fuzzy methods that are suitable for projects that require a framework to determine the eligibility of applicants who apply for aid. This objective was explained in Chapter 2 where the method adapted for the appropriate algorithm in this framework project is to implement the fuzzy rules method with the integration of the Analytical Hierarchical Process (AHP) where this algorithm method offers in handling the uncertainty that exists in the socio-economic data of the people when making financial aid applications for budgeting.

5.1.2 Project Objective 2

The second research objective of this project is to design and develop a fuzzy rule framework application using the Analytical Hierarchy Process (AHP) technique for eligibility of aid applicants in eGovernment. This objective is achieved in Chapter 3 and Chapter 4 through the explanation of the system architecture and prototype development process by demonstrating how the Fuzzy Rules and Analytical

Hierarchical Process (AHP) process can be integrated in the eGovernment framework system where it consists of important components including input data processing, fuzzy membership classification, pairwise comparison calculation and eligibility result score generation..

5.1.3 Project Objective 3

The third research objective of this project is to evaluate the effectiveness of the algorithm in the application of aid recipient eligibility. This objective is achieved in Chapter 4 through testing and evaluation of the framework by testing several samples based on the socioeconomic case scenarios of the applicants who apply. The applicant data will be processed in the framework with the fuzzy AHP development module process with the aim of showing a clear difference between the socioeconomics of the applicants in determining the eligibility to apply for the application. This evaluation process will be a reference for officers in confirming the eligibility of the applicant by giving a fuzzy eligibility score before displaying it to the applicant after making a decision on the applicant's eligibility status.

5.2 Project Contribution

This project has resulted in changes in the evaluation of public sector decisions in matters involving the people's affairs together and at the same time, it contributes to academic research, system development and government sector digitization policies in line with current government policies. First, the framework developed introduces a structured approach to managing the problem of ambiguity in decision-making with the application of fuzzy AHP in the evaluation of eligibility decisions for government assistance applications. This framework can also be categorized as a reference model in a decision-making system based on a hybrid fuzzy model. Next, this project also contributes to eGovernment in providing a framework to support a data-based budget decision system in ensuring that budget selection can be managed transparently and effectively. Finally, this project will also be a reference for government agencies as a pilot platform in future aid distribution process initiatives.

5.3 Project Limitations

Although the implementation of this project has shown encouraging results, there are several limitations that can be identified during the development of this project. First, the limited scope of the criteria set in assessing the applicant's qualifications is only given to several socioeconomic factors, namely income, dependents and employment. For the real word application scenario. there are several other scopes of criteria that are given attention such as asset ownership status and health status due to time constraints in the process of creating this project.

In addition, the data in the prototype system for this project cannot be integrated with the real government database where it requires permission from the government by taking a long-time process and the data is also data protected under the Official Secrets Act 1972 in protecting the interests of the people. Therefore, the data in the prototype system is dummy data created by using data from DOSM as a reference to create it. However, it still has an impact in testing the implementation of the prototype in a real-world situation.

5.4 Recommendation and Future Work

For recommendations and future work, there are several suggestions proposed to improve this project in the future with the aim of increasing the reliability and accuracy in the process of determining the eligibility of applicants in the e-Government framework, among which are that applicant data can be integrated with official government databases such as MyDigital ID, Inland Revenue Board (LHDN) and Land and Mining Office (PTG). The integration of official data is very important in automating the verification of applicant information in determining the eligibility of applicants in several strict criteria in addition to the main criteria (Income, Dependents and Employment) such as ownership of property and assets if the applicant has additional finances other than income. This can reduce fraud in the application process and can ensure that the assistance distributed is truly eligible for applicants who have critical financial problems and do not own high-value assets.

Next, the second suggestion is that the system can be expanded by implementing fuzzy AHP in any system that involves the assessment process using relevant criteria. Currently, the prototype of this project only assesses eligibility based on three important criteria, namely Income, Dependents and Employment. For future versions, it will include additional criteria such as health status, disability status and outstanding debt. This will enable the fuzzy AHP module algorithm to produce more in-depth and realistic eligibility scores in line with current social welfare policies.

Finally, the development of this project can be further diversified with other government assistance by developing large-scale projects and acting as a government assistance application centre. Ministries and their agencies, including the Ministry of Finance Malaysia and its agencies, can manage large-scale assistance with the aim of streamlining the application process and making it the main platform in accessing various assistance programs quickly. As a result, it will not only improve the efficiency of government administration but also increase accountability in the management of government resources and reduce the cost of developing various e-Work platforms that manage assistance that are currently seen as too many and unorganized.

5.5 Summary

In conclusion, this project successfully achieved all the research objectives by producing a prototype system that supports decision making in determining applicant eligibility in aid distribution in the eGovernment framework. The integration of fuzzy rules and Analytical Hierarchical Process (AHP) can prove to act as a solution in resolving the problem of uncertainty in applicant data and producing fair and accurate applicant eligibility decisions. Despite some limitations, this project has shown encouraging results for adoption in further development and it also offers contributions in the academic and public sector that are currently working on the process of public sector digitization. The suggestions provided can create improvements in the aid evaluation process by creating a centralized platform that supports a variety of public sources with the aim of transparency and efficient management of data-based aid.

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APPENDICES

APPENDIX 1

Project Timeline – Gantt Chart