UNIVERSITI TEKNOLOGI MARA

INTEGRATING GEO-MULTICRITERIA MODELLING AND HEDONIC PRICING FOR FLOOD RISK INFORMED PROPERTY VALUATION

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NURALYA NAJIHA BINTI MOHD RUSHDI

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ABSTRACT

Flooding has become a major environmental challenge in urban areas due to rapid urbanisation and climate change, resulting in significant social and economic impacts. Understanding the influence of flood risk on residential property values is essential for effective urban planning, risk management, and property valuation. This research develops an integrated framework that combines Geographic Information Systems (GIS)-based flood susceptibility modelling and the Hedonic Pricing Model (HPM) to evaluate the impact of flood risk on residential property values in Taman Sri Muda, Shah Alam. The Analytical Hierarchy Process (AHP) was employed to determine the relative importance of flood-conditioning factors, including rainfall intensity, elevation, slope, land use, and water levels, which were subsequently integrated within a GIS environment to produce a flood susceptibility map. The resulting flood risk indicators were incorporated into a hedonic regression model using residential property transaction data. The findings indicate that flood risk has a statistically significant influence on residential property values, with properties located in areas of higher flood susceptibility experiencing lower market values. Among the variables analysed, flood-related factors were found to contribute to variations in residential property prices alongside structural and locational attributes. The integrated framework demonstrates the effectiveness of combining spatial flood risk assessment and econometric valuation techniques to quantify the economic implications of flood exposure. This research contributes to risk-informed property valuation and provides valuable insights for urban planners, valuers, policymakers, and investors in promoting resilient and sustainable urban development.

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LIST OF ABBREVIATIONS

Abbreviations

AHP	Analytical Hierarchy Process
AI	Artificial Intelligence
ANN	Analytical Neural Networks
ANP	Analytical Network Process
CI	Consistency Index
CNN	Convolutional Neural Networks
CR	Consistency Ratio
DDF	Depth-Duration-Frequency
DEMs	Digital Elevation Models
DID	Department of Drainage and Irrigation
DL	Deep Learning
FRVI	Flood Risk-Value Indicator
GIS	Geographic Information Systems
GWR	Geographically Weighted Regression
HPM	Hedonic Pricing Method
IBM	International Business Machines
JUPEM	Department of Survey and Mapping
LULC	Land use and Land Cover

MetMalasyia	Meteorology Malaysia
MCDM	Multi-Criteria Decision Making
ML	Machine Learning
MYSA	Malaysian Space Agency
NADMA	National Disaster Management Agency
NAPIC	National Property Information Centre
NCC	National Climate Change
PCM	Pairwise Comparison Matrix
RF	Random Forest
RI	Random Index
RPV	Residential Property Value
RS	Remote Sensing
SLM	Spatial Log Model
SVM	Support Vector Machine

CHAPTER 1
INTRODUCTION

1.1 Introduction

Flooding is one of the most significant natural hazards affecting urban areas worldwide. In Malaysia, increasing flood frequency has been linked to climate change, rapid urbanisation, and inadequate drainage systems. These factors have created substantial challenges for residential communities and property markets (Hino & Burke,2021).

In Malaysia, this issue is particularly evident in the Klang Valley, where rapid urban expansion has increasingly encroached upon low-lying floodplains and river systems (Mokhtar et al., 2022). The conversion of natural surfaces into impervious urban structures reduces infiltration capacity and increases surface runoff, contributing to frequent flash floods in densely developed neighbourhoods. Beyond physical damage, flooding has broader economic consequences, particularly in residential property markets where values may be influenced by perceived environmental risk.

One of the most severely affected areas is Taman Sri Muda, Shah Alam, a residential neighbourhood situated within a low-lying floodplain adjacent to the Klang and Damansara River systems (Yusmah et al., 2020). The catastrophic flood of December 2021 highlighted the area's vulnerability, causing extensive damage to residential properties and infrastructure. More importantly, the event revealed the limited integration of flood-risk considerations into conventional property valuation practices in Malaysia.

Traditional property valuation approaches primarily emphasise structural and locational characteristics, while flood exposure is often treated as a secondary consideration rather than a measurable determinant of value. This limitation may result in valuation inaccuracies in flood-prone areas where environmental risk significantly influences buyer perception and investment decisions (J. J. Thompson et al., 2023).

From a property valuation perspective, flood risk may be capitalised into residential property prices through market perceptions and risk-discounting mechanisms. According to Hedonic Pricing Theory, property values reflect a bundle of structural, locational, neighbourhood, and environmental attributes (Rosen, 1974;

Bishop et al., 2020). Buyers may discount properties exposed to recurrent flooding due to anticipated repair costs, higher insurance premiums, reduced liveability, and uncertainty regarding future resale value (Bin & Polasky, 2004; Beltrán et al., 2018). Consequently, flood susceptibility becomes an implicit determinant of residential property prices.

While the Hedonic Pricing Model (HPM) provides an economic framework for valuing environmental risk, accurately estimating flood exposure requires robust spatial assessment techniques. Geographic Information Systems (GIS) and Remote Sensing (RS) technologies have increasingly been integrated with valuation models to represent flood exposure as a spatially continuous variable rather than a binary post-disaster condition (Cea & Costabile, 2022). Unlike conventional valuation approaches that rely primarily on transaction data, GIS enables the incorporation of spatial flood-risk information, thereby improving the accuracy and consistency of property value assessment in flood-prone areas. By integrating environmental, hydrological, and locational datasets, GIS provides an evidence-based framework for identifying spatial variations in risk exposure and supports more informed valuation, planning, and investment decision-making (Abidoye & Chan, 2017).

To address this gap, this research develops a validated spatial-economic model that combines GIS-based flood susceptibility modelling, the Analytical Hierarchy Process (AHP), and the Hedonic Pricing Model (HPM). GIS enables the spatial representation of flood-conditioning factors, while AHP provides a systematic approach for determining their relative importance (Saaty, 1980). The resulting flood susceptibility index is subsequently incorporated into the HPM to quantify the economic effects of flood exposure on residential property values. By integrating these techniques, the research establishes a unified framework that links environmental risk assessment with property valuation, supporting informed decision-making.

The findings are expected to support valuers, planners, policymakers, and investors in making more informed decisions in flood-prone urban environments. Furthermore, the research contributes to climate resilience and sustainable urban development by promoting risk-informed planning and investment. These outcomes align with the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action).

1.2 Problem Statement

Despite growing awareness of flood risks in Malaysia, current property valuation practices remain limited in their ability to capture the long-term economic implications of environmental exposure. The Klang Valley has experienced recurrent floods over the past decade, culminating in the severe December 2021 flood, which caused widespread residential damage and substantial economic losses (Zulkarnain et al., 2020). Nevertheless, property valuation frameworks continue to rely predominantly on structural and locational determinants, often overlooking the influence of environmental risk variables.

This limitation raises several important concerns. First, properties located within flood-prone areas may be systematically mispriced because spatial flood exposure is insufficiently incorporated into valuation models. Second, homeowners and property investors may face increased financial vulnerability when the economic consequences of flooding materialise through asset depreciation. Third, urban planners and policymakers lack empirically grounded tools for integrating spatial flood-risk indicators into land-use planning and property-market assessments.

Although Geographic Information Systems (GIS) and Remote Sensing (RS) technologies have significantly advanced flood susceptibility mapping, these analytical tools are rarely integrated with econometric property valuation frameworks in the Malaysian context. Most existing flood risk assessments focus primarily on hydrological variables such as rainfall intensity, river discharge, and flood depth, without systematically linking these environmental indicators to property transaction data.

Furthermore, many empirical studies examining the relationship between flooding and property prices rely on event-based comparisons, typically analysing property values before and after major flood events. While this approach provides useful insights, it treats flood risk as a binary condition rather than a spatially continuous insights, it treats flood risk as a binary condition rather than a spatially continuous phenomenon. As a result, the marginal effects of varying levels of flood susceptibility on residential property values remain insufficiently quantified.

Although previous studies have examined flood susceptibility and property valuation separately, limited research has integrated GIS–AHP flood-risk modelling with the Hedonic Pricing Model (HPM) to quantify flood-related depreciation of

property value in Malaysia. Consequently, there remains insufficient empirical evidence on how spatially derived flood-risk indicators can be systematically translated into measurable economic impacts within the Malaysian housing market. This gap limits the ability of valuers, planners, and policymakers to incorporate spatial flood-risk information into property valuation and urban planning decisions.

The novelty of this research lies in the development of an integrated flood risk-informed property valuation framework that combines Geographic Information Systems (GIS)-based flood susceptibility modelling, the Analytical Hierarchy Process (AHP), and the Hedonic Pricing Model (HPM) within a single analytical approach. GIS and AHP have been widely applied in flood susceptibility assessment to identify and spatially evaluate flood-prone areas based on multiple environmental and hydrological factors (Saaty, 1980; Islam et al., 2020; Ibrahim et al., 2024). Similarly, the Hedonic Pricing Model has been extensively employed to examine how environmental attributes and hazards are capitalised into residential property values (Rosen, 1974; Ismail et al., 2019).

By integrating these established approaches within a unified framework, the proposed methodology systematically translates spatial flood susceptibility into quantifiable economic effects on residential property values. The framework, therefore, provides a comprehensive methodology for incorporating environmental risk into property valuation, thereby advancing methodological innovation and supporting practical applications in urban planning, investment decision-making, and climate resilience.

1.3 Research Question

Based on the identified research problem, this research addresses the following questions:

i) What are the key environmental and spatial factors contributing to flood susceptibility in the Klang Valley, as identified through GIS and Remote Sensing analysis?

ii) To what extent does spatially modelled flood susceptibility influence residential property values in flood-prone urban neighbourhoods?

iii) How can Geographic Information Systems (GIS), the Analytical Hierarchy Process (AHP), and the Hedonic Pricing Model (HPM) be systematically integrated to produce a spatially explicit flood risk valuation framework?

1.4 Research Aim and Objectives

This research aims to examine the relationship between flood susceptibility and residential property values by integrating Geographic Information Systems (GIS), the Analytical Hierarchy Process (AHP), and the Hedonic Pricing Model (HPM). Specifically, the research seeks to quantify flood vulnerability, evaluate its influence on residential property values, and develop a spatially explicit framework that integrates environmental risk assessment with property valuation.

To achieve this aim, the research pursues the following objectives:

i) To identify flood-conditioning factors using GIS-AHP analysis.
ii) To estimate the effect of flood-risk exposure on residential property values using the Hedonic Pricing Model (HPM).
iii) To develop an integrated GIS–AHP–HPM framework for producing the Flood Risk - Value Indicator (FRVI) map.

1.5 Research Methodology

The methodology integrates quantitative and spatial analytical approaches to examine the relationship between flood risk and residential property values in the Klang Valley. A multi-stage research design ensures methodological coherence by integrating spatial and econometric models.

The overall research process, showing the connections among data input, analytical techniques, and expected outcomes, is presented in Figure 1.1.

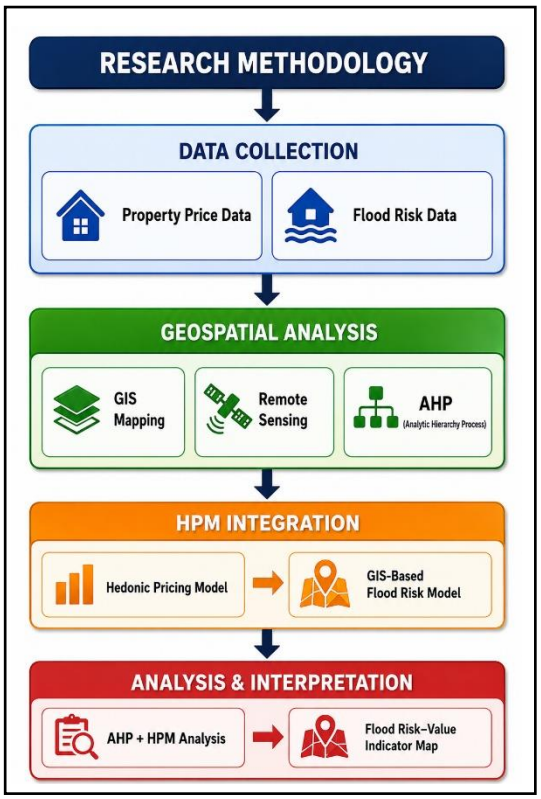


Figure 1.1 Flowchart of the Research Methodology

1.5.1 Data Collection

The first stage involves data collection, including:

i) Property Price Data: Market prices for residential properties in flood-prone zones (Taman Sri Muda) were obtained from government databases, real estate agencies, and land valuation records. Data quality is ensured by evaluating accuracy and consistency across multiple sources and verifying that the dataset adequately represents the selected flood-risk zones. One potential limitation is the imbalance in the volume of data obtained from different sources. Therefore, this research will apply statistical techniques, such as data normalisation and handling missing data, to ensure consistency in the analysis.

ii) Flood Risk Data: GIS flood-susceptibility maps are generated from remote sensing data, including satellite imagery. Environmental datasets on rainfall, water levels, elevation, slope, drainage density, and land use are pre-processed within a GIS environment to ensure projection harmonisation and spatial comparability (Rabie et al., 2025).

1.5.2 Geospatial Analysis

This second stage involves using Geographic Information Systems (GIS) and Remote Sensing (RS) tools to identify flood-prone areas and assess their spatial relationships to residential property locations. GIS-based Multi-Criteria Decision-Making (AHP) is used to assign relative weights to flood-conditioning factors. Weighted overlay analysis in ArcGIS is used to generate a composite Flood Susceptibility Index. This index represents spatial variations in flood risk across Taman Sri Muda.

1.5.3 Hedonic Price Model (HPM) Integration

The third-stage integration of GIS-based flood susceptibility modelling with the Hedonic Pricing Model is adopted because spatial environmental risks cannot be adequately captured by conventional valuation approaches that rely solely on structural and locational property attributes. Flood susceptibility scores are subsequently incorporated into a semi-logarithmic Hedonic Pricing Model estimated using the Statistical Package for the Social Sciences (SPSS). Structural, locational, and environmental attributes are incorporated into the model. These variables quantify the marginal price effect of flood exposure.

Regression techniques were used to assess the impact of flood risk factors on property values. This stage provides a detailed, spatially explicit understanding of how flood risk variables contribute to market fluctuations in flood-prone regions.

1.5.4 Analysis and Interpretation

The final stage combines the Analytic Hierarchy Process (AHP) and the Hedonic Pricing Model (HPM) to assess the relationship between flood risk exposure and residential property values. The AHP's weighted flood-susceptibility outputs integrate into the hedonic valuation framework to quantify the effect of varying levels of flood risk on housing prices (Chongwilaikasaem & Chalermyanont, 2022).

This stage produces a Flood Risk–Value Indicator Map, providing a spatially explicit representation of areas where flood vulnerability is associated with greater property-value depreciation. The results will support deeper interpretation of flood-induced market impacts and provide actionable insights for flood-resilient urban

planning and property risk management.

1.6 Software

The analysis will be conducted using:

1.6.1 ArcGIS (Version 10.8.3)

Developed by the Environmental Systems Research Institute (ESRI), ArcGIS is a leading platform for spatial analysis and geoprocessing. It integrates three key applications: (i) ArcMap, (ii) ArcCatalog, and (iii) Arc Toolbox. ArcMap is used for map creation and spatial modelling; ArcCatalog manages and organises geospatial data; and Arc Toolbox provides analytical tools for data conversion and processing. In this research, ArcGIS was used to generate flood-susceptibility maps, conduct overlay analyses, and integrate spatial datasets into the Analytical Hierarchy Process (AHP) model (Hammami et al., 2019).

1.6.2 Statistical Package for the Social Sciences

SPSS, developed by International Business Machines (IBM), is widely used for statistical analysis in social and environmental research (Pallant, 2010). It provides an intuitive interface for running descriptive and inferential analyses without complex programming. In this research, SPSS was used to conduct regression analysis within the Hedonic Pricing Model framework, examining the relationship between flood-related variables and residential property values. SPSS was also used to assess data reliability and ensure statistical consistency across datasets (Oyetunji et al., 2023).

1.7 Scope of Research

This research focuses on Taman Sri Muda, Section 25, Shah Alam, Selangor. The research focuses on double-storey residential properties in Taman Sri Muda; therefore, the findings may not be directly generalisable to other property types or geographical settings.

1.8 Summary of Chapter

Including a summary at the end of each chapter is essential to ensure clarity and continuity throughout the thesis. This section summarises the key elements discussed in Chapter 1 and provides a roadmap for the subsequent chapters.

1.8.1 Chapter 1: Research Background

Chapter 1 provided the research's foundational context by highlighting growing concerns about flood risk and its impact on residential property values, particularly in urban areas such as the Klang Valley, Malaysia. The chapter outlined the relationship between environmental risks, especially flooding, and property valuation, underscoring the importance of integrating Geographic Information Systems (GIS), Remote Sensing (RS), and the Hedonic Pricing Model (HPM) to provide a more comprehensive understanding of flood-induced property devaluation. The research aim, objectives, research questions, and methodology were established, setting the stage for the subsequent chapters. The focus was on creating an integrated framework that uses spatial and property data to enhance flood risk assessments and property valuation models.

1.8.2 Chapter 2: Literature Review

Chapter 2 presented an extensive review of the literature on flood risk, geospatial analysis, and property valuation. It critically analysed how previous research has addressed the relationship between flood risk and property values using traditional methods. It highlighted gaps in the literature regarding the integration of GIS and HPM. The review emphasised the importance of understanding both the physical and socio-economic impacts of flooding on property markets. The chapter identified a research gap by examining how GIS, RS, and the Analytical Hierarchy Process (AHP) could be synthesised with HPM to improve flood risk valuation models, offering a clearer approach for future urban planning and property valuation practices in flood-prone areas.

1.8.3 Chapter 3: Research Methodology

Chapter 3 outlined the research methodology, detailing the systematic approach to addressing the research questions. The research combined quantitative methods with spatial analysis to examine the relationship between flood risk and residential property values. The chapter also described the multi-stage research design, which included data collection, geospatial analysis using GIS and Remote Sensing, and the integration of HPM with flood risk data. The integration of AHP with GIS for multi-criteria decision-making was also discussed, providing a robust methodological framework. Tools such as ArcGIS and SPSS were identified as crucial for the spatial and statistical analyses required for the research.

1.8.4 Chapter 4: Results and Analysis

In Chapter 4, the results from both spatial and statistical analyses were presented. The integration of GIS-based flood risk mapping with the Hedonic Pricing Model reveals how flood-related attributes influence residential property values. The chapter discussed the findings in relation to theoretical perspectives from previous studies, illustrating how flood risks, including depth, frequency, and duration, contribute to depreciation of property values in the Klang Valley. Regression analysis quantifies the marginal impact of flood risk factors on residential property values. The findings confirm the significant role of geospatial data in property valuation. The findings were interpreted in the context of urban flood management and in relation to how this research contributes to the existing body of knowledge on flood risk valuation.

1.8.5 Chapter 5: Conclusion and Recommendation

Accordingly, the following chapter critically synthesises the theoretical and empirical literature on flood risk modelling, geospatial analysis, and property valuation to establish the conceptual foundations of the integrated GIS–AHP–HPM framework developed in this research. By critically synthesising prior studies, the literature review establishes the theoretical and empirical foundations necessary for understanding how environmental hazards are incorporated into housing market behaviour. This synthesis provides the conceptual justification for integrating Geographic Information Systems (GIS), the Analytical Hierarchy Process (AHP), and the Hedonic Pricing Model (HPM),

which collectively form the analytical framework applied in this research.

While Chapter 1 establishes the research problem and objectives, the following chapter critically reviews the theoretical and empirical literature on flood risk modelling, geospatial analysis, and property valuation to provide the conceptual foundation for the integrated analytical framework proposed in this research.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter provides a comprehensive review of the literature on integrating flood risk models with property valuation practices, particularly in the context of urban planning in Malaysia. Understanding how flood risks influence property values is increasingly important in rapidly urbanising regions affected by climate change. This concern is particularly relevant in flood-prone urban regions such as the Klang Valley. Traditional property valuation methods often fail to fully account for environmental risks, leading to mispricing and distorted market signals (Beltrán et al., 2019). Research by Hino & Burke (2021) suggests that flood events result in immediate depreciation of property values, with prolonged effects in areas subject to recurrent flooding. Recent studies indicate that incorporating advanced tools such as Geographic Information Systems (GIS), Remote Sensing (RS), and the Analytical Hierarchy Process (AHP) can significantly improve property valuation accuracy by spatially quantifying flood-risk factors (Cea & Costabile, 2022). These technologies enable precise identification of flood-prone areas and provide important insights for urban planners, property appraisers, and policymakers.

Building on the research problem outlined in Chapter 1, this chapter critically reviews the theoretical and empirical literature on flood risk modelling, geospatial analysis, and property valuation. The objective of this review is not only to summarise existing studies but also to identify methodological limitations in previous research, particularly regarding the integration of spatial flood susceptibility analysis with econometric property valuation models. Through this synthesis, the chapter establishes the conceptual foundation for the integrated GIS–AHP–HPM framework implemented in the subsequent methodology.

2.2 Conceptualising Floods: Definitions and Types of Floods

Floods are among the most economically disruptive environmental hazards, particularly in urbanised regions where dense infrastructure and concentrated property assets increase potential losses (Tariq et al., 2020). Beyond immediate physical damage,

flood events increasingly generate measurable economic consequences within housing markets, influencing buyer perceptions, investment behaviour, and long-term residential property valuation (Zhang et al., 2023). Floods can cause water contamination, disease spread, and ecosystem disruption, extending their impacts beyond the immediate aftermath (Devitt et al., 2023).

In Malaysia, flooding is a recurring phenomenon due to its tropical climate, which is heavily influenced by monsoon systems. The interaction among climatic conditions, land use, and the urban landscape has made flood events increasingly frequent and severe (Paterson et al., 2018). Rapid urban expansion has increased the extent of impervious surfaces in many cities. As a result, natural drainage systems have been replaced by artificial structures that are less capable of managing water flow, thereby increasing flood risk (Shaaban et al., 2021). This growing vulnerability underscores the importance of integrating comprehensive flood risk assessment models into urban planning to understand better and mitigate the impacts of flooding on property markets.

Flooding in Malaysia is primarily categorised into two types: monsoon floods and flash floods. Monsoon floods are driven by the prolonged rainfall during the Northeast and Southwest Monsoon seasons, with the former causing widespread flooding, particularly in the eastern states such as Kelantan, Terengganu, and Pahang (Buslima et al., 2018). These floods are relatively predictable, occurring seasonally and affecting large areas. However, flash floods are more localised, occurring rapidly after intense rainfall and overwhelming drainage systems in urbanised regions such as the Klang Valley (Yusmah et al., 2020). Flash floods tend to cause more immediate and severe damage due to their rapid onset and urban areas' inability to manage large volumes of water in a short time.

Both types of floods pose significant challenges to urban planning and property valuation. While monsoon floods may affect larger geographic areas, flash floods have a more immediate impact on densely populated areas, resulting in higher economic losses in urban settings (Tew et al., 2022). As urban development continues, particularly in areas with limited drainage capacity, the frequency and intensity of flash floods are expected to increase, likely leading to further depreciation in property values in high-risk areas (Bari et al., 2021). Understanding the characteristics of these flood types is essential for developing flood risk models that accurately capture their impacts on property markets, especially in flood-prone urban areas.

2.2.1 Types of floods in Malaysia: Monsoon and Flash Floods

Flood events in Malaysia are often classified as monsoon or flash floods, each exhibiting distinct hydrological behaviours, spatial footprints, and associated economic consequences. Monsoon floods typically occur during the Northeast and Southwest Monsoon seasons, driven by prolonged, high-intensity rainfall that saturates catchments and causes rivers to overflow.

The 2021–2022 Malaysian floods, recognised as among the most severe in recent history, were triggered by a tropical depression and resulted in widespread inundation across eight states, displacing more than 71,000 residents and causing estimated property damage of between RM5.3 billion and RM6.5 billion, according to government estimates (Ikram, 2022). These large-scale monsoon events notably disrupted regional property markets in Selangor, Pahang, and Kelantan, where extensive housing and infrastructure damage have led to both short- and potentially long-term declines in investor confidence and asset values (Department of Statistics Malaysia, 2022). Figure 2.1 compares the effects of Monsoon Floods and Flash Floods, highlighting differences in property-value impacts and economic losses, as well as their association with recent flood events in Malaysia.



Figure 2.1 Types of Floods in Malaysia and Their Economic Impact on Property Values

In contrast, flash floods occur rapidly with little warning, driven by intense, short-duration rainfall that overwhelms urban drainage systems. Urban centres such as the Klang Valley, including Shah Alam and Subang Jaya, experience recurrent flash

flooding, especially during intermonsoon periods, undermining both residential livability and real estate attractiveness. These sudden events often cause acute property damage, affect buyer behaviour, and contribute to localised depreciation in housing prices as risk awareness increases.

Previous studies suggest that flash floods tend to generate stronger short-term market reactions in urban areas than monsoon floods, due to their sudden onset and more severe immediate damage to residential properties (Bari et al., 2021). For example, survey data from Shah Alam indicate that most potential homebuyers consult flood risk maps before purchasing, reflecting heightened sensitivity to risk that could affect demand and transaction prices (Rahman et al., 2025). These urban flash floods, while geographically confined, are significant contributors to property-value erosion, especially in highly urbanised areas with inadequate drainage systems (Yusmah et al., 2020).

The economic impacts of these flood types differ in scale and persistence. Monsoon floods, due to their extensive spatial reach and prolonged duration, have been linked to systemic depreciation in property markets, as buyers avoid listings in flood-prone zones, resulting in reductions in market value of up to 30% in extreme cases (Department of Statistics Malaysia, 2021). This depreciation is compounded when infrastructure damage is severe, discouraging long-term investment in affected localities. Flash floods, although more geographically confined, often exert sharper short-term declines in property values within densely populated urban neighbourhoods due to immediate repair costs, temporary displacement, and higher insurance premiums (Bari et al., 2021). The December 2021 flash floods in Shah Alam, for instance, caused an immediate 10% reduction in property values, especially in low-lying areas, demonstrating how rapid inundation can alter real estate market conditions.

Recent national data confirm that flood-related economic losses remain significant. In 2023 alone, total flood losses were approximately RM755.4 million, with damage to homes exceeding RM168 million, highlighting ongoing flood risks to housing markets and the economy (Department of Statistics Malaysia, 2023). These figures show that, even during years without major monsoon events, flood risks continue to impose economic costs, influencing buyer perceptions, insurance costs, and property values in both regional and urban areas. As these losses accumulate, there is a clear need for improved flood-risk models in property valuation that incorporate environmental and economic factors to provide a more complete assessment.

The distinct hydrological mechanisms and spatial patterns of monsoon versus flash floods thus produce differentiated impacts on real estate markets, necessitating tailored risk integration in valuation models. Empirical research and market observations underscore that flood risk is increasingly internalised by property market participants, influencing demand, pricing trends, and urban planning decisions. This underscores the need for valuation frameworks that explicitly incorporate flood frequency, intensity, and exposure metrics to accurately capture the economic impacts on residential property values in Malaysia (Shaaban et al., 2021).

2.2.2 Flood History in Malaysia and Market Implications

Malaysia's flood history demonstrates a progressive intensification of hydrometeorological risk, accompanied by increasing economic exposure within urban property markets. The 1971 Kuala Lumpur flood remains one of the most significant events in the nation's history, causing an estimated RM2.85 billion in damages and displacing more than 225,000 people. This event marked a pivotal moment in Malaysian flood governance, catalysing early flood mitigation policies and institutional reforms (Ahmada et al., 2025). Beyond its humanitarian and infrastructural impacts, the 1971 flood underscored the vulnerability of rapidly urbanising floodplains to prolonged, high-intensity rainfall episodes typical of the monsoon climate system.

Over the subsequent decades, Malaysia has experienced increasingly severe rainfall variability and extreme precipitation events, reflecting broader regional trends in climate intensification (Tariq et al., 2020). These extreme rainfall episodes amplify surface runoff, often exceeding drainage capacity thresholds, particularly in urban environments dominated by impervious surfaces. The nationwide floods of 2021-2022, triggered by sustained heavy rainfall associated with a tropical depression, caused economic losses estimated at RM5.3 -RM6.5 billion, displaced over 71,000 residents, and affected eight states (Department of Statistics Malaysia, 2022, 2023). The magnitude of these losses reflects not only meteorological intensity but also the spatial concentration of high-value assets within hydrologically sensitive zones.

The comparative escalation from RM2.85 billion in 1971 to over RM6 billion in 2021–2022 illustrates a structural increase in exposure to flood risk. While climatic factors such as prolonged rainfall and intensified storm events remain primary contributors, urban expansion into low-lying floodplains has significantly amplified the

accumulation of risk (Mokhtar et al., 2022). Recent studies emphasise that climate variability, combined with land-use change, contributes to compound flood events in which high rainfall coincides with elevated river discharge and reduced infiltration capacity (Bari et al., 2021). This interaction highlights the need to model flood risk as a multidimensional phenomenon, shaped by meteorological, hydrological, and anthropogenic factors.

Importantly, the visual representation of Malaysia's flood history demonstrates the evolution of flood risk management models, which have shifted from structural mitigation plans to the integration of Geographic Information Systems (GIS), Remote Sensing technologies, and risk-informed valuation approaches (Figure 2.2). The shift towards GIS-based modelling acknowledges that flood susceptibility must be spatially quantified, rather than treated as an episodic hazard (Tariq et al., 2020). However, despite advances in flood hazard mapping, its integration into property valuation frameworks remains analytically fragmented.

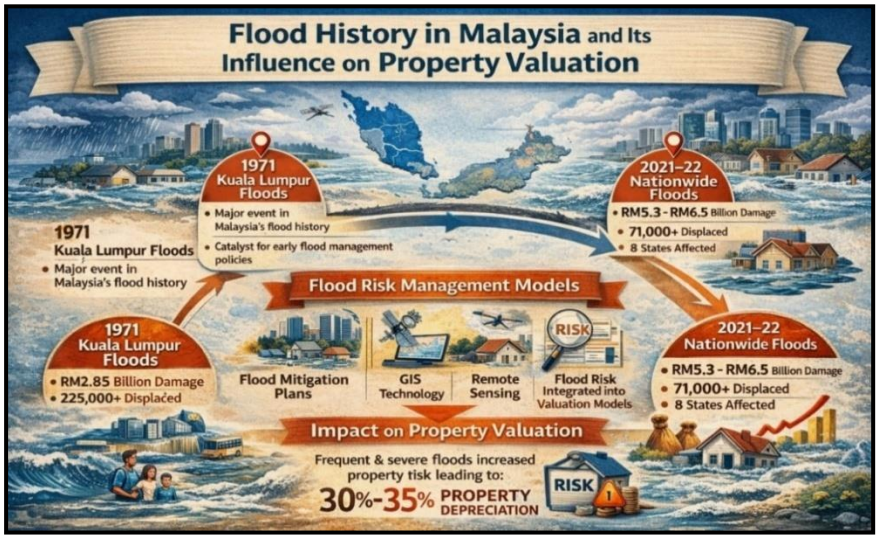


Figure 2.2 Flood History in Malaysia and its Influence on Property Valuation

From a property market perspective, repeated exposure to severe flood events has been linked to measurable depreciation in assets. Evidence suggests that frequent and severe flooding can result in property value discounts of 30%–35% in highly affected areas, particularly when risk perception becomes embedded in buyer decision-making (Zulkarnain et al., 2020; Ouyang et al., 2021). Following the 2021 flood events, residential areas such as Taman Sri Muda experienced significant market adjustments, driven by both physical damage and heightened expectations of future flood risk (Idris et al., 2025; Mokhtar et al., 2022). These depreciation effects align with the

capitalisation mechanism described in hedonic pricing theory, where environmental disamenities are internalised into housing prices through implicit risk premiums.

Collectively, Malaysia's flood history demonstrates that increasing flood frequency and urban expansion have intensified both physical and economic vulnerabilities, highlighting the importance of incorporating environmental risk into contemporary property valuation and urban planning.

2.3 Flood Risk Management in Malaysia

Flood risk management in Malaysia has evolved significantly; however, existing approaches still fail to address the economic impacts of flooding on property markets fully. Although structural flood mitigation measures reduce physical flood exposure, such measures do not necessarily eliminate market perceptions of flood risk. Consequently, residential property values in previously flooded areas may continue to reflect risk premiums even after infrastructure improvements. These approaches rarely account for how recurring flood exposure influences residential property markets through risk perception, insurance adjustments, and long-term investment decisions. Furthermore, such structural measures are often constrained by design capacity, high construction costs, and ongoing maintenance requirements. Studies have shown that even robust structural defences cannot fully protect areas beyond their design limits, resulting in sudden, catastrophic failures during extreme flood events (Rusdi et al., 2023). As a result, these methods fail to account for the broader economic consequences of flooding, including impacts on property values, livelihoods, and communities (Shahzad et al., 2021).

Figure 2.3 contrasts the effectiveness of Structural and Non-Structural Measures, highlighting their limitations and the need for integrated solutions that combine risk-based modelling with economic valuation. The figure emphasises that current flood management strategies fall short of addressing the economic vulnerabilities of the property market and underscores the need to integrate structural protections with economic assessments.



Figure 2.3 Flood Risk Management in Malaysia and its Impact on Property Markets

Non-structural measures, including flood zoning regulations, early warning systems, and public awareness campaigns, have been recognised as essential for flood risk mitigation. However, these measures often face challenges, including insufficient funding, weak enforcement, and low public awareness (Tariq et al., 2020). Additionally, translating the intangible benefits of these measures, such as community resilience and reduced flood-risk exposure, into quantifiable impacts on property values remains a significant challenge. The difficulty in incorporating these factors into property valuation models has been a critical barrier to fully integrating non-structural measures into mainstream flood risk management strategies (Bari et al., 2021).

To address the shortcomings of both structural and non-structural measures, there is growing recognition of the need for integrated flood risk management solutions that combine the strengths of both approaches with advanced risk-based modelling and economic valuation. This integrated approach aims to provide a more comprehensive assessment of flood risks, incorporating the economic impacts on property values into flood management strategies. Research indicates that integrating Geographic Information Systems (GIS) with remote sensing and economic valuation models 0yields a more accurate representation of flood risks in property markets (Zulkarnain et al., 2020). By incorporating these technologies, policymakers and real estate professionals can better assess flood vulnerability, ultimately leading to more informed decisions regarding flood mitigation and property valuation.

While flood risk management strategies traditionally focus on physical mitigation and disaster response, their economic implications are increasingly recognised within urban property markets. Recurrent flood exposure can influence buyer perceptions, insurance costs, and long-term investment decisions, thereby affecting the market valuation of residential properties. Understanding these economic responses requires analytical approaches that connect spatial flood risk assessment with property market behaviour, a central focus of the subsequent sections.

2.4 Overview of Flood Risk and Property Valuation

Flooding is a recurring and dangerous natural hazard that has both direct and indirect consequences on the built environment. The physical consequences of flooding in urban areas include the destruction of private and public properties and the disruption of business activities. The consequences for commercial activities can be permanent and affect property values in the affected area. Flood risk is commonly assessed using indicators such as flood depth, frequency, and duration, which influence property market behaviour. Scholars, including Beltrán et al. (2019), have studied the impact of flood risk on property values and are in consensus that properties at risk of flooding are valued lower. Flood risk is commonly assessed using indicators such as flood depth, frequency, and duration, which influence property market behaviour. Scholars, including Beltrán et al. (2019), generally agree that properties exposed to flood hazards tend to experience lower market values due to increased perceived risk and potential future losses. Consequently, incorporating environmental risk into property valuation has become increasingly important for improving valuation accuracy and supporting risk-informed decision-making.

Flood risk influences residential property markets by altering buyer perceptions, investment decisions, and willingness to pay. As flood awareness increases, environmental risk becomes progressively incorporated into housing prices, creating measurable differences between flood-prone and non-flood-prone locations. Buyers and investors often perceive properties exposed to recurrent flooding as carrying higher future repair costs, insurance premiums, and financial uncertainty, resulting in reduced demand and lower market values. Consequently, environmental risk has become an increasingly important consideration in residential property valuation and urban planning, reflecting the growing need to account for flood susceptibility when assessing

market behaviour and investment decisions.

The increasing frequency and severity of floods in Malaysia have significantly altered both public risk perception and housing market behaviour. Homebuyers, investors, and insurers have become more risk-averse, increasingly factoring flood risk into their decision-making. The growing awareness of the economic costs of frequent flooding has led to higher flood insurance premiums, as insurers adjust their pricing to account for the heightened risks. This shift has further compounded the depreciation of property values in flood-prone areas, as higher premiums and potential future repair costs discourage investment. Moreover, the perceived risk of future flooding, even in areas not directly impacted by recent events, has begun to influence overall market dynamics, with some previously sought-after locations now experiencing reduced demand and stagnated property prices. The long-term implications of these changes underscore the need for urban planners, developers, and policymakers to adopt a more integrated approach to flood risk management that considers both immediate and future economic impacts on the property market.

2.4.1 Historical and Theoretical Perspectives on Flood Risk and Property Valuation

Historically, the economic theory underlying the relationship between environmental hazards and property values dates to the Hedonic Pricing Model (HPM). Introduced by Rosen (1974), HPM posits that a property's price is determined by various attributes, including tangible characteristics (e.g., size, location) and intangible characteristics (e.g., environmental risk, flood susceptibility). Early studies applying HPM to flood risk have shown that flood-prone properties typically have lower market values than similar properties in less risky areas. However, these studies often relied on simple models and lacked the spatial granularity necessary for accurate risk assessment (Lisi, 2019; Zhang & Crawford, 2020).

With advances in GIS and RS technologies, recent studies have integrated these tools into HPM to better account for spatial variability in flood risk. GIS and RS technologies provide high-resolution spatial data that can map flood zones, assess flood frequency and severity, and inform property valuation models. By enhancing HPM with these technologies, researchers can now quantify flood risk with greater precision, offering a more nuanced understanding of its impact on property values (Abdrabo et al.,

2020; Narimani et al., 2021).

2.5 Role of Geospatial Technologies in Flood Management

Geographic Information Systems (GIS) and Remote Sensing (RS) are powerful tools in modern flood risk management, enabling urban planners and property valuers to move beyond basic spatial analysis to more sophisticated risk assessment models. GIS and RS technologies integrate topographic, hydrological, and land-use datasets to identify flood-susceptible zones with high spatial precision. Such spatial modelling capabilities provide an essential analytical foundation for examining how exposure to environmental risks may subsequently influence residential property valuation patterns (Idris et al., 2025; Tariq et al., 2020). In addition, incorporating dynamic datasets allows stakeholders to visualise flood risk relative to property values, enabling more informed decision-making regarding real estate investments and urban development. These technologies extend beyond traditional flood maps by providing real-time data that supports flood prediction, making them essential for assessing both current and future flood risks in relation to property exposure (Godyń, 2021).

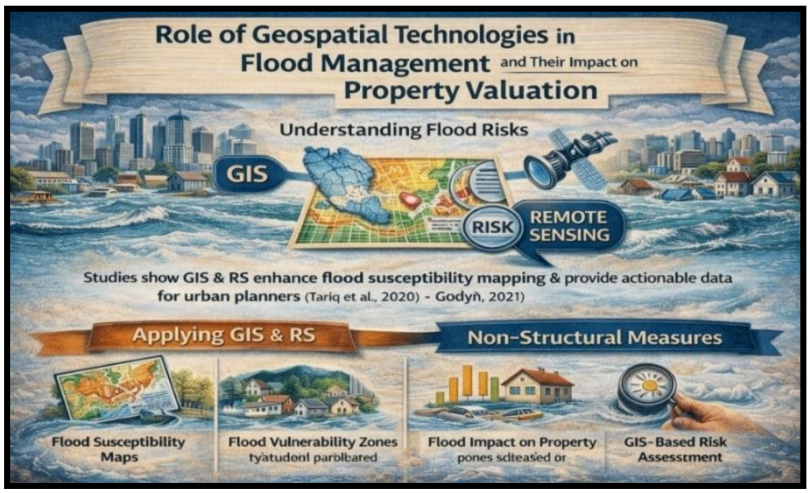


Figure 2.4 Role of Geospatial Technologies in Flood Management and Their Impact on Property Valuation

Figure 2.4 illustrates how GIS and RS contribute to understanding flood risks and their impact on property values. The infographic highlights the integration of GIS-based flood susceptibility maps and risk assessment models, demonstrating how these tools can identify vulnerable areas and provide actionable data for urban planners and property appraisers.

The integration of GIS and RS into flood management has been particularly valuable for identifying flood-susceptible and vulnerability zones, which are essential for urban planning and property valuation. Despite the analytical advantages of GIS-based flood modelling, several studies highlight limitations related to data resolution, model assumptions, and the difficulty of integrating spatial outputs with economic valuation models. Some studies have shown that a GIS-based Flood Susceptibility Map can predict areas at high risk of flooding, allowing developers, property buyers, and insurers to adjust their decisions based on flood exposure (Godyń, 2021). For instance, the use of GIS to map flood hazards in the Klang Valley has enabled planners to target mitigation efforts in the most flood-prone areas and to influence property values in those zones by highlighting the risk of flooding (Shahzad et al., 2021).

As flood risks are increasingly incorporated into property valuation models, GIS and RS tools are becoming indispensable for accurately assessing market trends and forecasting future property values in flood-prone areas. Nevertheless, while GIS and Remote Sensing substantially improve spatial flood assessment, these technologies alone cannot quantify the economic consequences of environmental risk without integration into property valuation models.

2.6 Analytical Hierarchy Process (AHP) in Flood Risk Indicators Assessment

The Analytical Hierarchy Process (AHP) is a structured multi-criteria decision-making (MCDM) technique used to prioritise flood-related parameters through systematic pairwise comparison. When combined with Geographic Information Systems (GIS) and Remote Sensing (RS), AHP enhances the ability to assess and prioritise flood risks across large and complex landscapes. This integration enables urban planners and risk managers to understand better how factors such as rainfall, elevation, and land use interact to influence flood susceptibility (Su et al., 2023).

The Analytical Hierarchy Process is effective because it evaluates multiple, often conflicting, criteria simultaneously, providing a more holistic approach to flood risk management, particularly in areas prone to frequent or extreme flooding. Figure 2.5 illustrates the integration of AHP with GIS and RS, highlighting both the advantages and challenges of this approach. The infographic emphasises the multi-criteria decision-making process, which combines expert judgment with geospatial data to provide comprehensive flood risk insights and actionable solutions for urban planning.

A significant advantage of AHP in flood risk assessment is its ability to improve decision-making by ranking and weighting criteria based on their relative importance. For instance, in flood vulnerability mapping, AHP can rank factors such as proximity to rivers, elevation, land cover, and historical flood data to develop a prioritisation system for flood mitigation efforts. This approach not only streamlines complex decision-making processes but also helps stakeholders identify high-risk areas where mitigation measures should be focused (Godyń, 2021).

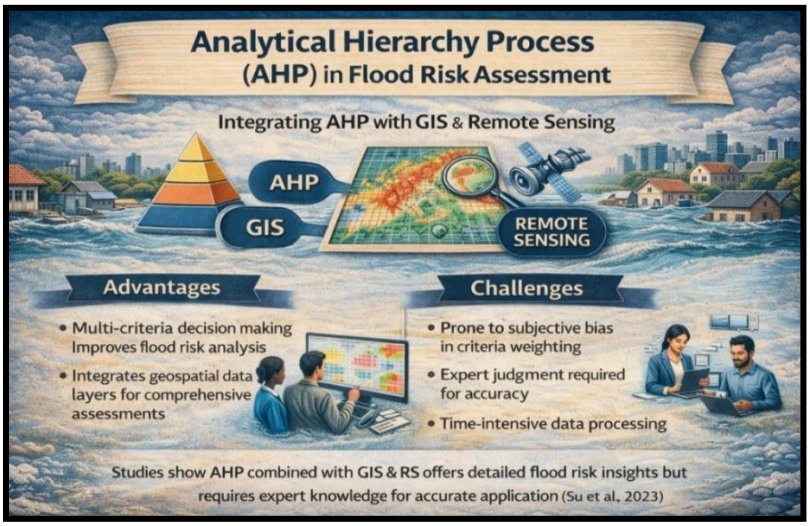


Figure 2.5 Analytical Hierarchy Process (AHP) in Flood Risk Assessment

However, the approach's reliance on expert judgment introduces subjectivity, which can lead to inconsistent results if the weights of the criteria are not clearly defined or the expert input is poorly calibrated (Shahzad et al., 2021). Despite its advantages, the AHP approach also faces several limitations when integrated with GIS and RS in flood risk management. One major challenge is the time-intensive nature of data processing, as AHP requires substantial amounts of data to be gathered, analysed, and continuously updated. Moreover, the subjective nature of expert judgment in weighting criteria can introduce biases, especially when dealing with complex, multi-dimensional flood risk factors (Su et al., 2023).

These limitations highlight the need for improved methodologies that integrate the AHP decision framework with robust, data-driven risk models to reduce reliance on subjective inputs. Recent studies have suggested incorporating machine learning and artificial intelligence (AI) to automate and refine the weighting process, thus improving the accuracy and consistency of flood risk assessments (Tariq et al., 2020). Similarly, although AHP provides a systematic framework for weighting flood-conditioning

factors, its reliance on expert judgement introduces subjectivity, underscoring the need for complementary econometric approaches to validate spatial risk using observed market behaviour.

2.7 Residential Property Value Response to Flooding

Flood-induced depreciation is a significant concern in housing markets because environmental risks are increasingly internalised into property prices. Within the framework of hedonic pricing theory, flood exposure functions as an environmental disamenity that reduces buyers' willingness to pay, thereby generating observable price adjustments in flood-prone neighbourhoods. Modelling this depreciation requires integrating geospatial data, such as flood risk maps and historical damage data, to assess reductions in property value accurately. Geographic Information Systems (GIS) and Remote Sensing (RS) play a significant role in improving the precision of property value assessments by providing detailed flood hazard mapping, which is essential for determining flood susceptibility in residential areas. These tools allow for more accurate estimates of the flood risks a property faces, which, in turn, help appraisers calculate depreciation rates that reflect actual flood risks rather than relying on generalised data (Nguyen et al., 2022).

This approach enables urban planners and property valuers to quantify the economic impacts of flooding more accurately, offering a clearer picture of long-term market trends and potential investment risks. Figure 2.6 illustrates how geospatial data enhances the accuracy of modelling flood-related depreciation, showing the short-term and long-term effects of flooding on property values. It highlights the importance of flood awareness and mitigation efforts in reducing property devaluation and demonstrates the potential for recovery in flood-prone areas when effective management strategies are implemented.

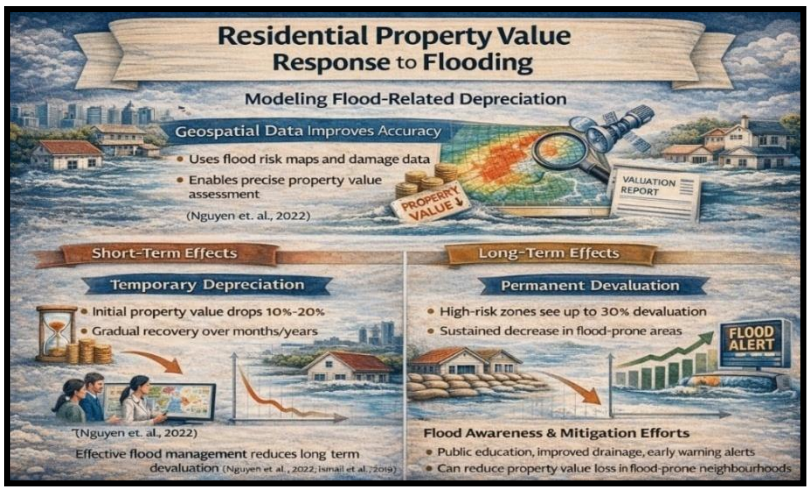


Figure 2.6 Residential Property Value Response to Flooding

The effects of flooding on property values can be categorised into short-term and long-term impacts. In the short term, properties affected by flooding can experience a 10%-20% depreciation. However, this decline is often temporary, with values gradually recovering over months or years as the area stabilises and flood damage is repaired (Nguyen et al., 2022). In contrast, long-term effects can be much more severe, with properties in high-risk flood zones experiencing sustained devaluation of up to 30%, particularly if these areas are subject to recurring floods.

However, flood awareness and mitigation efforts have been shown to help mitigate long-term depreciation. Studies by Ismail et al. (2019) found that proactive flood management measures, such as improved drainage systems, flood barriers, and early warning systems, significantly reduce property value loss over time. These efforts enhance public awareness and preparedness, which, in turn, reduces the long-term economic impact of floods on property values by improving overall community resilience.

These observed reductions in residential property values can be theoretically explained by the Hedonic Pricing Model, which assumes that environmental disamenities, such as flood risk, are capitalised into market prices through buyers' willingness to pay. This theoretical perspective provides the foundation for understanding how environmental risk is reflected in housing prices. It motivates the use of hedonic valuation approaches to quantify the economic effects of flood susceptibility.

2.8 Environmental Risk and Hedonic Valuation Approaches

Among the available valuation approaches, the Hedonic Pricing Model (HPM) is particularly well-suited for analysing the economic effects of environmental hazards because it estimates the implicit value of individual property attributes embedded in market prices. In the context of flood risk, HPM enables the quantification of how varying levels of flood susceptibility are capitalised into residential property values, thereby providing a theoretical and empirical basis for risk-informed property valuation.

Property valuation methodologies have evolved in response to growing recognition that environmental risks, particularly flooding, have a measurable influence on housing markets. Traditional approaches, such as the sales comparison and cost-based methods, primarily focus on structural attributes and prevailing market conditions, offering limited capacity to incorporate spatially differentiated risk exposure. As flood events become more frequent and economically disruptive, valuation research has increasingly adopted econometric frameworks to isolate the marginal price effects of environmental disamenities. Among these frameworks, the Hedonic Pricing Model (HPM) has emerged as a dominant analytical tool for estimating how flood risk is capitalised into property values (Nguyen et al., 2022).

The Hedonic Pricing Model provides a robust econometric framework for isolating the marginal contribution of individual property attributes to overall housing prices. By incorporating environmental risk variables such as flood susceptibility, the model enables researchers to quantify the extent to which spatially distributed hazards are capitalised into residential property values within urban housing markets. Empirical studies consistently report that residential properties in flood-prone areas command lower prices, with discounts typically ranging from 2% to 4%, depending on exposure intensity and recurrence (Wei & Zhao, 2022). Variability in depreciation effects is often associated with factors such as flood duration, depth, and frequency, indicating that risk intensity significantly shapes market response (Eves, 2004).

Beyond conventional regression applications, recent studies have integrated spatial modelling techniques to account for geographic dependence and spatial autocorrelation in property markets (Su et al., 2023). Incorporating GIS-derived flood-susceptibility indicators enhances the explanatory power of property value models by capturing proximity to rivers, elevation gradients, and drainage characteristics. Such spatially explicit modelling allows for differentiation between immediate depreciation

during flood events and longer-term market adjustments influenced by risk perception and insurance dynamics (Shahzad et al., 2021). However, many studies in Malaysia have examined the continuous and spatial nature of flood exposure (Ismail et al., 2019).

Overall, the transition from traditional appraisal techniques to hedonic and spatial econometric approaches reflects a broader methodological shift towards risk-sensitive valuation. While HPM provides a theoretically grounded mechanism for estimating the capitalisation of environmental risks, its integration with multi-criteria flood susceptibility modelling remains underdeveloped in Malaysia. This gap underscores the need for a structured GIS–AHP–HPM framework that links spatial flood vulnerability with transaction-based property valuation within a unified analytical model.

2.8.1 Flood Damage Classification

Flood damage can typically be classified into two (2) broad categories: tangible and intangible. Tangible damage refers to losses that can be readily expressed in monetary terms, including the destruction of physical structures or property. Intangible damage, on the other hand, encompasses losses that cannot be directly quantified in monetary terms, such as psychological trauma, loss of life, or disruption of social networks (Kuiper, 1971). Additionally, tangible damage can be further divided into direct and indirect categories. Direct damage refers to the immediate destruction of physical assets, such as buildings, warehouses, or shops, due to direct contact with water or total submersion. Indirect damage, however, is caused by disruptions to physical and monetary systems, such as income loss from business closures or disruptions to transportation and trade flows.

Merz et al. (2010) define direct damage as the harm resulting from physical interaction between floodwater and people, property, or other objects. Indirect damages occur as a consequence of the direct damages but are spatially and temporally removed from the flood event itself. This division of direct and indirect damages into further subcategories applies equally to both tangible and intangible damages, depending on whether the damages can be monetised. Tangible damages are losses incurred to physical structures or economic processes that can be monetarily assessed. In contrast, intangible damages involve non-market assets, for which quantifying their financial impact is more complex (Merz et al., 2010).

Flood damage of different types has been addressed by Dutta et al. (2003), Penning-Rowsell & Chatterton (1978), and Lee & Mohamad (2013). Dutta et al. also classified tangible damage into direct and indirect, thereby distinguishing between primary and secondary damage, as shown in Table 2.1. Moreover, Merz et al. (2010) provide illustrative examples of these classifications in Table 2.2.

Table 2.1
Tangible and Intangible Damage

Category			Examples
Tangible	Direct	Primary	Structures, contents, and agriculture
		Secondary	Land as well as environmental recovery
	Indirect	Primary	Business interruption
		Secondary	Impact on the regional as well as the national economy
Intangible			Health and psychological damage

Source: Lee & Mohamad (2013)

Table 2.2
Example of Tangible and Intangible Damage

	Tangible	Intangible
Direct	(a) Harm to private structures and belongings (b) Interruption of infrastructure like roadways (c) Railways (d) Degradation of agricultural soil (e) Destruction of crops and harm to animals (f) Evacuation and rescue operations (g) Disruption of business activities within the flooded zone (h) Expenses for cleanup	(a) Fatalities (b) Wounds (c) Destruction of keepsakes Psychological (d) Emotional trauma, harm to cultural heritage (e) Adverse impacts on ecosystems
Indirect	(a) Interruption of public services in areas not affected by the flooding (b) Production losses for businesses outside the flooded region (e.g., suppliers to flooded companies) (c) Expenses incurred from traffic disruptions (d) Reduction in tax revenue due to businesses relocating after the flood	(a) Emotional or psychological injury (b) Erosion of faith in authorities

Source: Merz et al. 2010

2.8.2 Flood Indicators

Flood indicators, as shown in Table 2.3, such as depth, duration, and frequency, play a crucial role in assessing flood hazards and associated risks. These indicators help provide essential insights into the potential impacts of flooding on communities and infrastructure, forming the foundation for effective flood risk management and mitigation strategies. Flood depth measures the extent of water inundation, which directly affects potential damage to structures and infrastructure (Nair & Rao, 2016). Flood duration, the length of time that floodwaters remain above a specified threshold, significantly influences property damage, as prolonged flooding increases the likelihood of severe impacts (Safarina et al., 2021). Flood frequency, which refers to how often flood events occur in a given area, is another critical factor in risk assessment (Barna et al., 2023).

Together, these indicators provide a comprehensive framework for assessing flood hazards, allowing policymakers and urban planners to develop targeted response measures and resilience strategies. Advanced models such as Flood-Duration-Frequency (QDF) and Depth-Duration-Frequency (DDF) curves are used to predict flood magnitude for different return periods, aiding flood forecasting and risk management. While these indicators are critical for assessing flood hazards, other factors such as flow velocity, sediment load, and contamination also play vital roles in determining the overall severity and impact of a flood.

Table 2.3
Flood Indicator

Flood Indicator	Description
Flood Depth	Flood depth is the height of water above the ground surface during a flood event. It serves as a primary indicator of flood severity and directly influences potential damage to structures and infrastructure (Nair & Rao, 2016). Various techniques are employed to measure flood depth, including image processing and sensor-based methods. Image processing involves algorithms for character recognition and feature extraction, whereas sensor-based techniques use hardware, such as level indicators, to monitor water levels (Nair & Rao, 2016). Additionally, depth-damage curves are used to estimate potential damage as a function of flood depth. These curves are derived from historical flood data and expert assessments, with variations across regions and assets.
Flood Duration	Flood duration is the period during which floodwaters remain above a specified threshold, significantly affecting properties and ecosystems; prolonged flooding can lead to greater damage (Safarina et al., 2021). It is typically analysed using mathematical models that account for river- and overland-flow dynamics, with inundation duration serving as a key factor in flood quantification indices that assess overall flood impact (Safarina et al., 2021). To evaluate flood risk across different durations, Flood-Duration-

	Frequency (QDF) Models estimate flood magnitude for various return periods. These models play a vital role in infrastructure planning and design by helping assess long-term flood risks (Barna et al., 2023).
Flood Frequency	Flood frequency refers to the recurrence of flood events in a given area and is a crucial factor in risk assessment and hazard classification (Barna et al., 2023). Statistical methods, such as copula-based analysis, are commonly used to model the joint distribution of rainfall depth and duration, yielding valuable insights into flood frequency and the relationships among different flood indicators. Depth-Duration-Frequency (DDF) curves are also used to predict rainfall depths for specified durations and return periods, thereby aiding flood forecasting and risk management. These curves are developed from historical rainfall data and statistical models, thereby enabling accurate predictions for flood preparedness and mitigation (Beloulou et al., 2015).

2.8.3 Economic Attributes Influence Residential Property Value

Residential property values are influenced by several economic factors that can be classified into four primary categories: structural, locational, neighbourhood, and macroeconomic. These characteristics shape a potential buyer's perception of a property's value and utility, thus influencing its market price.

Among these factors, structural attributes are the most influential. They pertain to the physical components of a building, including its design, spatial arrangement, and construction materials, and the number of rooms (McKenzie & Levendis, 2010). Larger properties or those with superior amenities (e.g., more bathrooms, larger living areas, or higher-quality materials) typically command higher market values.

Locational attributes also play a significant role in determining property values. Properties located in areas with easy access to major roads, public transportation, and essential services (e.g., shopping centres, hospitals, and schools) tend to have higher appeal and, consequently, higher value (Aluko, 2011). Neighbourhood characteristics further influence property values, with neighbourhoods perceived as safer and offering higher socioeconomic amenities being more attractive to buyers (Coffee et al., 2020).

The macroeconomic environment, including the overall economic climate, interest rates, and government policies, also affects property values. Additionally, cultural norms and location-specific preferences can further influence how these factors are valued in each market. These economic attributes collectively contribute to the valuation of a residential property, guide investment decision-making, and influence market dynamics.

2.8.4 Factors of Economic Attributes

The economic characteristics influencing property values in flood-prone areas can be categorised into structural, locational, and neighbourhood factors. A detailed breakdown of each factor is provided in Table 2.4.

Table 2.4
Summary of Factors of Economic Attributes

	FLOOD			HOUSING													ENVIRONMENTAL																	
AUTHOR (YEARS)	Depth	Duration	Frequency	Age of House	Air Condition	Building Material	Elevator/Lift	Floor/ Building Size	Land Size	Living Area	Number of Bathrooms	Number of Bedrooms	Parking Space	Property Condition	Sewerage	Type of House/ building	Education Institution	Park/Lake	Golf	Mosque/Church	Convenience Store	Hospital	MRT/LRT Station	Bank	Bus Rapid Transit	Industrial Area	Commercial Area	River	Highway/Road	Neighbourhood Greenery	Crime Rate	Disaster Zone	Floodplain
(Aluko, 2011)															/	/	/	/			/	/									/		/
(Sani et al., 2023)				/				/			/	/			/	/	/	/				/	/								/		
(Shi et al., 2024)									/		/	/	/															/					/
(Zhang, 2016)				/						/	/	/						/	/									/					/
(Zulkarnain et al., 2020)	/	/	/	/				/	/	/	/	/					/	/		/	/	/	/										
(Aliyu et al., 2016)	/	/	/					/																				/					/
(Osti & Nakasu, 2014)	/	/	/																														
(Pommeranz & Steininger, 2020)			/	/				/		/		/				/		/										/	/			/	/
(Syariffuddin et al., 2024)								/	/								/				/	/	/										

2.9 Recent Case Studies and Scenario Applications

Collectively, these case studies demonstrate that the integration of spatial flood modelling with property valuation remains limited, particularly in Southeast Asian urban contexts, thereby reinforcing the need for integrated analytical frameworks. In Malaysia, recent case studies have highlighted the impact of flooding on residential property values, particularly in flood-prone areas such as the Klang Valley. As shown in Figure 2.7, flood events typically lead to an immediate decline in property values, followed by a gradual recovery period and lingering market uncertainty. The devastating floods of December 2021 in areas such as Shah Alam and Taman Sri Muda underscore the significant economic consequences of flooding. According to the National Disaster Management Agency (NADMA) (2021), the 2021 floods caused damage exceeding RM6 billion, with residential properties incurring the greatest losses. Consequently, property values in the affected areas have been slow to recover, as homeowners face declining buyer confidence, reduced market demand, and rising insurance premiums.

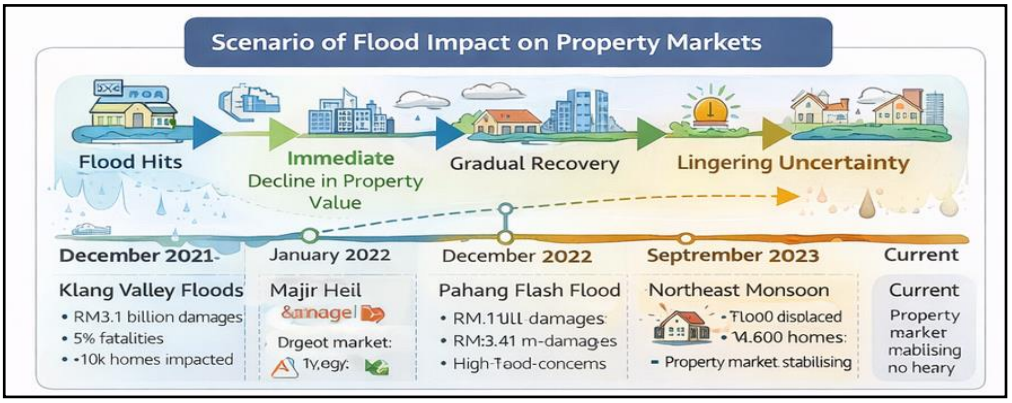


Figure 2.7 Scenario of Flood Impact on Property Markets

The integration of GIS and HPM in flood-prone urban areas in Malaysia remains in its early stages. However, studies by Mokhtar et al. (2022) suggest that flood risk assessments based on geospatial data can provide valuable insights into the economic implications of flooding. For example, GIS-based flood maps can help identify the most vulnerable areas to flooding and facilitate the prediction of potential property devaluation. The integration of flood risk data with HPM allows urban planners to make more informed decisions regarding land use, infrastructure development, and flood management.

For example, in the Klang Valley, the use of GIS and HPM in assessing the impact of flooding on property values has shown promising results. Studies by Bari et al. (2021) and Romali et al. (2020) indicate that areas such as Taman Sri Muda and Kampung Baru in Shah Alam, frequently affected by flash floods, have experienced property devaluation of up to 30%. These findings highlight the necessity for more comprehensive flood risk assessments that incorporate both spatial data and economic modelling techniques.

2.10 Literature Gaps and Research Opportunities

The preceding sections have demonstrated that flood risk in Malaysia is shaped by interacting hydrological drivers, urban expansion, and different types of floods, each of which produces distinct economic consequences. Monsoon floods generate systemic regional exposure, while flash floods create spatially concentrated but economically acute depreciation effects. Simultaneously, advances in Geographic Information Systems (GIS) and multi-criteria modelling techniques have enhanced the precision of spatial quantification of flood susceptibility. Despite these advancements, translating spatially differentiated flood risk into quantifiable effects on property value remains analytically fragmented.

While the Hedonic Pricing Model (HPM) offers a robust mechanism for estimating environmental capitalisation, most empirical applications in Malaysia rely on simplified flood indicators or post-event comparisons. Such approaches often treat flood exposure as a binary condition rather than a continuous spatial gradient. As discussed in Section 2.8.4, although spatial econometric enhancements have improved explanatory power in international studies (Su et al., 2023), their integration with weighted flood susceptibility modelling remains limited in neighbourhood-scale research.

Existing studies tend to examine either hazard mapping or property depreciation in isolation, without systematically incorporating GIS-derived flood susceptibility indices into hedonic estimation frameworks (Ismail et al., 2019; Mokhtar et al., 2022). This separation hinders the ability to quantify marginal price effects associated with incremental changes in environmental exposure. Given that flood typologies (monsoon versus flash) elicit distinct market responses, valuation models must account for exposure intensity and spatial variation rather than relying solely on historical flood

occurrence. A key limitation lies in scale. Many flood risk assessments are conducted at the basin or district levels, whereas property market dynamics typically operate at the neighbourhood scale. Without fine-resolution spatial integration, the economic impact of flood susceptibility cannot be accurately isolated. The historical evidence presented earlier, including depreciation rates of up to 30%–35% in highly exposed zones, underscores the magnitude of potential capitalisation effects. However, the mechanisms underlying such variation remain insufficiently quantified.

Therefore, addressing this research gap requires a methodological framework that links spatial flood susceptibility modelling to transaction-based property valuation analysis. Accordingly, this research adopts an integrated GIS-based Analytical Hierarchy Process (AHP) and Hedonic Pricing Model (HPM) framework, operationalising flood susceptibility as a spatially continuous index embedded within econometric valuation models. The following chapter presents the research design and analytical procedures developed to implement this integrated approach.

2.11 Stakeholders and their Roles

The success of this research, which integrates flood susceptibility modelling with property valuation analysis, relies heavily on contributions from key stakeholders. Each stakeholder group plays a distinct role in shaping the quality, accuracy, and applicability of the research's findings. Table 2.5 elaborates on the roles and responsibilities of each party involved in this research.

The collaboration among these stakeholders ensures that the proposed GIS–AHP–HPM framework is supported by reliable hydrological, spatial, and property-market data, while enhancing the practical applicability of flood-risk-informed property valuation and urban planning. Their collective contributions facilitate the integration of geospatial analysis, flood susceptibility assessment, and econometric modelling, thereby strengthening the robustness and relevance of the research outcomes.

Table 2.5
Stakeholders in Flood Risk Assessment and Property Valuation

Stakeholders	Role in Research
Government Agencies (DID, NAPIC, MetMalaysia)	Provide hydrological data (flood history, rainfall, water level), property transaction records, and climate data for flood risk modelling.
Academic Institutions & Researchers	Conduct geospatial analysis, flood modelling, and economic valuation using GIS, Remote Sensing, and AHP-based MCDM techniques. Also responsible for data validation and for developing the theoretical framework.
Real Estate & Property Developers	Provide property market trends, transaction data, and investment risk assessments, all essential to the hedonic pricing model.
Insurance & Financial Institutions	Assess flood-related financial risks, insurance premiums, and economic resilience of affected properties. Contribute to risk mitigation strategies.
GIS & Remote Sensing Providers (ESRI, Google Earth, OpenStreetMap, Sentinel-2)	Supply spatial data (satellite imagery, DEMs, land use maps) for flood mapping, 3D visualisation, and property exposure analysis.
National Disaster Management Agency (NADMA)	Coordinates national disaster response, implements flood emergency action plans, and manages flood relief efforts.
Local Communities & Property Owners	Provide ground-truthing flood data, firsthand flood experiences, and property valuation trends in flood-prone areas.

2.12 Synthesis of Past and Current Research on Flood Risk Modelling and Property Value Analysis

This section presents a comparative overview of previous studies that integrate flood risk assessment with property valuation, with a particular emphasis on the use of Hedonic Pricing Models (HPM), Remote Sensing (RS), Geographic Information Systems (GIS), and Multi-Criteria Decision-Making (MCDM) techniques. Table 2.6 provides a detailed analysis of each study listed, highlighting its methodology, key findings, and relevance to the current research framework.

Table 2.6
Past and Current Research on Flood Risk Modelling and Property Value Analysis

Author(s) & Year	Research Area	Methodology	Tools/Tech Used	Key Findings	Relevance to Current research
Ismail et al. (2019)	Klang Valley, Malaysia	HPM + GIS flood mapping	ArcGIS, SPSS	Flood-prone residential areas saw 18.5% price depreciation: urban areas more sensitive than rural	Local evidence supports the impact of flood zones on property prices using GIS-HPM approach
Razali et al. (2021)	Peninsular Malaysia	HPM + Flood hazard zone overlay	Remote sensing imagery + regression	Longer flood duration = higher property devaluation; each flood day ≈ 0.015% price drop	Highlights importance of flood duration as a factor in property valuation
Lee et al. (2025)	Johor Bahru, Malaysia	GIS + RS + MCDM (AHP)	Sentinel-2, Landsat 8, ArcGIS Pro	Developed flood susceptibility maps using multi-criteria RS indicators (NDVI, slope, LULC)	Demonstrates use of RS-GIS to spatially model flood risk factors for urban planning
Bellaver et al. (2025)	Northern Italy	HPM + Repeated Event Impact + GWR	GIS + Spatial econometrics	Single flood had negligible effect, but repeated floods caused ~4% property discount	Supports integration of spatial heterogeneity (GWR) in HPM models
Nguyen & Li (2022)	Ho Chi Minh City, Vietnam	HPM + Spatial Lag/Error Model	Remote sensing + SAR/SEM models in R	Flood exposure showed spatial clustering effect on property values	Spatial econometric modeling enhances price prediction accuracy in urban flood contexts
Yeo et al. (2025)	Singapore	GIS + Remote Sensing for urban resilience	LiDAR + high-res DEM + ArcGIS	Used fine-scale terrain data for micro-zonation of flood risk	Shows how high-resolution DEMs improve flood mapping accuracy
Zhou et al. (2021)	Wuhan, China	Integrated GIS-RS-HPM approach	RS (Landsat), GIS (ArcMap), OLS regression	Combined LULC, elevation, and flood extent layers to assess impacts on housing value	A comprehensive example of full HPM-RS-GIS integration

2.13 Summary

This chapter has examined the key theoretical and conceptual foundations underpinning the research, drawing extensively from prior scholarly literature. It began by defining flood events and distinguishing their types, with particular emphasis on monsoon and flash floods in Malaysia, their respective hydrological behaviours, and their economic implications. The discussion highlighted how recurrent flooding, intensified by climate change and rapid urbanisation, has increasingly influenced property markets, urban planning, and investment confidence.

The review further explored flood risk assessment frameworks and property valuation theory, particularly the application of Geographic Information Systems (GIS), Remote Sensing (RS), the Analytic Hierarchy Process (AHP), and the Hedonic Pricing Model (HPM). While GIS has been widely applied internationally for flood mapping and risk assessment, the literature reveals significant gaps in the Malaysian context. Specifically, there remains no localised, integrated methodological framework that combines high-resolution flood-risk data with socio-economic and property-specific variables within valuation models.

Existing studies in Malaysia have largely focused on short-term flood impacts and hazard mapping, with limited attention to long-term property market responses to recurrent flooding. Furthermore, the integration of spatial technologies into property valuation modelling remains underdeveloped. Although recent advances in spatial technologies enable more precise flood-risk assessment and spatial data analysis (Zhang & Crawford, 2021), their application within Malaysian property valuation frameworks remains limited. This gap is particularly significant given the increasing frequency and intensity of flood events, which directly affect property values, urban resilience, and risk-sensitive investment decisions.

The literature reviewed in this chapter demonstrates that although flood susceptibility assessment and residential property valuation have advanced considerably as independent research domains, their integration remains limited, particularly within the Malaysian context. Existing studies rarely incorporate spatially continuous flood-susceptibility indicators into econometric valuation models that quantify the marginal effects of environmental risk on housing prices. This methodological gap provides the foundation for the present research, which proposes an integrated GIS–AHP–HPM framework to support flood risk-informed property valuation and evidence-based urban planning. The following chapter presents the research methodology and analytical procedures developed to operationalise this integrated framework.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

Guided by the theoretical insights and research gaps identified in Chapter 2, this chapter outlines the methodological framework adopted to examine the relationship between flood susceptibility and residential property values. The methodological design integrates spatial analysis and econometric modelling to translate environmental risk exposure into measurable market outcomes. Specifically, the framework combines GIS-based flood susceptibility modelling using the Analytical Hierarchy Process (AHP) with the Hedonic Pricing Model (HPM) to evaluate how flood risk is capitalised into property prices.

The methodological architecture of this research is founded on the conceptualisation of flood risk as a spatially differentiated environmental externality that interacts with urban land markets. Rather than treating flood exposure as a discrete historical event, this research models susceptibility as a continuous spatial index derived from multi-criteria analysis and embeds it within a Hedonic Pricing Model (HPM) (Ismail et al., 2019). This integrated structure enables estimation of marginal price effects associated with incremental changes in flood vulnerability.

The methodological framework adopted in this research is designed to address the limitations identified in the preceding literature review. Specifically, the research integrates spatial modelling techniques with econometric analysis to capture both the environmental and economic dimensions of flood risk. The use of Geographic Information Systems (GIS) enables the spatial representation of flood-conditioning factors. At the same time, the Analytical Hierarchy Process (AHP) provides a structured mechanism for determining the relative importance of these factors in flood susceptibility modelling.

Complementing this spatial analysis, the Hedonic Pricing Model (HPM) is employed to estimate the extent to which environmental risk variables are capitalised in residential property values. By integrating these analytical components, the for the methodology enables the systematic translation of spatial flood susceptibility indicators into quantifiable economic effects in the housing market. This integrated approach

therefore provides a more comprehensive analytical framework compared to conventional flood risk studies that examine either hydrological hazards or property market behaviour in isolation.

A quantitative approach was selected because the study aims to measure and statistically evaluate the relationship between flood-risk exposure and residential property values using spatial and numerical datasets. Quantitative methods enable the objective analysis of flood susceptibility and property market behaviour through GIS-based modelling and econometric techniques.

3.2 Research Area

This section outlines the geographical, environmental, and spatial characteristics of the research area and explains its relevance for analysing the relationship between flood susceptibility and residential property values. Taman Sri Muda, located in Shah Alam, Selangor, was selected due to its documented history of flooding, observable spatial variation in flood exposure, and the availability of residential property transaction data for hedonic pricing analysis.

Understanding the spatial and environmental context of the research area is essential for implementing GIS-based flood susceptibility modelling and integrating the results with residential property valuation analysis. The following subsections describe the location of the research area, its physical and topographical characteristics, its historical flood vulnerability, and the justification for selecting the area as the case research for this research.

Taman Sri Muda is in Section 25, Shah Alam, Selangor, Malaysia (3°01′57″ N, 101°32′05″ E), covering approximately 4.86 km² within the Klang Valley metropolitan region in Figure 3.1. The neighbourhood forms part of the urban area of Shah Alam and is predominantly residential. The built environment is characterised by medium-density housing developments, primarily intermediate double-storey terraced houses, supported by neighbourhood commercial facilities and local road infrastructure.

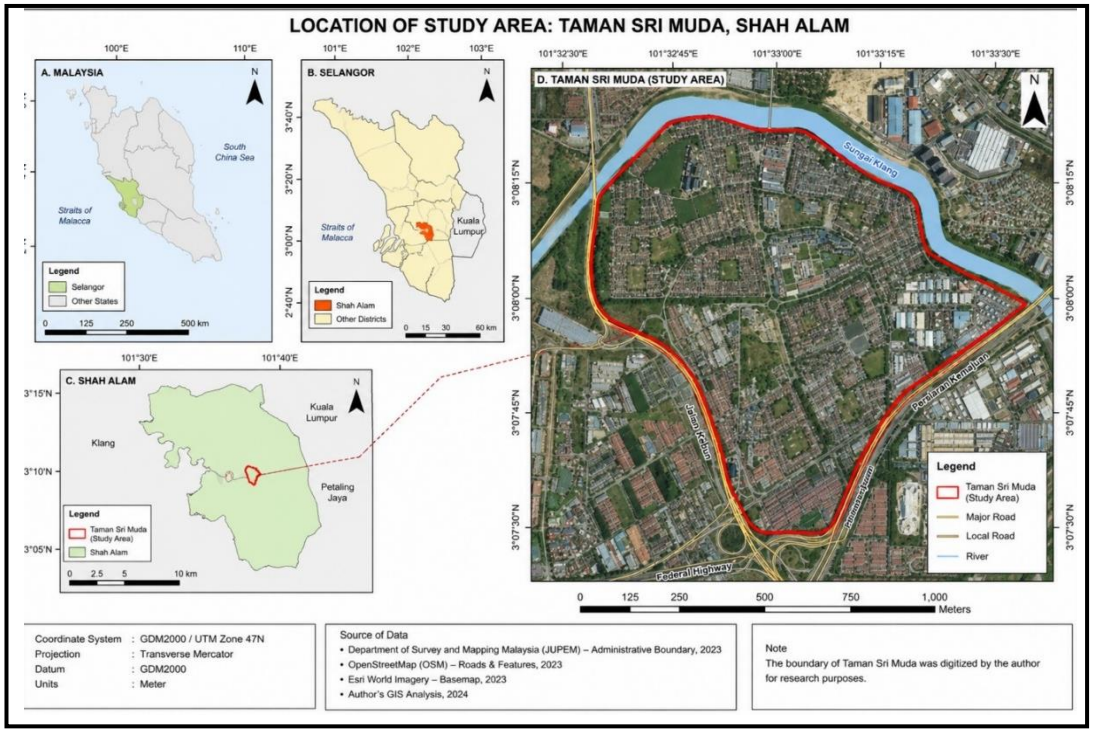


Figure 3.1 Location of Research Area: Taman Sri Muda, Shah Alam

Based on the NAPIC residential transaction data (2005–2024) for Taman Sri Muda, double-storey terrace houses account for approximately 62% of recorded residential property transactions, making them the dominant housing type in the dataset. Other residential categories, including single-storey terrace houses, semi-detached houses, and detached houses, account for the remaining transactions. Consequently, this study focuses on double-storey terrace houses to ensure a representative and relatively homogeneous sample for analysing the impact of flood risk on residential property values.

3.2.1 Physical and Topographical Characteristics

Topographically, Taman Sri Muda is situated on a relatively flat and low-lying floodplain within the Klang River basin. The limited variation in elevation limits the efficiency of natural drainage, increasing the likelihood of water accumulation during periods of intense rainfall. In urban environments where impervious surfaces dominate, rainfall infiltration is significantly reduced, thereby increasing surface runoff volumes.

In addition to its topographical characteristics, the area is hydrologically influenced by the Klang River and its surrounding drainage network. During heavy rainfall events, elevated river discharge combined with constrained local drainage

capacity may lead to overflow or localised inundation. These geomorphological and hydrological conditions create a spatial environment particularly well-suited to flood susceptibility modelling using GIS-based multi-criteria analysis (Ibrahim et al., 2024).

3.2.2 Flood History and Vulnerability Context

Taman Sri Muda has experienced multiple flood events over the past decades, reflecting its location within a major urban river basin that is vulnerable to hydrological variability. Among these incidents, the December 2021 flood was among the most severe, resulting in extensive damage to residential properties, infrastructure, and public facilities across the neighbourhood.

A combination of physical and urban development factors influences the area's vulnerability. Its floodplain location, proximity to river channels, and high proportion of impervious urban surfaces increase exposure to both fluvial flooding from river overflow and pluvial flooding caused by intense rainfall and limited drainage capacity. These historical flood events highlight the importance of assessing flood susceptibility spatially in the area.

3.2.3 Justification for Case Research Selection

In addition to its exposure to flood hazards, Taman Sri Muda provides several methodological advantages for analysing the relationship between environmental risk and residential property values. The relative homogeneity of residential housing types reduces structural heterogeneity in hedonic modelling, enabling price variations to be more clearly associated with locational and environmental characteristics such as flood susceptibility.

Furthermore, while flood risk studies are commonly conducted at broader basin or district scales, fewer studies integrate neighbourhood-scale flood susceptibility modelling with transaction-based residential property valuation within a single analytical framework. The selection of Taman Sri Muda, therefore, provides an appropriate setting for examining how spatial variations in environmental risk may be capitalised on in urban housing markets.

3.3 Research Framework

The analytical framework adopted in this research comprises four sequential and interrelated phases designed to achieve the research objectives systematically. The first phase focuses on data collection and preparation, involving the acquisition of spatial, hydrological, environmental, and residential property transaction datasets from authoritative sources. These datasets undergo preprocessing, including georeferencing, coordinate system standardisation, raster conversion, and data normalisation, to ensure compatibility with subsequent spatial and statistical analyses.

The second phase implements flood susceptibility modelling by integrating the Analytical Hierarchy Process (AHP) with Geographic Information Systems (GIS). Seven flood-conditioning factors, namely rainfall intensity, river water level, elevation, slope gradient, land use and land cover, drainage density, and distance to river, are weighted through the AHP pairwise comparison process and combined using GIS-based weighted overlay analysis to generate the Flood Susceptibility Map.

The third phase applies the Hedonic Pricing Model (HPM) to evaluate the relationship between residential property values and flood-related environmental factors. Property transaction data are analysed using a semi-logarithmic regression model, enabling estimation of the marginal effects of structural, locational, and environmental attributes on housing prices and assessment of the extent to which flood risk is capitalised in the residential property market.

Finally, the fourth phase integrates the spatial outputs of the GIS–AHP flood susceptibility model with the econometric results of the HPM to produce a comprehensive spatial–economic assessment. This integration enables the visualisation and interpretation of how variations in flood susceptibility correspond with residential property values across the research area, providing evidence to support flood risk-informed property valuation and urban planning decisions.

This framework ensures that environmental vulnerability is first quantified spatially and subsequently translated into measurable economic effects in the residential property market. The methodological structure is operationalised through four sequential yet analytically interconnected phases, as illustrated in Figure 3.2.

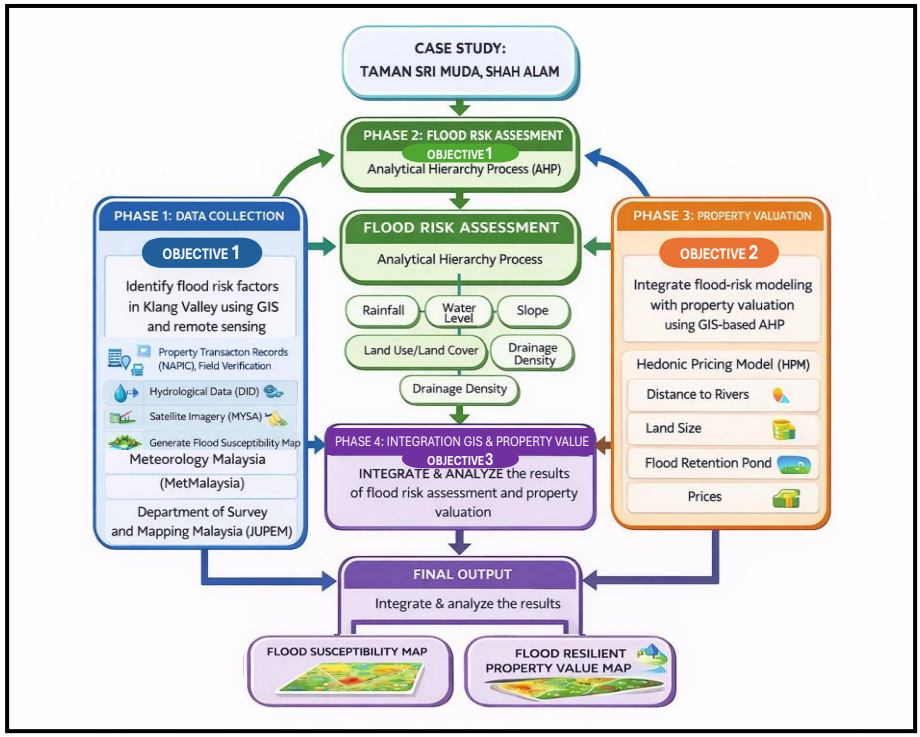


Figure 3.2 Research Framework

Figure 3.2 illustrates the overall methodological framework adopted in this research and the interrelationship among the four analytical phases. The framework demonstrates how spatial, hydrological, and property transaction data are systematically processed using GIS–AHP flood susceptibility modelling and Hedonic Pricing Model analysis, and then integrated to evaluate the relationship between flood vulnerability and residential property values. The sequential workflow ensures that environmental risk is first quantified spatially and subsequently translated into measurable economic outcomes that support flood risk-informed property valuation and urban planning.

3.4 Phase 1: Data Collection

This section describes the datasets utilised for flood susceptibility modelling and property valuation analysis. All spatial datasets were standardised to a common coordinate reference system and spatial resolution to ensure analytical consistency.

3.4.1 Data Sources and Preparation

The data used in this research comprises both primary and secondary sources to support the development of the GIS–AHP flood susceptibility model and the Hedonic Pricing Model (HPM). The integration of multiple data sources enhances the reliability

and comprehensiveness of the analysis by combining direct field observations with authoritative geospatial, hydrological, and property market datasets.

3.4.1.1 Primary Data

Primary data were collected through field verification and site observations conducted within Taman Sri Muda. The fieldwork involved verifying residential property locations, observing neighbourhood characteristics, documenting visible indicators of flood exposure, and validating the spatial accuracy of the GIS outputs. Photographic evidence and on-site inspections were also undertaken to confirm flood-related conditions and support the interpretation of spatial modelling results.

3.4.1.2 Secondary Data

Secondary data were obtained from official government agencies and recognised data providers to ensure accuracy and reliability. These datasets include Digital Elevation Model (DEM) data from the Department of Survey and Mapping Malaysia (JUPEM), rainfall records from the Malaysian Meteorological Department (MetMalaysia), river water level data from the Department of Irrigation and Drainage (DID), satellite imagery from the Malaysian Space Agency (MYSA), residential property transaction data from the National Property Information Centre (NAPIC), and river network data from OpenStreetMap (OSM). Before analysis, all datasets were screened for missing values, duplicate records, spatial inconsistencies, and extreme outliers, then standardised and preprocessed within the GIS environment.

3.4.2 Data Preparation

Data preparation involved several procedures, including coordinate system projection, spatial resolution standardisation, and raster conversion. All spatial layers were projected into the RSO Malaya coordinate system to maintain consistency across datasets. The processed datasets were subsequently integrated into the GIS platform to support flood susceptibility modelling using the AHP–GIS framework.

3.4.2.1 Flood-Conditioning Data

Flood-conditioning factors represent the environmental and hydrological variables that influence the occurrence and spatial distribution of flood events. Based on hydrological theory and previous empirical flood modelling studies, seven key flood-conditioning factors were selected for this research (Islam et al., 2020).

(a) Elevation

Elevation data were derived from a Digital Elevation Model (DEM) obtained from the Department of Survey and Mapping Malaysia (JUPEM) with a spatial resolution of 0.5 metres. The dataset was provided in raster format and projected into the RSO Malaya coordinate reference system before being clipped to the research boundary (Figure 3.3).

Elevation plays a critical role in flood occurrence because lower-lying areas generally have a greater potential for water accumulation during heavy rainfall or river overflow events. Areas located at higher elevations typically allow faster drainage and therefore exhibit lower flood susceptibility. The elevation layer was extracted directly from the DEM and subsequently reclassified into standardised classes for integration into the AHP-based flood susceptibility model.

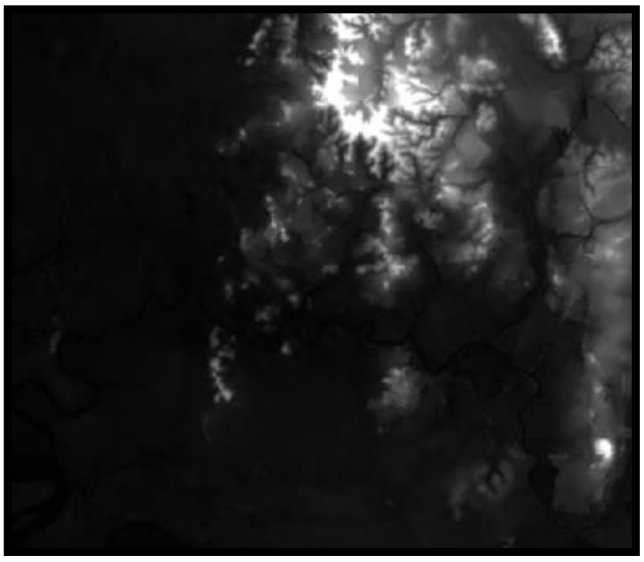


Figure 3.3 DEM Data Department of Survey and Mapping Malaysia (JUPEM)

(b) Slope Gradient

The Slope gradient was derived from the DEM using spatial analysis tools in the GIS environment. The slope function calculates the rate of elevation change between neighbouring cells and produces a raster layer representing terrain steepness in degrees.

Slope influences flood dynamics by affecting the velocity of surface runoff. Areas with low slope gradients tend to retain water for longer periods due to slower runoff movement, increasing the likelihood of water accumulation. Conversely, steeper slopes facilitate faster drainage and reduce the probability of flooding. The slope raster was therefore reclassified into standardised categories before being incorporated into the flood susceptibility analysis.

(c) Rainfall Data

Rainfall data were obtained from the Malaysian Meteorological Department (MetMalaysia) for the period 2016-2024 (Table 3.1). The primary dataset consists of monthly precipitation records from the Subang meteorological station in Selangor. These data indicate variability and intensity of rainfall within the region.

To improve spatial representation, supplementary gridded rainfall data were acquired from the Centre for Hydrometeorology and Remote Sensing (CHRS). The CHRS dataset contains multiple precipitation grid points across Selangor and was used to generate a continuous rainfall surface within the GIS environment. Rainfall intensity is a critical flood-conditioning factor because higher precipitation levels increase surface runoff and river discharge, thereby elevating flood risk.

Table 3.1
Rainfall Summary Data (2016-2024) (MetMalaysia)

DEPARTMENT OF METEOROLOGY MALAYSIA							
Station:	SUBANG						
Lat:	3° 7' 50.01" N						
Long:	101° 33' 8.99" E						
Ht above M.S.L.:	16.64 m						
Year	Month						Annual
	Jan	Mac	May	Jul	Sep	Nov	
2016	240.0	141.4	367.4	230.6	247.4	363.2	2635.8
2017	242.6	218.2	233.0	147.2	267.2	336.4	2632.8
2018	426.6	351.0	531.2	119.8	375.6	416.6	3535.4
2019	242.8	161.2	246.6	151.6	138.0	307.0	3138.6
2020	192.0	315.0	164.6	439.6	341.8	418.2	3236.0
2021	297.6	421.2	404.6	171.8	295.6	348.4	3564.8
2022	220.6	386.4	181.8	104.4	164.0	388.0	2810.3
2023	203.6	384.4	256.0	218.2	123.8	327.8	3197.1
2024	282.2	324.0	336.0	152.2	204.4	415.2	3321.8

d) Groundwater Depth (Water Level)

Groundwater Depth (Water Level) data were obtained from the Department of Irrigation and Drainage (DID) Selangor for the year 2024. The monitoring station used in this research (Station ID: 3015084 – WL) is located in Sungai Klang, Taman Sri Muda, and records hourly water-level measurements. An example of hourly water-level records is presented in Table 3.2.

These measurements provide important hydrological information on fluctuations in river discharge and potential overflow conditions. Higher river water levels increase the likelihood of riverbank overflow and increase flood susceptibility in surrounding areas. The processed water-level data were incorporated as a hydrological conditioning variable in the flood-susceptibility model.

Table 3. 2
Water level per hour per day in the year 2024 (DID)

No.	Station ID	Station Name	Date	Time	Water Level (m)
1	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	1:00	2.46
2	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	2:00	2.18
3	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	3:00	1.95
4	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	4:00	1.75
5	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	5:00	1.64
6	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	6:00	1.51
7	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	7:00	1.56
8	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	8:00	1.78
9	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	9:00	2.43
10	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	10:00	2.6
11	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	11:00	2.61
12	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	12:00	2.41
13	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	13:00	2.13
14	3015084(WL)	Sg. Klang di Taman Sri Muda	1/1/2024	14:00	1.88

(e) Land Use and Land Cover (LULC)

Land Use and Land Cover data were derived from SPOT-7 satellite imagery obtained from the Malaysian Space Agency (MYSA) for the year 2024. The satellite imagery has a spatial resolution of approximately 1.5 metres and provides detailed information on surface characteristics within the research area (Figure 3.4).

The imagery was classified into major land-cover categories, including built-up areas, vegetation, water bodies, and open land. Land use and land cover significantly influence flood dynamics because impervious urban surfaces increase surface runoff, whereas vegetated areas promote infiltration. The classified LULC layer was converted to raster format and reclassified to integrate it into the AHP-based flood susceptibility model.



Figure 3.4 Satellite Image of Taman Sri Muda in 2024

(f) Drainage Density

Drainage density represents the concentration of drainage channels within a given area and was derived from the DEM using hydrological analysis tools within the GIS environment. Flow direction and flow accumulation analyses were conducted to delineate stream networks and generate drainage patterns across the research area.

Areas with higher drainage density indicate a greater concentration of stream channels, which may influence the movement and accumulation of surface runoff during heavy rainfall events. The drainage density layer was calculated using the line density function and expressed in kilometres per square kilometre (km/km^2). The resulting raster layer was reclassified into standardised categories for use in the flood susceptibility model.

(g) Distance to River

River network data were obtained from OpenStreetMap (OSM) as shapefiles, representing rivers and streams within the research area (Figure 3.5). The river layer was processed and used as the basis for proximity analysis.

Euclidean Distance analysis was applied to generate a raster surface representing the distance of each location from the nearest river channel. Areas located closer to rivers are generally more vulnerable to fluvial flooding due to the increased possibility of river overflow during periods of high discharge. The resulting distance-to-river raster was reclassified into standardised categories before being incorporated into the AHP-based flood susceptibility model.



Figure 3.5 Data Waterways (OSM)

Each dataset was projected to the RSO Malaya coordinate system to ensure spatial consistency across all layers. The datasets were subsequently standardised to a uniform spatial resolution and converted into raster format to facilitate integration and analysis within the AHP–GIS flood susceptibility modelling framework.

3.4.2.2 Property Transaction Data

Residential property transaction data were obtained from the National Property Information Centre (NAPIC). A total of 198 residential property transactions within Taman Sri Muda were collected for the study period, as detailed in **Appendix A**. The dataset includes key variables such as transaction price, property type, and land size, which provide the empirical basis for examining the relationship between flood susceptibility and residential property values.

Table 3.3 presents a sample of the residential transaction records, including spatial coordinates, property type, land area, and transaction price. The dataset consists predominantly of intermediate double-storey terrace houses, which represent the dominant housing typology in the study area. This relative structural homogeneity reduces variation associated with building characteristics and facilitates a clearer assessment of locational and environmental influences on property values.

Prior to analysis, the dataset underwent data-cleaning procedures to ensure reliability and consistency. Duplicate records were removed, incomplete observations were excluded, and extreme outliers were reviewed to minimise potential bias in the regression analysis. Only residential property transactions relevant to the

research objectives were retained. Property transaction records were screened for missing values, duplicate entries, and outliers. Spatial datasets were verified for projection consistency and coordinate accuracy before GIS analysis.

Following data preparation, property transactions were geocoded and converted into spatial point features within the GIS environment. The resulting property layer was spatially verified and integrated with the flood susceptibility map developed through the GIS–AHP modelling process. This integration enabled the extraction of flood-risk information for each property transaction and facilitated subsequent analysis using the Hedonic Pricing Model (HPM).

Table 3.3
Sample of the Residential Property Records at Taman Sri Muda (NAPIC)

No.	District	Date of Valuation	Area (m^2)	Building Type	No. of storeys	Address	Location	Share	Value (RM)
1	Klang	3/2/2010	78.036	Double Storey Terrace (Intermediate)	2	34, Jln Cekap 25/45	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	140,000
2	Klang	9/11/2005	78.036	Double Storey Terrace (Intermediate)	2	No 52, Jln Jasa 25/27	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	140,000
3	Klang	31/10/2006	78.036	Double Storey Terrace (Intermediate)	2	39, Waja Satu 25/13a	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	125,000
4	Klang	22/11/2006	78.036	Double Storey Terrace (Intermediate)	2	No.27, Jln Bakti 25/15a	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	105,000
5	Klang	12/11/2007	78.036	Double Storey Terrace (Intermediate)	2	No. 90, Jln Bakti 25/15	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	133,000
6	Klang	26/9/2007	78.036	Double Storey Terrace (Intermediate)	2	52, Jalan Mahir 25/44	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	140,000
7	Klang	26/11/2008	78.036	Double Storey Terrace (Intermediate)	2	No. 15, Jalan Harapan 25/29	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	130,000
8	Klang	29/12/2009	78	Double Storey Terrace (Intermediate)	2	No.2, Jalan Waja Satu 25/13a	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	180,000
9	Klang	22/12/2009	78.036	Double Storey Terrace (Intermediate)	2	No. 31, Jalan Mahir Satu 25/44a	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	148,000
10	Klang	14/12/2010	78.036	Double Storey Terrace (Intermediate)	2	No. 26, Jalan Wangi 25/19	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	125,000
11	Klang	18/1/2011	78.036	Double Storey Terrace (Intermediate)	2	37, Jln Mahir Dua 25/44b	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	155,000
12	Klang	30/11/2010	78.036	Double Storey Terrace (Intermediate)	2	11, Jln Harum 25/49	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	118,000
13	Klang	12/11/2007	78.036	Double Storey Terrace (Intermediate)	2	11, Jln Bahagia 25/17	Tmn Sri Muda, Sek. 25 Shah Alam	1/1	80,000

3.4.2.3 Field Verification

Field verification was conducted to validate the spatial accuracy of the property dataset and to confirm the flood-related conditions within the research area. This process involved on-site inspections to verify property locations, assess neighbourhood characteristics, and observe visible flood impacts affecting residential structures and surrounding infrastructure.

The field observations also provided an opportunity to cross-check the property transaction data with the spatial flood susceptibility zones generated in the GIS analysis. This verification process strengthens the reliability of the spatial–economic integration conducted in the research. Figure 3.6 presents photographs taken during the field verification exercise, illustrating the condition of residential properties and observable flood impacts within Taman Sri Muda.

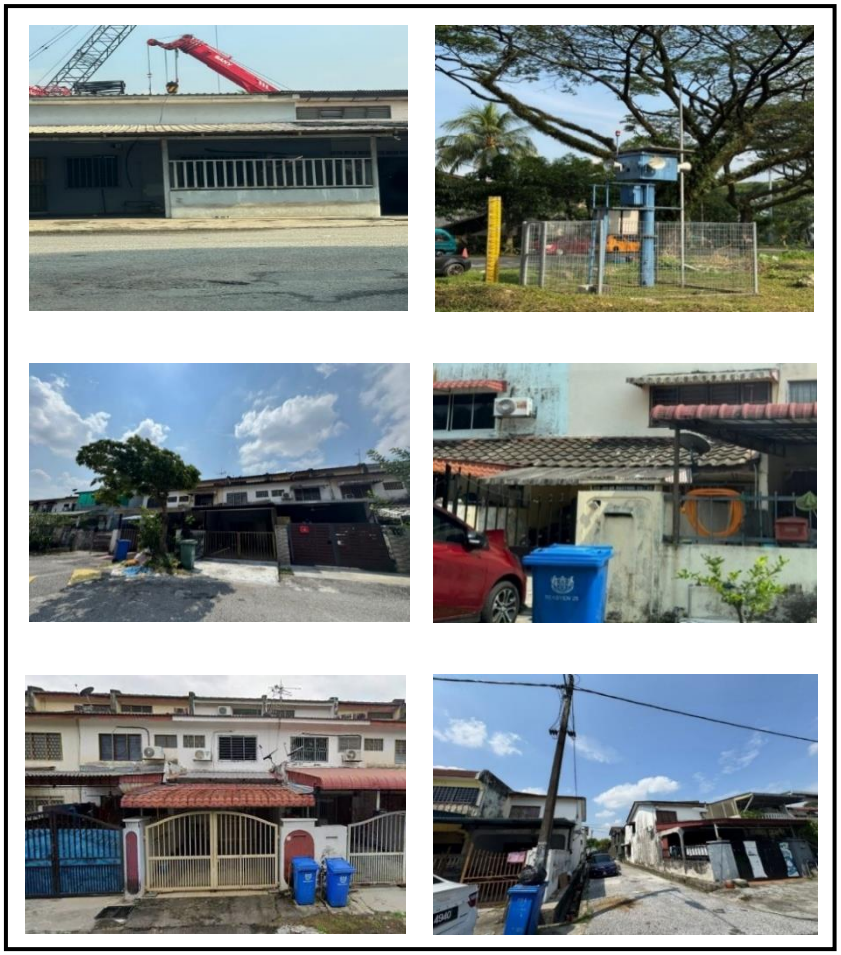


Figure 3.6 Field Verification Photograph Showing Residential Property Conditions in Taman Sri Muda.

3.4.3 Data Pre-processing and Spatial Referencing

Data pre-processing was conducted to prepare the spatial datasets for implementation within the GIS–AHP flood susceptibility model. Because the analysis integrates multiple environmental variables obtained from different sources and formats, systematic preprocessing was required to ensure spatial alignment, comparability, and analytical consistency. The pre-processing procedures undertaken in this research are described as follows.

i) Coordinate System (RSO Malaya)

All spatial datasets were transformed into a unified projected coordinate reference system, namely the Rectified Skew Orthomorphic (RSO) Malaya projection. Projection harmonisation ensures that spatial layers share the same geographic reference, allowing them to align accurately when overlaid in the GIS environment. This step is essential when datasets originate from different institutions, as they may initially be stored in different coordinate systems.

Accurate coordinate harmonisation also improves the reliability of spatial calculations such as distance measurements and area estimation. Variables that rely on spatial proximity, including drainage density and distance to river, are particularly sensitive to projection inconsistencies. Therefore, ensuring a consistent coordinate reference system is critical to maintaining the spatial integrity of the flood susceptibility model.

ii) Georeferencing and Spatial Verification

Certain spatial datasets, particularly satellite imagery and base maps, required georeferencing to ensure accurate alignment with the research area boundary. Georeferencing involves assigning real-world coordinates to spatial data by referencing known control points within the GIS environment. This process ensures that the datasets correspond correctly to their actual geographic locations.

Following georeferencing, spatial verification procedures were conducted to confirm positional accuracy. This included checking boundary alignment with administrative layers and visually inspecting spatial layers to identify potential misalignment. These verification procedures ensure that flood-conditioning variables

accurately represent environmental conditions within the research area.

iii) Raster Conversion of vector datasets

Since the AHP-based weighted overlay model operates in a raster environment, all spatial datasets were converted into raster format before analysis. Raster datasets represent spatial information as a grid of cells, where each cell contains a value corresponding to a specific environmental variable.

Vector datasets such as river networks and land use layers were therefore rasterised to ensure compatibility with continuous raster datasets, including elevation, slope, and rainfall. Raster conversion enables the modelling process to evaluate spatial relationships on a cell-by-cell basis, which is required to implement the weighted overlay procedure used in flood susceptibility analysis.

iv) Resampling to a Common Grid Resolution

Spatial datasets obtained from different sources often contain varying spatial resolutions. For example, elevation data may have a higher spatial resolution than rainfall datasets or satellite imagery. To ensure analytical consistency, all raster layers were resampled to a common grid resolution.

Resampling standardises the spatial cell size across datasets so that each environmental variable represents the same geographic unit. This step is important because overlay analysis requires that each raster cell correspond spatially to cells in other layers. Maintaining a consistent resolution ensures that spatial comparisons between variables remain accurate throughout the modelling process.

v) Reclassification into Five Susceptibility Classes

Flood-conditioning variables often take continuous numerical values measured in different units, such as metres for elevation, degrees for slope, or millimetres for rainfall. To enable meaningful comparison between variables, each dataset was reclassified into five ordinal susceptibility classes: very low, low, moderate, high, and very high.

The classification thresholds were determined using hydrological knowledge and relevant flood modelling literature. For example, lower elevation areas may correspond to higher flood susceptibility, while steeper slopes may correspond to lower

susceptibility. Reclassification simplifies complex environmental data into categories that reflect their relative contribution to flood occurrence.

vi) Rating Scale Development (1-5)

Following the reclassification process, each susceptibility category was assigned a rating of 1 to 5 in Table 3.4. These rating values represent the relative contribution of each category to flood susceptibility, where higher values indicate a stronger influence on flood occurrence.

Table 3.4
Rating Scale for Flood Susceptibility Classification

No	Scales
1	Very Low
2	Low
3	Moderate
4	High
5	Very High

The rating scale transforms environmental variables measured in different units into a unified analytical framework. By standardising the influence of each variable through an ordinal scale, the model can evaluate the combined effects of multiple environmental factors during the AHP weighting process. This step is necessary for implementing multi-criteria evaluation within the GIS environment.

vii) Preparation of standardised layers for AHP analysis

The final stage of preprocessing involved preparing the reclassified and rated raster layers as input criteria for the Analytical Hierarchy Process. Each layer was carefully examined to ensure that it contained no null values, spatial gaps, or inconsistencies that could affect the modelling process.

In addition, all layers were verified to ensure identical spatial extent and grid alignment. This verification ensures that each environmental variable consistently contributes to the weighted overlay analysis. The resulting standardised datasets constituted the final set of input variables for generating the flood susceptibility model in the subsequent analytical phase.

3.4.4 Research Equipment and Software

Table 3.5 summarises the equipment and software utilised throughout the research. These tools supported spatial data processing, flood susceptibility modelling, econometric analysis, field verification, and map production.

Table 3.5
Equipment and Software Used in the Research

Equipment / Software	Description
ArcGIS Pro	Spatial analysis, raster processing, weighted overlay analysis, flood susceptibility mapping
SPSS	Hedonic Pricing Model (HPM) regression analysis and statistical diagnostics
Microsoft Excel	Data cleaning, organisation, and preprocessing
GPS-enabled Smartphone	Field verification and location validation
Google Earth Pro	Visual verification of land use and property locations
Digital Camera / Smartphone Camera	Photographic documentation during field verification

3.5 Phase 2: Flood Risk Indicators Assessment (Objective 1)

This section explains how flood risk is assessed using an integrated Analytical Hierarchy Process (AHP) and Geographic Information Systems (GIS) approach. After the data have been collected in Section 3.4, this stage focuses on analysing the identified flood-conditioning factors and on developing a spatial flood susceptibility model. AHP is used to determine the relative importance (weights) of each factor through a systematic pairwise comparison process, while GIS is applied to process, standardise, and overlay the spatial layers. By combining these weighted factors, the research produces a Flood Susceptibility mapping that classifies areas by flood risk. This section completes Objective 1 by transforming prepared data into a measurable, spatially explicit flood risk assessment.

3.5.1 Identification of Flood-Conditioning Factors

Flood susceptibility modelling requires identifying environmental variables that influence the occurrence and spatial distribution of flooding. The selection of flood-conditioning factors in this research is grounded in hydrological theory, empirical flood modelling literature, and the physical characteristics of the research area. A combination of meteorological drivers, topographic controls, hydrological processes, and land surface characteristics generally influences flood events in urban environments.

i) Rainfall Intensity

Rainfall intensity represents the primary meteorological driver of flood occurrence. High-intensity precipitation increases surface runoff generation, particularly in urban areas characterised by impervious surfaces. Prolonged rainfall events further contribute to soil saturation, thereby reducing infiltration capacity and increasing overland flow. During extreme rainfall events, accumulated runoff may exceed the drainage system's capacity and river channel thresholds, resulting in surface ponding and fluvial overflow.

Rainfall data were obtained from the Malaysian Meteorological Department (MetMalaysia). The dataset was processed and reclassified into intensity-based categories reflecting monsoon and flash-flood conditions relevant to the Klang Valley region. These categories were subsequently standardised for integration into the GIS–AHP flood susceptibility model.

ii) Groundwater Depth (Water Level)

Groundwater depth (water level) directly influences the probability of fluvial overflow within low-lying urban areas. Elevated river levels increase hydraulic pressure and reduce channel capacity, thereby raising the likelihood of overbank flooding. High river stages may also generate backwater effects, particularly in areas with limited drainage gradients. In locations near river confluences, the convergence of upstream discharge can intensify compound flooding conditions when high river levels coincide with heavy rainfall. Seasonal fluctuations in river stage, especially during monsoon periods, further influence spatial exposure patterns within the research area.

Water level records were obtained from the Department of Irrigation and Drainage (DID) monitoring station located along Sungai Klang at Taman Sri Muda. The data were processed and standardised for integration into the GIS–AHP flood susceptibility model.

iii) Elevation (Digital Elevation Model - DEM)

Elevation plays a fundamental role in controlling gravitational flow and surface water accumulation. Low-lying areas are more susceptible to inundation due to their reduced capacity for natural drainage and higher potential for water retention. Variations in elevation influence runoff concentration patterns, directing surface flow

from higher terrain to lower catchment zones. In relatively flat areas, limited elevation gradients reduce drainage efficiency and increase the likelihood of surface ponding during intense rainfall events.

Elevation data were derived from a Digital Elevation Model (DEM) obtained from the Department of Survey and Mapping Malaysia (JUPEM). The DEM was projected, clipped to the research boundary, and processed to a uniform spatial resolution before being integrated into the GIS–AHP flood susceptibility model.

iv) Slope Gradient

Slope gradient influences the velocity of surface runoff and the capacity for water infiltration. Steeper slopes accelerate runoff movement, reducing the time available for infiltration but typically limiting prolonged surface ponding. In contrast, gentle slopes slow runoff velocity, increasing the potential for water accumulation and localised inundation. Flat terrain is particularly vulnerable to prolonged flooding, as minimal gradient reduces drainage efficiency and promotes surface water retention during heavy rainfall events.

Slope values were derived from the Digital Elevation Model (DEM) using GIS spatial analysis tools. The resulting slope layer was generated in degrees, reclassified into susceptibility categories, and standardised for integration into the GIS–AHP flood susceptibility model.

v) Land Use and Land Cover

Land Use and Land Cover (LULC) significantly influence hydrological response by altering surface permeability, runoff generation, and drainage behaviour. Built-up areas increase impervious surface coverage, thereby reducing infiltration capacity and accelerating surface runoff during rainfall events. Industrial and commercial zones, which are typically characterised by extensive paved surfaces, further intensify runoff concentration and overload the drainage system. In contrast, vegetated areas enhance infiltration, promote evapotranspiration, and reduce peak runoff, thereby reducing flood susceptibility.

High-resolution satellite imagery obtained from the Malaysian Space Agency (MYSA) was classified into standard land-use categories relevant to the research area. The classified LULC layer was subsequently converted to raster format and reclassified

into susceptibility-based categories before integration into the GIS–AHP flood susceptibility model.

vi) Drainage Density

Drainage density represents the total length of drainage channels per unit area and reflects the degree of surface flow concentration within a catchment. Areas with high drainage density indicate closely spaced stream networks, which facilitate rapid runoff concentration and downstream flow accumulation during intense rainfall events. In urban environments, high drainage density combined with limited channel capacity can exacerbate flash-flood risk, particularly where drainage infrastructure is insufficient to accommodate peak discharges.

The drainage network was derived from the Digital Elevation Model (DEM) through hydrological processing and converted into polyline features. Line density analysis was subsequently applied to generate a drainage density raster expressed in km/km^2. The resulting layer was reclassified into susceptibility categories before being integrated into the GIS–AHP flood susceptibility model.

vii) Distance to River

Distance to the river represents spatial proximity to primary fluvial channels and serves as an indicator of potential flood exposure. Areas located closer to river systems are more vulnerable to overbank flooding, particularly during periods of elevated river water levels. Shorter distances increase susceptibility to direct inundation, backwater effects, and overflow propagation. In highly urbanised riverbank zones, concentrated development along channel margins further intensifies the risk of exposure.

The river network dataset was processed in a GIS environment, and an Euclidean Distance analysis was applied to generate a continuous raster representing the distance from each grid cell to the nearest river channel. The resulting distance-to-river raster was expressed in metres, reclassified into susceptibility categories, and incorporated into the GIS–AHP flood susceptibility model.

3.6 Analytical Hierarchy Process (AHP)

The use of AHP in this research is particularly suitable because it enables multiple flood-conditioning factors to be systematically weighted according to their relative importance, thereby improving the reliability of spatial flood susceptibility modelling. AHP is a multi-criteria decision-making method developed by Saaty (1980) that enables complex environmental factors to be systematically compared and weighted according to their relative influence on a specific objective. In the context of flood susceptibility modelling, AHP enables the integration of multiple environmental variables by assigning weights that reflect their contribution to flood occurrence.

Through pairwise comparison, AHP evaluates the relative importance of each factor using a structured decision matrix. The weighting process ensures that variables influencing flood susceptibility are incorporated proportionally within the GIS-based weighted overlay analysis. This approach improves the reliability of the flood susceptibility model by providing a systematic method for evaluating environmental criteria.

3.6.1 AHP Hierarchical Structure

The AHP hierarchical structure organises the decision problem into different levels, allowing complex spatial relationships to be evaluated in a structured manner. In this research, the hierarchy consists of two levels: the overall objective and the set of evaluation criteria.

The goal of the hierarchy is the Flood Susceptibility Map, the first objective being to identify areas more vulnerable to flooding within the research area. This goal forms the top level of the hierarchical framework and guides the subsequent weighting process.

The criteria level comprises the seven flood-conditioning variables used in the analysis: elevation, slope gradient, rainfall intensity, river water level, land use and land cover (LULC), drainage density, and distance to river. These variables were selected based on hydrological principles and previous flood susceptibility studies, as they represent key environmental conditions that influence flood occurrence.

3.6.2 Pairwise Comparison Matrix

A pairwise comparison matrix was constructed to determine the relative importance of each flood-conditioning factor within the Analytical Hierarchy Process (AHP) framework. In this procedure, each criterion was systematically compared against every other criterion to evaluate its relative contribution to flood susceptibility. The comparison process enables the transformation of qualitative expert judgments into quantitative weights for incorporation into spatial modelling.

The comparisons were conducted using Saaty's (1980) fundamental 1–9 scale of relative importance, where numerical values represent the intensity of preference of one factor over another. Table 3.6 presents the fundamental scale used in the pairwise comparison process (Hamka & Harjono, 2020).

Table 3.6
Fundamental Scale for Pairwise Comparison in the (AHP)

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Notion between two proximate values

The assignment of comparison values was informed by hydrological theory, empirical flood modelling literature, and the environmental characteristics of Taman Sri Muda. Expert consultation in hydrology and GIS-based flood assessment was also considered to ensure that the weighting process was grounded in scientific reasoning rather than subjective judgment.

After constructing the pairwise comparison matrix, it was normalised by dividing each element by the sum of its column. The principal eigenvector, also known as the priority vector, was subsequently calculated to determine the relative weight of each flood-conditioning factor. These weights represent the proportional contribution of each criterion to overall flood susceptibility within the modelling framework.

3.6.3 Consistency Ratio (CR) Assessment

To evaluate the logical consistency of the pairwise comparison matrix, the Consistency Index (CI) and Consistency Ratio (CR) were computed following Saaty's (1980) procedure. Consistency assessment is an essential step in AHP because pairwise comparisons rely on human judgment, which may occasionally yield inconsistent evaluations.

The Consistency Index (CI) was calculated as in (3.1):

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{3.1}$$

Where:

λ_{max} = principal eigenvalue

n = number of factors

A perfectly consistent matrix would yield $\lambda_{max} = n$, resulting in $CI = 0$. Deviations from this condition indicate increasing levels of inconsistency in the judgment matrix.

To determine whether the level of inconsistency is acceptable, the Consistency Ratio (CR) was calculated as in (3.2):

$$CR = \frac{CI}{RI} \tag{3.2}$$

Where:

RI= Random Index (Saaty's benchmark value based on matrix size)

For a matrix of size $n = 7$, the corresponding is $RI = 1.32$. According to AHP standards, a matrix is considered acceptably consistent if:

$$CR < 0.10$$

If CR is below 0.10, the pairwise comparisons should be revised to improve logical consistency.

In this research, the calculated Consistency Ratio was:

$$CR = 0.019$$

This value is substantially below the acceptable threshold of 0.10, indicating a high degree of internal consistency in the pairwise judgments and confirming the reliability of the derived factor weights.

3.6.4 Weighted Derivation

Following the derivation of weights and the verification of consistency, a weighted overlay analysis was conducted to generate the composite flood susceptibility map for 2024. Seven (7) key spatial parameters were incorporated into the modelling framework: rainfall intensity, river water level, elevation, slope gradient, land use/land cover (LULC), drainage density, and distance to river. These factors were identified as dominant flood-conditioning variables influencing flood vulnerability within the research area based on hydrological theory and empirical literature.

Each parameter was reclassified into susceptibility categories and assigned a standardised rating scale ranging from 1 (very low susceptibility) to 5 (very high susceptibility). The AHP-derived weights from the pairwise comparison matrix were then applied to the rated raster layers using a weighted linear combination.

The resulting composite Flood Susceptibility Index (FSI) integrates both the relative importance of each conditioning factor and its spatial variability, producing a continuous surface representing the spatial distribution of flood vulnerability across the research area.

3.7 GIS-Based Flood Susceptibility Modelling

Following the derivation of factor weights using the Analytical Hierarchy Process (AHP), spatial modelling was conducted within a Geographic Information Systems (GIS) environment to generate the Flood Susceptibility Map. The modelling process integrates the weighted flood-conditioning variables using a weighted overlay analysis, producing a composite index that represents the spatial distribution of flood vulnerability within the research area.

Each environmental variable was first standardised and reclassified into susceptibility categories, after which the AHP-derived weights were applied to evaluate the relative influence of each factor. The resulting model produces a spatial representation of flood susceptibility, which serves as the basis for the subsequent spatial–economic analysis in Chapter 4.

3.7.1 Flood Susceptibility Index (FSI)

Flood Susceptibility Index (FSI) represents a composite spatial indicator used to quantify the relative likelihood of flooding across the research area. The index integrates multiple flood-conditioning variables, each contributing to flood occurrence based on its environmental influence and relative importance.

The FSI was calculated using a weighted linear combination of the reclassified flood-conditioning variables. Each variable was assigned a rating score representing its contribution to flood susceptibility, while the corresponding weight reflects its relative importance derived from the AHP pairwise comparison matrix. The Flood Susceptibility Index is expressed as in (3.3):

$$FSI = \sum_{i=1}^{n} (w_i \times x_i) \tag{3.3}$$

Where:

w_i= AHP-derived weight

x_i= standardised raster score for each factor

3.7.2 Weighted Overlay Analysis

Weighted overlay analysis was conducted within the GIS environment to integrate the flood-conditioning variables into a single flood susceptibility surface. This approach enables multiple environmental factors to be combined systematically by incorporating both the spatial distribution of each factor and their relative importance derived from the Analytical Hierarchy Process (AHP).

The weighted overlay operation was implemented using raster-based spatial analysis tools in the GIS environment. Each reclassified raster layer was multiplied by its corresponding AHP weight to reflect its relative influence on flood occurrence. The

weighted layers were then combined using a linear additive model to produce the final Flood Susceptibility Index (FSI) surface.

The resulting raster output represents the cumulative spatial influence of all flood-conditioning variables and provides a continuous representation of flood vulnerability across the research area. This flood susceptibility surface forms the basis for classifying flood risk zones. It serves as a key spatial input for the subsequent analysis examining the relationship between flood exposure and residential property values.

3.7.3 Flood Susceptibility Classification

This classification facilitates visual interpretation of flood vulnerability patterns and allows the spatial distribution of flood risk to be compared with the locations of residential property. The classified Flood Susceptibility Map generated in this stage is presented and analysed in Chapter 4 (Section 4.3.1). The final AHP weights are presented in Table 4.1 in Chapter 4 (Section 4.3.3)

To facilitate interpretation of the flood susceptibility results, the continuous Flood Susceptibility Index values were categorised into five susceptibility classes. These classes represent different levels of flood vulnerability across the research area and allow for clear spatial comparison of flood risk patterns.

These categories are Very Low, Low, Moderate, High, and Very High flood susceptibility. These categories provide a simplified representation of flood risk levels and form the basis for the Flood Susceptibility Map presented in Chapter 4 (Section 4.3.1). The classified susceptibility zones are subsequently used to examine the relationship between flood exposure and residential property values within the research area.

3.8 Phase 3: Property Value Analysis (Objective 2)

The flood susceptibility indicators generated through the GIS–AHP modelling process serve as key environmental variables within the hedonic valuation framework. By incorporating spatially derived flood exposure measures into the regression analysis, the research evaluates how variations in environmental vulnerability are reflected in residential property prices.

The housing market often reflects buyers' perceptions of environmental risk through price adjustments. Properties in areas perceived as more vulnerable to environmental hazards may experience reduced demand or lower prices, while properties in safer locations may command higher market values. Using an econometric modelling approach, this phase examines whether flood-susceptibility conditions influence residential property valuation within the research area.

Through this approach, the research moves beyond spatial flood-risk assessment and evaluates the economic implications of environmental vulnerability. The integration of spatial risk indicators with property transaction data enables a quantitative assessment of how environmental conditions interact with housing market behaviour at the neighbourhood scale.

3.8.1 Hedonic Pricing Model (HPM)

The Hedonic Pricing Model (HPM) is adopted because it enables the decomposition of property value into the implicit prices of individual attributes. In housing markets, residential properties are heterogeneous goods that differ in structural characteristics, locational advantages, and environmental surroundings. The HPM allows the overall property price to be expressed as a function of these attributes, enabling estimation of each factor's contribution to market valuation.

Under this framework, environmental risk can be quantified as a marginal price effect rather than treated merely as a descriptive contextual factor. This is particularly relevant for environmental hazards such as flooding, where the perceived risk may influence buyer decision-making and property demand. By incorporating GIS-derived flood susceptibility variables into the hedonic regression specification, this phase operationalises the interdisciplinary linkage between spatial modelling and urban economic theory.

3.8.1.1 Theoretical Basis

The Hedonic Pricing Model is grounded in hedonic price theory, which holds that the individual characteristics of a housing unit determine property values. Residential properties are viewed as bundles of attributes, and the market price reflects the combined value of these attributes as perceived by buyers and sellers.

Under this framework, property prices are influenced by three primary categories of characteristics: structural, locational, and environmental. Structural attributes refer to the property's physical characteristics; locational attributes capture accessibility and neighbourhood advantages; and environmental attributes reflect the surrounding conditions that affect residential desirability.

The incorporation of flood susceptibility variables as environmental attributes allows the model to estimate how flood-related risk factors are capitalised into housing market prices. This provides an empirical mechanism for evaluating whether environmental vulnerability influences property valuation within the residential market.

3.8.1.2 Model Specification

To enhance interpretability and accommodate potential nonlinearity in the relationships between housing prices and explanatory variables, a semi-logarithmic functional form is adopted. Housing price distributions are typically right-skewed, and the logarithmic transformation stabilises variance while enabling elasticity-based interpretation of coefficients.

The general form of the model in equation (3.4) is expressed as:

$$\ln(P) = \beta_0 + \beta_1 S + \beta_2 L + \beta_3 E + \epsilon \tag{3.4}$$

Where:

P is the property price,
S represents structural attributes,
L represents locational attributes,
E represents environmental attributes (including flood susceptibility score),
ϵ is the error term.

Semi-log specification adopted in equation (3.5):

$$Price_i = \beta_0 + \beta_1 Land\ Size_i + \beta_2 Distance\ to\ Pond_i + \beta_3 Distance\ to\ River_i + \varepsilon_i \tag{3.5}$$

Where:

$Price_i$	=	house price for i,
β_0	=	intercept;
$Land\ Size$	=	Land size in m^2 for i;
$Distance\ to\ Pond$	=	distance to pond from i;
$Distance\ to\ River$	=	distance to River from i;
$\beta_1, \beta_2, \beta_3$	=	coefficients; and
ε	=	error term.

In this research, a semi-logarithmic functional form was adopted, where the dependent variable is property price. This allows for direct economic interpretation of risk capitalisation effects.

3.8.1.3 Variable Definition

The explanatory variables included in the hedonic regression model were categorised into three attribute groups consistent with conventional property valuation frameworks.

Table 3.7 presents the independent and dependent variables used in the hedonic pricing model. The variables are categorised by their roles within the regression framework and are subsequently described in detail in the following subsections.

Table 3.7
Dependent and Independent Variables

Variable type	Variable	Measurement	Role
Dependent	Log of Property Price	Natural logarithm of transaction price	Dependent variable
Structural	Land Size	Square metres (m^2)	Independent variable
Locational	Distance to Retention Pond	Metres (m)	Independent variable
Environmental	Distance to River	Metres (m)	Independent variable

i) Structural Attributes

Structural attributes represent the intrinsic physical characteristics of the property. In this research, land size (square metres) was selected as the principal structural variable. Land size reflects the physical extent of the property parcel and is generally expected to be positively related to property value, as larger parcels typically command higher market prices.

Given the relatively homogeneous housing typology within Taman Sri Muda, primarily double-storey terraced houses, land size serves as an appropriate structural control variable for isolating the influence of locational and environmental factors.

ii) Locational Attributes

Locational variables account for spatial accessibility and neighbourhood advantages. These include proximity to transportation networks, commercial centres, schools, and other public amenities. In urban property markets, accessibility and convenience significantly influence price formation. Therefore, controlling for locational factors isolates the environmental risk effect from general spatial desirability influences.

In this research, Distance to the nearest retention pond and river were included to account for local flood mitigation infrastructure and environmental amenity effects. Retention ponds function as stormwater management facilities that reduce surface runoff and mitigate flood intensity. Proximity to such infrastructure may positively influence buyers' perception of flood protection and contribute to neighbourhood environmental quality.

iii) Environmental Attributes (Flood Susceptibility Variable)

Environmental attributes constitute the central analytical focus of this research. Rather than relying solely on a composite flood susceptibility index, this research incorporates the seven individual flood-conditioning factors derived from the GIS–AHP modelling framework into the hedonic regression model. These include rainfall intensity, river water level, elevation, slope gradient, land use/land cover (LULC), drainage density, and distance to river.

Each variable represents a distinct dimension of spatial flood vulnerability and was operationalised using GIS-derived measures at the property level. By incorporating these variables separately into the regression specification, the model enables direct examination of how specific components of flood risk influence residential property values. The empirical results indicate that among the seven flood-related variables, only distance to the river is statistically significant. This suggests that housing market participants may respond more directly to observable spatial proximity to river channels, while other flood-conditioning factors may not be fully internalised into price

formation.

This approach allows the research to identify which dimensions of flood susceptibility are effectively capitalised into property values and which remain statistically insignificant within the market context. The structured inclusion of these three attribute categories strengthens the model's internal validity and ensures theoretical consistency with established valuation principles.

3.8.1.4 Regression Model Development

To examine the relationship between flood-related variables and residential property prices, a semi-logarithmic hedonic pricing model was employed. In this specification, the dependent variable (property transaction price) was transformed to its natural logarithm to improve data normality, reduce skewness, and stabilise variance. The model expresses property price as a function of structural, locational, and environmental attributes, allowing estimation of the marginal impact of each variable on housing values.

The regression analysis was conducted using the Statistical Package for the Social Sciences (SPSS) (Kafle, 2019). The model was estimated using linear regression, with coefficients derived from the relationship between the dependent variable and the selected explanatory variables. Before estimation, the dataset was screened for missing values, outliers, and potential multicollinearity to ensure statistical reliability.

Several statistical indicators were used to evaluate the reliability and explanatory power of the hedonic regression model. These indicators include the coefficient of determination (R^2), the F-statistic, the t-test for individual coefficients, and the p-values.

i) R-Squared (R^2)

The coefficient of determination (R^2) measures the proportion of variation in residential property prices explained by the independent variables included in the model (Rumelt & R.P., 1998). The R^2 value is obtained from the Model Summary table in SPSS and ranges from 0 to 1, with higher values indicating greater explanatory power. In this research, R^2 indicates how well structural, locational, and environmental variables collectively explain variation in housing prices.

ii) F-Test

The F-test, as reported in the ANOVA table, assesses the overall statistical significance of the regression model (Sureiman & Mangera, 2020). Specifically, the F-statistic tests whether the explanatory variables jointly explain variation in the dependent variable. A statistically significant F-test indicates that the model provides better explanatory power than a model containing only the mean property price.

iii) T-Test and p-value

The t-test is used to evaluate the statistical significance of each regression coefficient. The t-statistic and its corresponding p-value, obtained from the Coefficients table, determine whether a particular variable significantly influences property prices. A p-value below the significance level ($p < 0.05$) indicates that the variable has a statistically significant effect on the dependent variable (Akpan & Clark, 2023).

These diagnostic indicators provide the methodological basis for interpreting the regression results presented in Chapter 4 (Section 4.6), in which the estimated coefficients and statistical values are analysed to assess how structural, locational, and environmental factors influence residential property values in the research area.

3.9 Phase 4: GIS Integrating and Flood Risk-Value Mapping (Objective 3)

This phase integrates the spatial flood susceptibility outputs with the econometric results from the Hedonic Pricing Model (HPM) to examine how environmental risk is reflected in property values. The integration enables spatial–economic interpretation of flood vulnerability within the research area.

3.9.1 Integration of Flood Risk Indicators and Property Data

This section describes the procedures for integrating the flood susceptibility outputs with residential property transaction data. Integration was conducted in a GIS environment to ensure that each property observation could be evaluated not only by its transaction price and property characteristics but also by its spatial exposure to flood-susceptibility conditions.

The integration process allows the research to move from two separate analytical outputs: (i) a flood susceptibility surface representing spatial flood vulnerability and (ii) a regression-based valuation model estimating the influence of environmental risk on residential property values. This integrated dataset is required to map flood susceptibility and property price outcomes simultaneously and to generate spatial indicators that can be interpreted for planning and valuation decision-making.

3.9.1.1 Data Alignment

Data alignment refers to the procedures undertaken to ensure that the flood susceptibility raster layers and the property transaction dataset are spatially compatible and analytically consistent. This step is necessary because the flood susceptibility output is represented as a raster surface with values assigned to grid cells, whereas property transactions are represented as discrete point observations. Without careful alignment, overlay operations may produce inaccurate exposure assignment due to coordinate mismatches, scale inconsistencies, or edge misalignment between datasets.

First, the residential property transaction dataset was prepared as a GIS point layer using validated spatial coordinates. Each point represents the location of a transacted property and functions as the spatial reference for linking flood susceptibility values to individual observations. The property point layer was projected into the same coordinate reference system used in the flood susceptibility modelling, namely RSO Malaya, to ensure positional accuracy and consistency during spatial overlay analysis. Projection harmonisation is critical because even small positional shifts can lead to incorrect classification of flood exposure, particularly in neighbourhood-scale studies.

Second, the Flood Susceptibility Index raster was verified to ensure consistent spatial extent, grid resolution, and cell alignment across the research boundary. Once both datasets were harmonised, the property points were overlaid onto the flood susceptibility raster, and the raster value underlying each property point was extracted and appended to the property attribute table. As a result, every transaction record was assigned a corresponding flood susceptibility class, enabling subsequent spatial–economic mapping and interpretation.

3.9.1.2 Spatial Overlay Techniques

Spatial overlay techniques were applied to integrate the flood susceptibility surface with residential property transaction data within a GIS environment. Three main operations were implemented: weighted overlay, spatial join, and property value mapping, which together form the workflow linking environmental flood risk to housing market outcomes.

First, weighted overlay analysis was used to generate the Flood Susceptibility Index (FSI) by combining all reclassified flood-conditioning variables using AHP-derived weights. The result is a continuous raster surface representing cumulative flood vulnerability across the research area, which serves as the primary environmental risk layer for the analysis.

Second, a spatial join operation was conducted to link property transaction points with the flood susceptibility raster. This process assigns a flood susceptibility class to each property based on its geographic location, thereby converting the general flood risk surface into property-level exposure indicators that can be analysed alongside transaction prices and property characteristics.

Finally, property value mapping was conducted to visualise the spatial distribution of residential property prices across the research area. The property transaction dataset, which includes the geographic coordinates and transaction prices of residential properties, was represented as a point layer in the GIS environment.

3.9.1.3 Development of Flood Risk–Value Indicator (FRVI)

A Flood Risk–Value Indicator (FRVI) was developed to integrate the environmental flood-susceptibility results with the residential property valuation analysis. The purpose of this indicator is to identify spatial relationships between flood vulnerability and housing market behaviour within the research area. By combining flood risk information with property value patterns, the FRVI provides a spatial representation of how environmental exposure may correspond with variations in residential property prices.

The first component of the FRVI is the Flood Susceptibility Index (FSI) derived from the GIS–AHP modelling process. The FSI represents the spatial distribution of flood vulnerability across the research area by combining multiple flood-conditioning variables, including elevation, slope gradient, rainfall intensity, river water level, land

use and land cover, drainage density, and distance to river. The resulting raster surface provides a continuous representation of environmental flood risk across the research area.

The second component is derived from the Hedonic Pricing Model (HPM) framework, which estimates the influence of structural, locational, and environmental variables on residential property prices. The regression outputs provide a statistical basis for identifying the relative importance of property attributes within the housing market. By incorporating these econometric insights into the spatial analysis framework, the FRVI enables environmental risk indicators to be interpreted alongside property valuation variables within a unified analytical structure.

By integrating these two components, the FRVI framework enables spatial comparison of flood-susceptibility conditions and residential property values, providing a methodological basis for analysing the interaction between environmental vulnerability and housing market behaviour.

3.9.1.4 Map Production

The final stage of Phase 4 involved producing thematic maps that summarise the spatial relationships between flood susceptibility and residential property values within the research area. All maps were generated using GIS-based cartographic procedures with consistent projection, spatial scale, classification schemes, and visual hierarchy to ensure clarity and comparability. These maps provide a visual representation of the analytical outputs and facilitate interpretation of how environmental flood risk interacts with housing market patterns across Taman Sri Muda.

The Flood Susceptibility Map illustrates the spatial distribution of flood vulnerability derived from the Flood Susceptibility Index (FSI) produced through the GIS–AHP modelling process. The FSI values were classified into five categories: Very Low, Low, Moderate, High, and Very High susceptibility. This map provides an environmental baseline by identifying areas with varying levels of flood exposure within the neighbourhood. It serves as a spatial reference for understanding how physical and hydrological factors contribute to flood risk conditions across the research area.

Finally, the Flood Risk–Value Indicator (FRVI) Map was produced by integrating the flood susceptibility layer with the spatial distribution of residential property values. The FRVI map enables spatial comparison between flood risk zones and residential property price patterns within the research area. By displaying these datasets together, the map provides a visual framework for examining the potential spatial relationship between environmental flood exposure and housing market characteristics.

The integrated map, therefore, serves as a spatial analytical tool that facilitates the interpretation of how flood-susceptibility conditions may correspond with residential property valuation patterns. The results and spatial relationships observed from this integrated mapping process are further analysed and discussed in Chapter 4.

3.10 Model Validation and Reliability Assessment

Model validation and reliability assessment were conducted to ensure the robustness and credibility of the analytical procedures used in this research. Because the research integrates multi-criteria spatial modelling and econometric analysis, it is important to verify that both the flood susceptibility model and the hedonic regression model produce logically consistent and reliable results. Validation was conducted through three main procedures: verification of the AHP consistency ratio, evaluation of regression diagnostics, and spatial verification via field observations.

The reliability of the Analytical Hierarchy Process (AHP) weighting procedure was evaluated using the CR. The CR measures the logical consistency of the pairwise comparison matrix used to derive the relative weights of the flood-conditioning factors. In accordance with Saaty's (1980) methodology, the consistency ratio was calculated by comparing the matrix's CI with the RI for the matrix size. A CR value below 0.10 indicates acceptable consistency in expert judgments. In this research, the calculated consistency ratio (CR) was 0.019, which is substantially below the threshold. This result indicates a high level of internal consistency in the pairwise comparisons. It confirms that the derived weights reliably represent the relative importance of the flood-conditioning variables used in the susceptibility modelling.

The reliability of the hedonic pricing model was assessed through standard regression diagnostic measures. Model adequacy was evaluated using the coefficient of determination (R^2) to measure explanatory power, the F-statistic to test the overall

significance of the regression model, and t-statistics to evaluate the significance of individual explanatory variables. The corresponding p-values were used to determine statistical significance using a threshold of $p < 0.05$. These diagnostic statistics help verify whether the selected structural, locational, and environmental variables provide meaningful explanatory power in estimating residential property values and ensure that the regression model produces statistically interpretable results.

Spatial verification was conducted through field observations to confirm the accuracy of the GIS-based flood-susceptibility outputs and property location data. Site visits were conducted in Taman Sri Muda to verify the spatial positions of selected residential properties and observe physical indicators of flood impacts in the neighbourhood. Photographic documentation and on-site inspection were used to cross-check the spatial correspondence between mapped flood susceptibility zones and actual environmental conditions. This field validation process provides additional empirical support for the spatial modelling results and strengthens confidence in the integration of flood risk assessment with property valuation analysis. These procedures enhance methodological robustness.

3.11 Practical Applications and Implications

The integrated GIS–AHP–HPM framework developed in this research provides practical insights that extend beyond academic analysis. By linking spatial flood susceptibility modelling to residential property valuation, the framework provides a methodological approach to understanding how environmental risk interacts with housing market behaviour. The findings can support evidence-based decision-making in urban planning, property valuation practice, and flood risk management by providing spatially explicit information on areas where flood vulnerability may influence residential property values.

The integrated spatial analysis can assist urban planners and local authorities in identifying neighbourhoods that are more susceptible to flood hazards. By incorporating the Flood Susceptibility Map into land-use planning and zoning regulations, planning authorities can guide future residential development toward areas with lower environmental risk. In addition, identifying high-susceptibility zones enables planners to implement appropriate development controls, such as restrictions on high-density residential construction, requirements for flood-resilient building designs, and the

integration of improved drainage infrastructure. Such measures contribute to more sustainable urban development and reduce the long-term vulnerability of residential communities to flood hazards.

From a disaster risk management perspective, the combined spatial–economic analysis provides valuable information for flood mitigation and resilience planning. By identifying areas where high flood susceptibility coincides with residential development, policymakers and disaster management agencies can prioritise targeted mitigation measures such as improved drainage systems, retention ponds, river channel improvements, and community-based flood preparedness programs. The spatial identification of vulnerable residential zones also supports long-term resilience planning by informing infrastructure investment decisions and risk communication strategies. Ultimately, integrating flood risk assessment with property valuation analysis contributes to a more comprehensive understanding of the socio-economic implications of flood hazards within urban environments.

The methodological procedures described in this chapter provide the analytical foundation for examining the interaction between flood susceptibility and residential property values. Through the integration of spatial modelling and econometric analysis, the research framework enables the systematic evaluation of both environmental and market-based variables. The following chapter presents the empirical findings from these analytical procedures, including the spatial distribution of flood susceptibility, the results of the hedonic pricing regression analysis, and the spatial integration of flood-risk and property-value indicators.

For property valuation professionals, the integrated framework provides an additional analytical tool for incorporating environmental risk into valuation practice. By quantifying flood susceptibility at the property level, valuers can better assess risk-adjusted market values in flood-prone areas. The framework may also assist financial institutions, insurers, and investors in evaluating property-related risks and in supporting more informed decision-making.

3.12 Summary

This chapter operationalised the integrated GIS–AHP–HPM framework proposed to address the literature gap identified in Chapter 2. By modelling flood susceptibility as a continuous spatial index and incorporating it within a hedonic pricing regression framework, the research establishes a structured linkage between environmental risk assessment and residential property valuation.

The methodological design was organised into four sequential phases to ensure analytical coherence. Phase 1 focused on the data collection, preparation, and standardisation of spatial and property transaction datasets. Phase 2 implemented the GIS–AHP approach to identify and weight seven flood-conditioning factors, resulting in the development of a composite Flood Susceptibility Index (FSI) representing spatial flood vulnerability across the research area. Phase 3 introduced the hedonic pricing model to estimate the influence of structural, locational, and environmental attributes on residential property values. Finally, Phase 4 integrated spatial modelling outputs with econometric estimates to produce the Flood Risk–Value Indicator (FRVI) map, enabling spatial–economic interpretation of environmental vulnerability.

The integrated framework represented flood susceptibility as a continuous spatial index and incorporated it into property valuation analysis, thereby linking environmental risk assessment to residential property values. This approach provides a systematic and spatially informed methodology for evaluating the influence of flood risk on housing market behaviour.

The methodological procedures described in this chapter provide the analytical foundation for the empirical analyses presented in Chapter 4, where the GIS-based flood susceptibility modelling, hedonic regression results, and the integrated Flood Risk–Value Indicator (FRVI) Map are presented and discussed.

CHAPTER 4
RESULTS AND ANALYSIS

4.1 Introduction

This chapter presents the empirical findings corresponding to the research objectives. The first section discusses the spatial flood-susceptibility analysis (Objective 1), followed by the hedonic pricing estimation of property values (Objective 2), and finally the integration of both analyses through flood-risk–value spatial mapping (Objective 3). The chapter concludes by integrating these results to produce a spatially explicit Flood Risk–Value Indicator Map, which illustrates the relationship between environmental risk exposure and residential property valuation.

Section 4.5 then reports the Property Value Analysis, presenting the regression outputs and statistical evaluation of the hedonic pricing model. Finally, Section 4.8 integrates spatial and econometric findings through Flood Risk–Value Indicator mapping, providing a spatially explicit representation of the relationship between flood risk and residential property values. Together, these sections offer a comprehensive interpretation of the physical and economic dimensions of flood vulnerability.

4.2 Flood Risk Indicators Assessment Results (Objective 1)

Flood Risk Analysis is crucial for understanding the geographic distribution of flood-prone areas and the factors contributing to flooding. This analysis helps identify vulnerable areas and informs flood management practices that mitigate the impact of flooding on communities. By incorporating advanced techniques such as GIS and AHP, we gain valuable insights into the spatial and environmental dynamics of flood risk in the research area.

This section, based on the methodology outlined in Chapter 3, identifies key flood-conditioning factors using GIS and AHP. Focusing on critical factors such as elevation, rainfall intensity, slope, water level, and distance from rivers, the analysis enables the creation of a Flood Susceptibility Map. This map provides a clear visual representation of the areas in Taman Sri Muda most at risk of flooding, helping to identify flood-prone zones for further action. Using GIS, these flood-related factors are accurately mapped, while AHP assigns appropriate weights to each factor based on

expert opinions and empirical data. This combination ensures a robust flood risk assessment, enhancing the reliability of the results and providing a more accurate picture of flood susceptibility across Taman Sri Muda.

For instance, areas near the Klang and Damansara Rivers were identified as high-risk zones due to their proximity to water bodies and low-lying topography, making them particularly vulnerable to riverine and flash flooding, especially during heavy rainfall. Conversely, areas at higher elevations with better drainage systems were classified as low-risk zones. These findings are critical for urban planners and policymakers, as they provide valuable data on where flood mitigation strategies are most urgently needed.

4.2.1 Spatial Characteristics of Flood-Conditioning Factors

Seven flood-conditioning factors were identified as significant determinants of flood susceptibility in Taman Sri Muda: namely, rainfall intensity, river water level, elevation, slope gradient, land use/land cover (LULC), drainage density, and distance to river. The spatial distribution of these variables reveals distinct patterns that collectively shape flood vulnerability across the research area.

The thematic maps illustrate how physical terrain characteristics, hydrological proximity, and land surface conditions interact to influence flood-prone zones. Low-elevation areas are concentrated in the central and southern portions of Taman Sri Muda, forming a natural basin for water accumulation. These zones coincide with gentle slope gradients, which reduce runoff velocity and increase the potential for surface ponding. In contrast, slightly elevated regions exhibit comparatively lower flood susceptibility due to improved natural drainage capacity.

Land use patterns further reinforce spatial vulnerability. The dominance of built-up residential areas reduces infiltration capacity and increases surface runoff, particularly during high rainfall events. Areas located closer to the Klang and Damansara Rivers display higher exposure levels, reflecting the influence of fluvial overflow and backwater effects. Similarly, zones characterised by higher drainage density indicate areas where runoff concentration may intensify during peak rainfall conditions.

Collectively, the spatial characteristics of these factors indicate that flood risk within Taman Sri Muda is not uniformly distributed but concentrated in specific low-lying, river-adjacent zones. These spatial variations form the basis for the composite Flood Susceptibility Index presented in the subsequent section.

i) Elevation

The elevation map of Taman Sri Muda in Figure 4.1 illustrates the topographic variation across the research area, with elevation values ranging from 0 to 30 metres above mean sea level. The terrain is characterised by relatively gentle relief, reflecting its location within the Klang River floodplain. The map classifies elevation into five categories, showing gradual transitions between lower and higher zones rather than abrupt terrain changes. This overall low-relief morphology indicates that much of the area lies within a naturally flat to mildly undulating landscape.

In terms of spatial distribution, the lowest elevation zones (0–5 metres) are concentrated primarily in the northern and northeastern sections of the research area. These areas are situated closer to the Klang River and associated drainage systems. In contrast, higher-elevation classes (15.1–30 metres) are predominantly located in the central and southern portions, where the terrain is relatively elevated compared with surrounding areas. The contrast between low-lying and elevated zones, although moderate, creates identifiable topographic gradients that influence the spatial distribution of flood susceptibility.

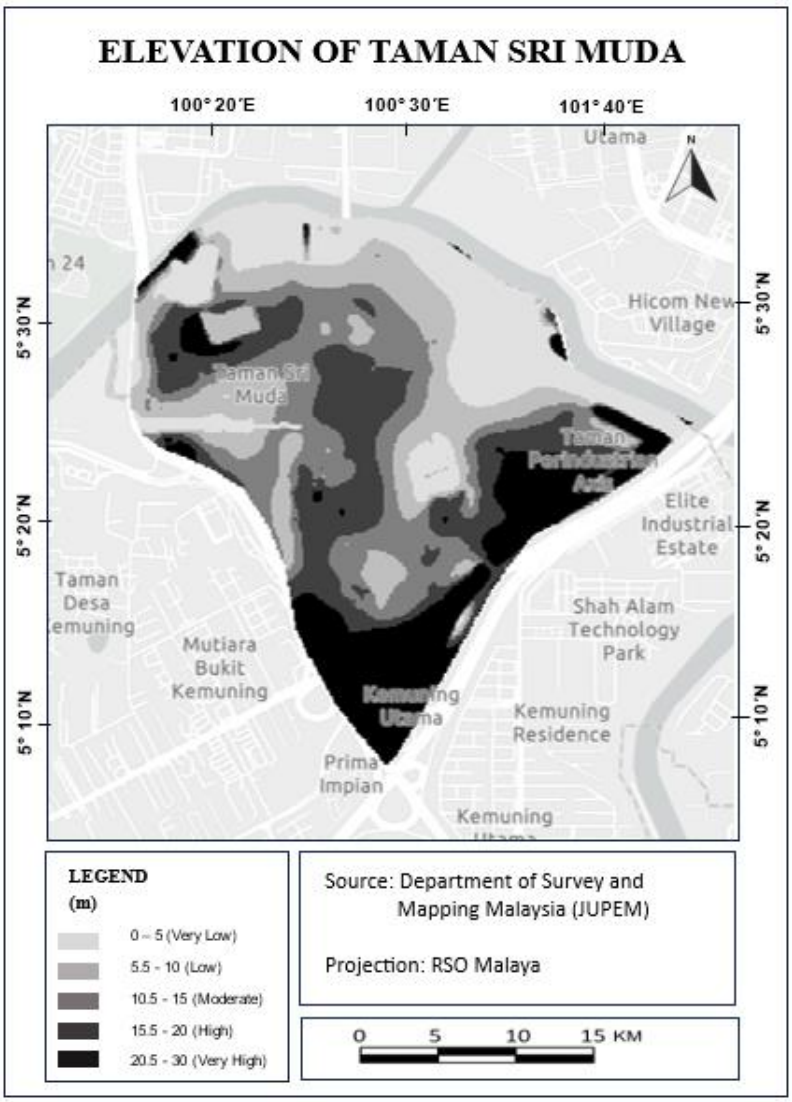


Figure 4.1 Elevation Map of Taman Sri Muda

From a hydrological perspective, low-lying areas are more likely to accumulate surface runoff during intense rainfall or river overflow events. Due to limited natural gravitational drainage, water tends to collect in these depressions, increasing the likelihood of prolonged inundation. Conversely, higher elevation zones facilitate more efficient runoff dispersal, thereby reducing water retention and flood duration. The elevation pattern, therefore, plays a critical role in shaping flood vulnerability within Taman Sri Muda, particularly in the northern and northeastern sectors, where lower terrain coincides with proximity to rivers.

ii) Slope

The slope map of Taman Sri Muda shows variations in terrain steepness across the research area, classified into five categories ranging from very low (0.1°–1°) to very high (11°–21.3°) as shown in Figure 4.2. The map reveals that a substantial proportion of the area, particularly within the central region, falls within the very low to low slope classes (0.1°–3°). This indicates that much of Taman Sri Muda is characterised by flat or gently undulating terrain, consistent with its floodplain setting.

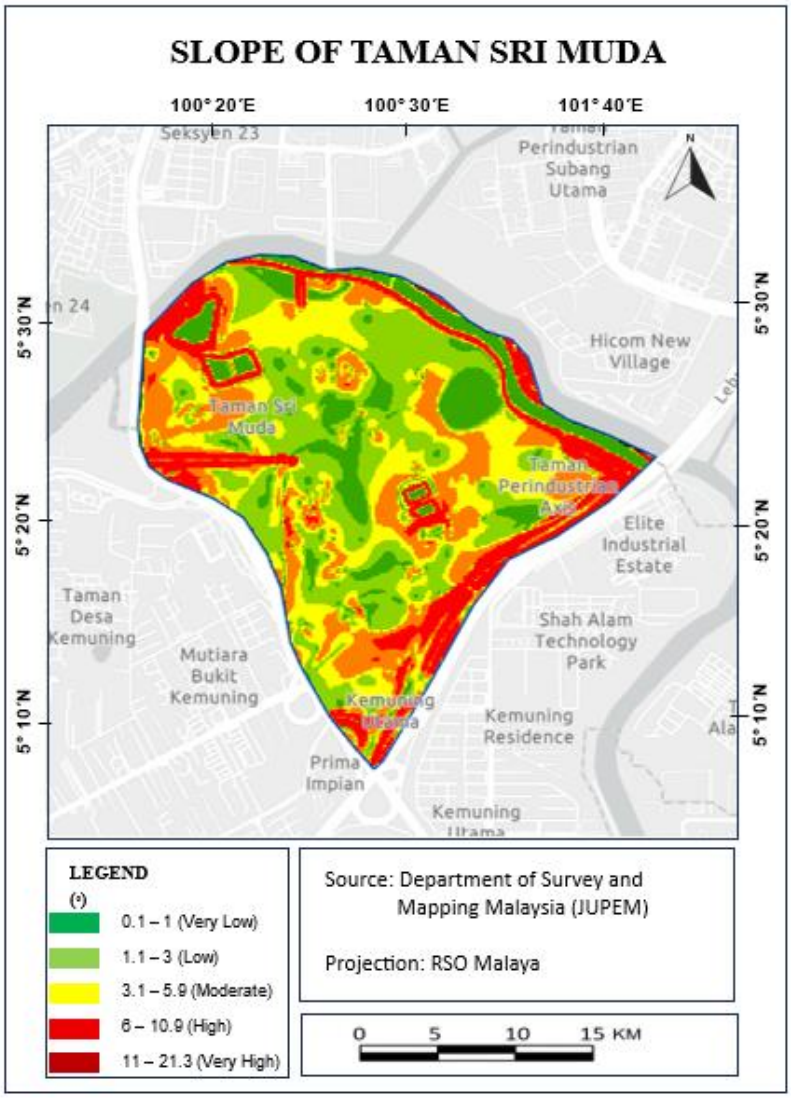


Figure 4.2 Slope Map of Taman Sri Muda

Zones with higher slope values (above 6°) are spatially concentrated along the outer boundaries of the research area, especially toward the northern and southeastern sections. These steeper areas appear as narrow bands rather than extensive zones, reflecting localised topographic variation rather than widespread changes in terrain

elevation. Moderate slopes (3.1°–5.9°) are scattered in small pockets but do not dominate the landscape.

From a hydrological perspective, the dominance of gentle slopes significantly influences surface runoff behaviour. Flat terrain reduces runoff velocity, slowing rainwater movement and increasing the likelihood of water retention and surface ponding during heavy rainfall events. In contrast, steeper slopes promote faster runoff, reducing the duration of water accumulation but potentially increasing the intensity of surface runoff. Therefore, the prevalence of low-gradient terrain in Taman Sri Muda contributes to conditions that favour prolonged inundation, reinforcing its flood susceptibility.

iii) Rainfall Density

The rainfall map of Taman Sri Muda, shown in Figure 4.3, illustrates spatial variation in annual precipitation across the research area, with recorded values ranging from approximately 5,219 mm/year to 5,283 mm/year. Although the overall variation is moderate, the map reveals discernible spatial gradients in rainfall intensity. Darker blue zones represent higher rainfall classes, while lighter shades indicate comparatively lower precipitation levels. This pattern confirms that rainfall input is not uniformly distributed across the research boundary.

Higher rainfall zones (5,253–5,283 mm/year) are concentrated in the northern and eastern portions of Taman Sri Muda. In contrast, lower rainfall classes are more evident in the southern section of the research area. Transitional moderate rainfall zones occupy the central region, forming a gradient between high- and low-intensity areas. The spatial concentration of higher rainfall in the northern sector indicates greater precipitation input in that part of the neighbourhood.

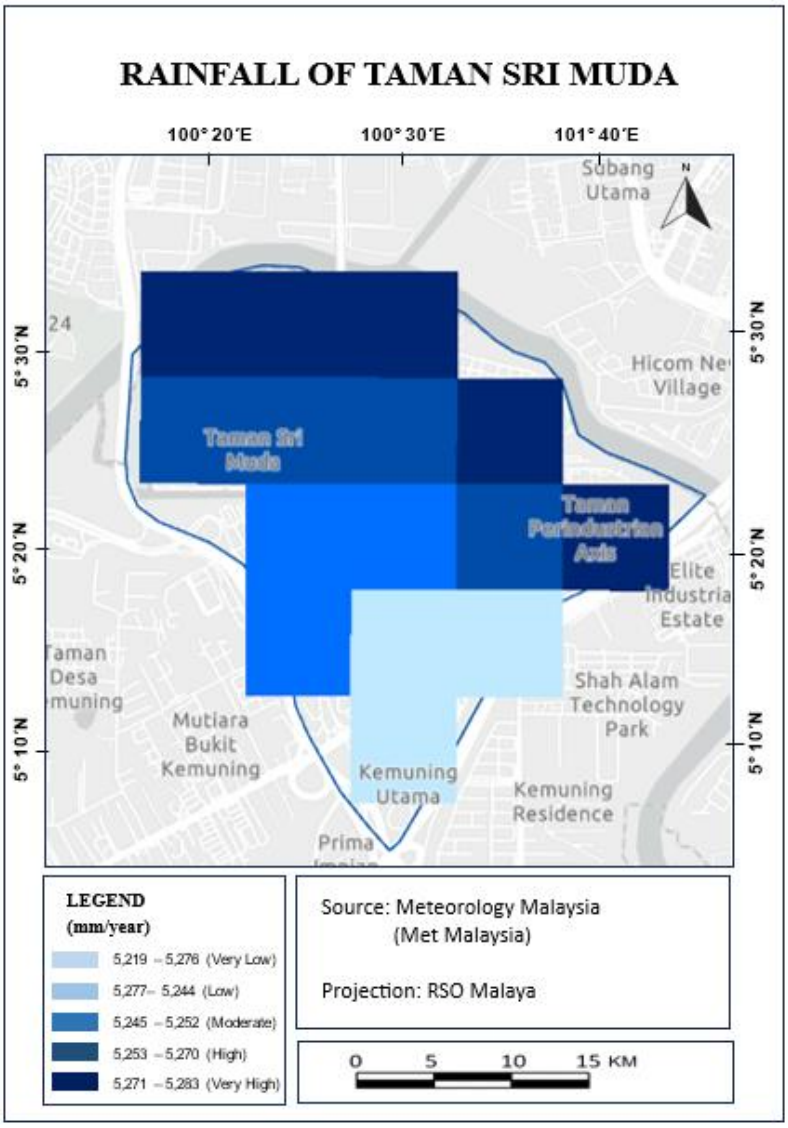


Figure 4.3 Rainfall Map of Taman Sri Muda

Hydrologically, zones receiving higher rainfall intensity exhibit greater potential for surface runoff generation. Elevated precipitation levels can exceed local infiltration and drainage capacity, particularly in areas characterised by low elevation and gentle slope gradients. When intense rainfall coincides with limited runoff dispersion and proximity to river systems, the probability of surface water accumulation and overflow increases. Therefore, the spatial distribution of rainfall significantly shapes flood susceptibility within Taman Sri Muda.

iv) Groundwater Depth (water level)

The Groundwater Depth (water level) map of Taman Sri Muda, shown in Figure 4.4, depicts the spatial variation in subsurface water levels across the research area. Lighter blue shades represent shallower groundwater depths, while darker tones indicate relatively deeper groundwater levels. The map shows that shallow groundwater zones are primarily concentrated in the central and northeastern portions of Taman Sri Muda. These areas closely correspond to low-lying terrain identified in the elevation analysis, suggesting a spatial association between topographic depressions and elevated groundwater tables.

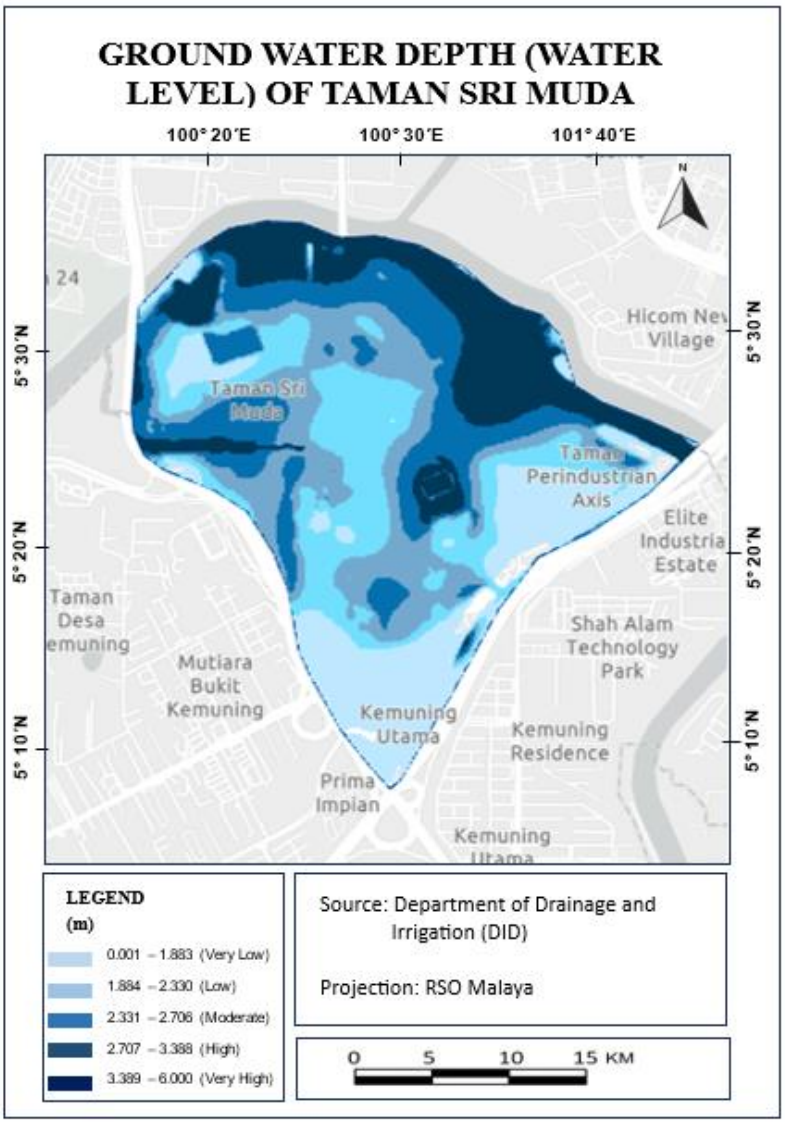


Figure 4.4 Groundwater Depth (Water Level) Map of Taman Sri Muda

Zones characterised by shallow river water depths exhibit higher water-retention potential. When groundwater is close to the surface, soil storage capacity is reduced, limiting vertical infiltration during rainfall events. As a result, surface runoff accumulates more rapidly, increasing the likelihood of prolonged ponding and localised inundation. Conversely, areas with relatively deeper groundwater are more evident in the southern and western sections, allowing greater subsurface storage and improved drainage efficiency. Therefore, the spatial distribution of shallow groundwater depth reinforces the concentration of flood-prone conditions within the central and northeastern sectors of Taman Sri Muda.

v) Land Use and Land Cover (LULC)

The land use and land cover (LULC) map of Taman Sri Muda, shown in Figure 4.5, illustrates the distribution of land-use and land-cover types within the research area. The map categorises land cover into five primary classes: built-up areas (red), water bodies (blue), forested and vegetation areas (green), and barren land (yellow). Most of the region is covered by built-up areas, indicated by the prominent red sections, reflecting the area's urbanised nature. Forested regions are concentrated in the western and northern parts of the research area, while water bodies are scattered across the central and southern parts. The map also shows some barren land in the southeast. This spatial distribution is critical for understanding how different land covers affect flood risk and drainage patterns.

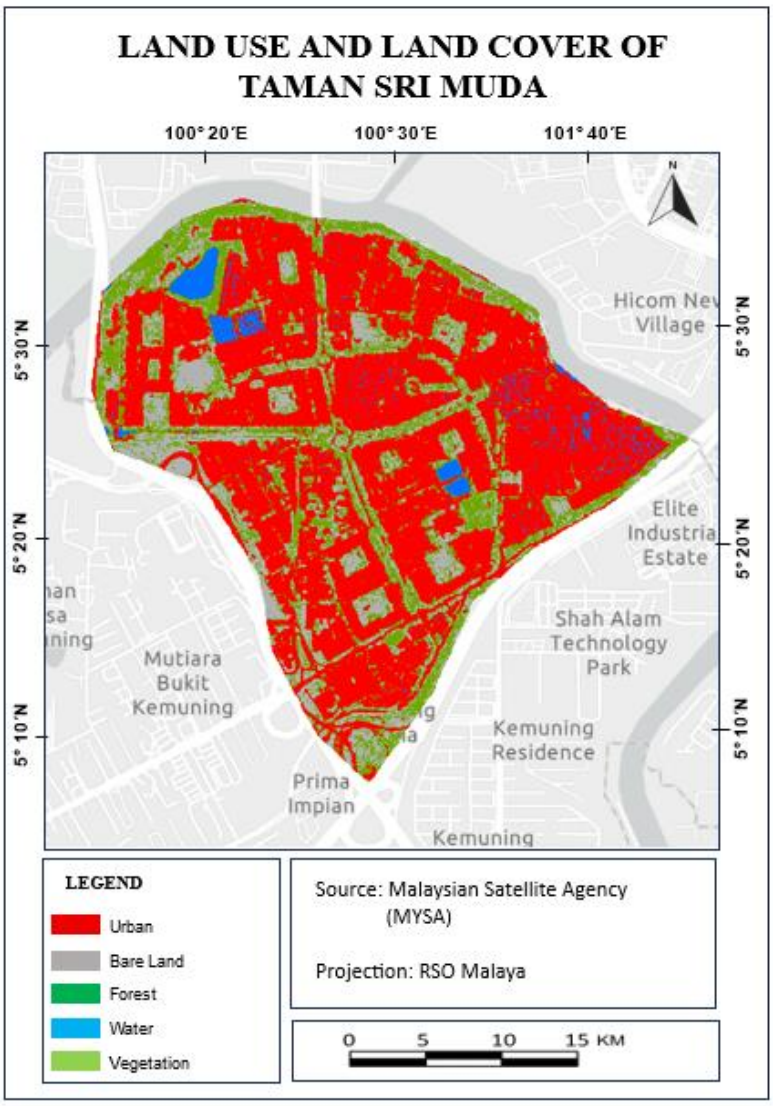


Figure 4.5 Land Use and Land Cover Map of Taman Sri Muda

The high prevalence of built-up areas, shown in red, is a direct consequence of urbanisation in Taman Sri Muda. As the area developed, land was converted into residential, commercial, and infrastructure spaces, replacing natural landscapes with impervious surfaces such as roads and buildings. These impervious surfaces prevent water infiltration into the ground, increasing surface runoff during rainfall and exacerbating flooding. In contrast, the green areas representing forested regions act as natural flood mitigators by promoting infiltration of water into the soil. Water bodies also help control runoff, but can exacerbate local flooding when drainage systems are inadequate. The presence of barren land in the southeast is less significant for flood risk. Still, it indicates areas with minimal vegetation cover, which can contribute to soil erosion and increased runoff.

The LULC map of Taman Sri Muda underscores the significant role of urbanisation in increasing flood risk, particularly in areas with extensive built-up zones. Converting land to impervious surfaces reduces the natural capacity to absorb rainwater, leading to higher surface runoff and increased flood vulnerability. Forested areas, by contrast, provide a natural buffer against flooding by enhancing water infiltration, while water bodies can both mitigate and exacerbate flooding, depending on the state of surrounding infrastructure. These findings highlight the need for urban planners to incorporate green spaces and effective drainage systems to counter the effects of urbanisation and reduce flood risk in Taman Sri Muda.

vi) Drainage Density

The drainage density map of Taman Sri Muda, shown in Figure 4.6, depicts the spatial distribution of drainage networks within the research area. The map categorises drainage density into five levels, from very low to very high, with red areas indicating the highest drainage density (10.54 –14.94 km/km^2) and green areas representing the lowest drainage density (0.01–1.82 km/km^2). The highest drainage density is observed in the northern and northeastern parts of the region, where a dense network of drainage channels exists. These areas are likely to experience rapid surface runoff during rainfall, increasing the risk of flooding by concentrating water flow in narrow drainage channels. In contrast, the central and southern regions show much lower drainage density, indicating fewer drainage paths and potentially slower runoff.

Both natural and anthropogenic factors primarily influence the variation in drainage density across Taman Sri Muda. In the northern and northeastern parts of the region, the higher drainage density results from a combination of natural topography and extensive infrastructure development. These areas may have been developed with dense drainage systems to manage natural water flow, particularly in low-lying zones prone to water accumulation. By contrast, areas with lower drainage density in the central and southern parts of the research area may be less developed in terms of drainage infrastructure, or their elevated topography may naturally support better water flow and a reduced need for artificial drainage systems. The dense drainage networks in some areas may lead to faster runoff, potentially causing flash flooding. In contrast, low drainage density zones may lead to slower water movement and prolonged flooding.

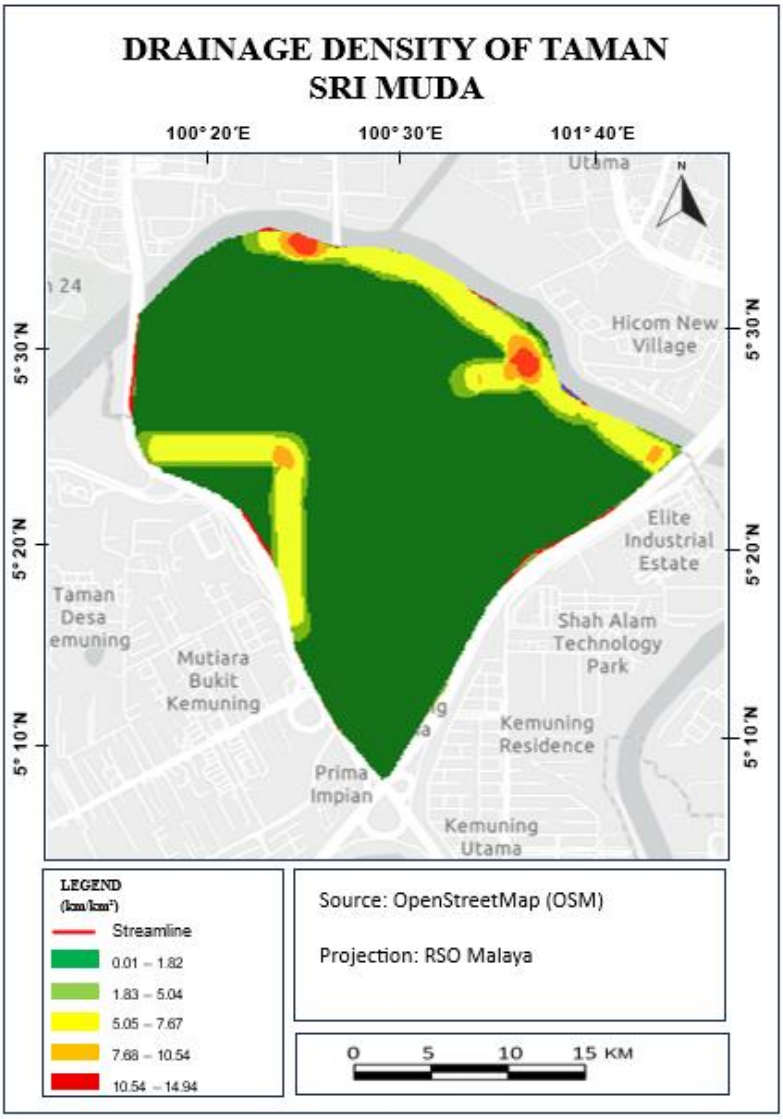


Figure 4.6 Drainage Density of Taman Sri Muda

The drainage density map highlights significant differences in the capacity to manage surface water runoff across Taman Sri Muda. Areas with high drainage density are more prone to rapid runoff, increasing the risk of flash floods. In contrast, regions with low drainage density may experience slower drainage, exacerbating the risk of prolonged flooding. These findings underscore the importance of improving drainage infrastructure in high-density areas to prevent flash floods and enhancing drainage capacity in low-density areas to facilitate quicker runoff. Effective flood management in Taman Sri Muda requires a balanced approach to improving drainage infrastructure in both high- and low-density areas to mitigate flooding impacts.

vii) Distance from Rivers

The distance-to-river map of Taman Sri Muda, shown in Figure 4.7, displays the spatial distribution of areas by their proximity to the nearest river or drainage network. The map categorises distances into five classes, with green areas representing the zones closest to the river (0.01–159.83 metres) and yellow and brown areas indicating zones further from the river (up to 994.08 metres). As indicated in the figure, areas near the river (green and yellow) are at higher risk of flooding due to their proximity to water bodies, increasing the likelihood of river overflow during heavy rainfall events. Zones further from the river are less exposed to direct river-induced flooding but may still be at risk due to other factors, such as poor drainage or heavy rainfall.

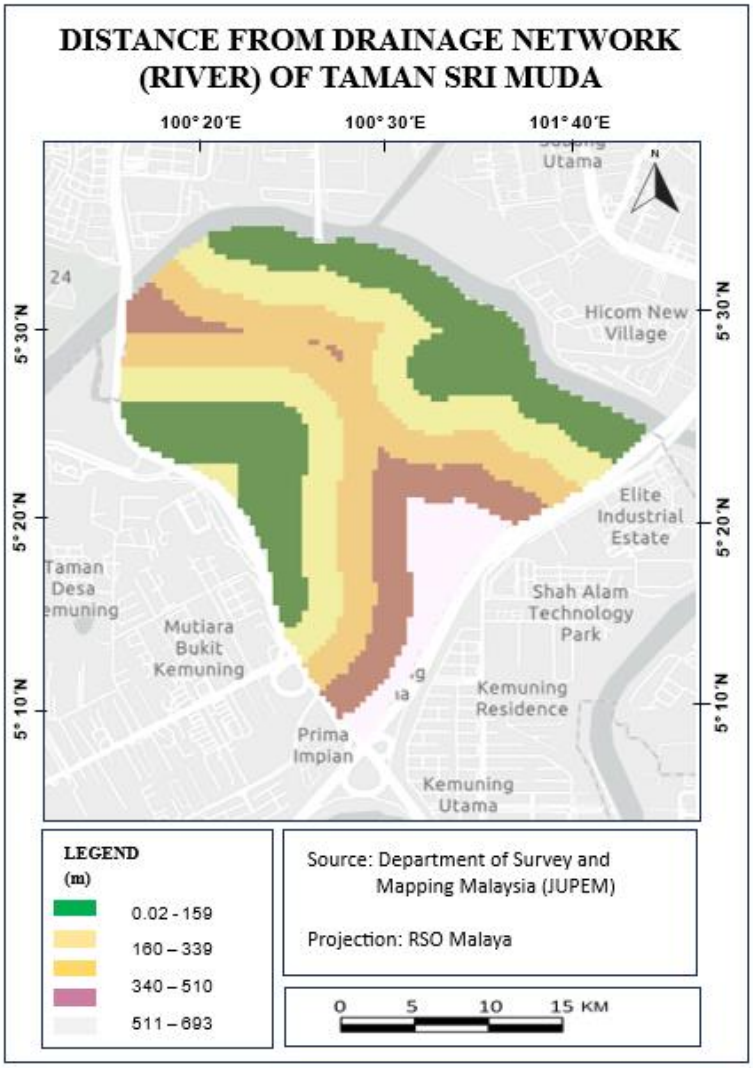


Figure 4.7 Distance to River Map of Taman Sri Muda

The distances to drainage networks and river systems significantly influence flood risk, as areas closer to rivers are more vulnerable to flooding during periods of high discharge. When rainfall increases the river's water volume, overflow can inundate areas adjacent to the riverbanks, especially in low-lying regions. As shown on the map, the zones marked in green and yellow near the river are directly exposed to such flooding risks. In contrast, areas farther from the river, represented by brown shades, are less likely to experience direct flooding from river overflow but may still be affected by other flood-prone factors, such as surface runoff or drainage issues in more distant regions.

The drainage network map shows that areas near rivers in Taman Sri Muda are at heightened risk of flooding due to direct exposure to river overflows. The map underscores the importance of considering proximity to rivers in flood risk assessments, as regions close to rivers require targeted flood mitigation measures to manage riverine flood risks effectively. Areas farther from the river may still be vulnerable to flooding, especially if drainage systems are inadequate or rainfall intensity is high. Effective flood risk management strategies should prioritise both high-risk river-adjacent areas and areas farther from the river that may experience surface runoff.

These factors were processed as raster layers and reclassified according to their influence on flood susceptibility. Each factor was then weighted using AHP, with pairwise comparisons conducted and a Consistency Ratio (CR) calculated to ensure the reliability of the weighting system. The final weights were determined using expert judgement, field observations, and established hydrological principles.

4.3 Flood Susceptibility Map

This section presents the composite Flood Susceptibility Map generated by integrating seven flood-conditioning factors. The map synthesises the spatial influence of terrain characteristics, hydrological proximity, rainfall intensity, land use patterns, and groundwater conditions into a single Flood Susceptibility Index. The resulting classification illustrates the overall spatial distribution of flood vulnerability across Taman Sri Muda.

The FSM categorises the research area into five classes: Very Low, Low, Moderate, High, and Very High susceptibility. The spatial distribution indicates that flood risk is concentrated rather than evenly dispersed. The concentration of high-flood-

susceptibility zones in low-elevation areas indicates that topographical conditions play a dominant role in determining flood exposure within the research area. High and Very High susceptibility zones occupy a significant portion of the northern and central sections, while Moderate zones form transitional areas surrounding these clusters. Low and Very Low susceptibility classes are comparatively limited and are primarily located along selected peripheral zones.

The observed spatial configuration reflects the combined influence of proximity to the river, low elevation, gentle slopes, and extensive urban land cover. Areas where these high-risk characteristics overlap exhibit greater flood susceptibility, highlighting the cumulative effect of multiple environmental conditions in shaping flood vulnerability. The composite map, therefore, provides a spatially integrated representation of flood vulnerability, forming the empirical basis for subsequent economic analysis in the following sections.

4.3.1 Flood Susceptibility Classification

Flood Susceptibility Map of Taman Sri Muda derived from the integration of seven flood-conditioning factors as shown in Figure 4.8. The research area is classified into five susceptibility levels: Very Low (green), Low (light green), Moderate (yellow), High (orange), and Very High (red). The map clearly indicates that flood risk is spatially heterogeneous rather than evenly distributed across the neighbourhood.

Very High and High susceptibility zones dominate a substantial portion of the research area, particularly in the northern, northwestern, and central-western sectors. Extensive red and orange zones visually represent these areas. Moderate susceptibility areas form transitional belts surrounding the high-risk clusters, while Low and Very Low classes appear in smaller, scattered patches mainly along peripheral sections.

The dominance of High and Very High classes suggests that a considerable proportion of Taman Sri Muda is highly vulnerable to flooding. The spatial pattern indicates that flood susceptibility intensifies in zones where multiple conditioning factors converge, including proximity to river systems, low elevation, and dense urban land cover. This composite distribution forms the basis for further spatial concentration analysis in the subsequent section.

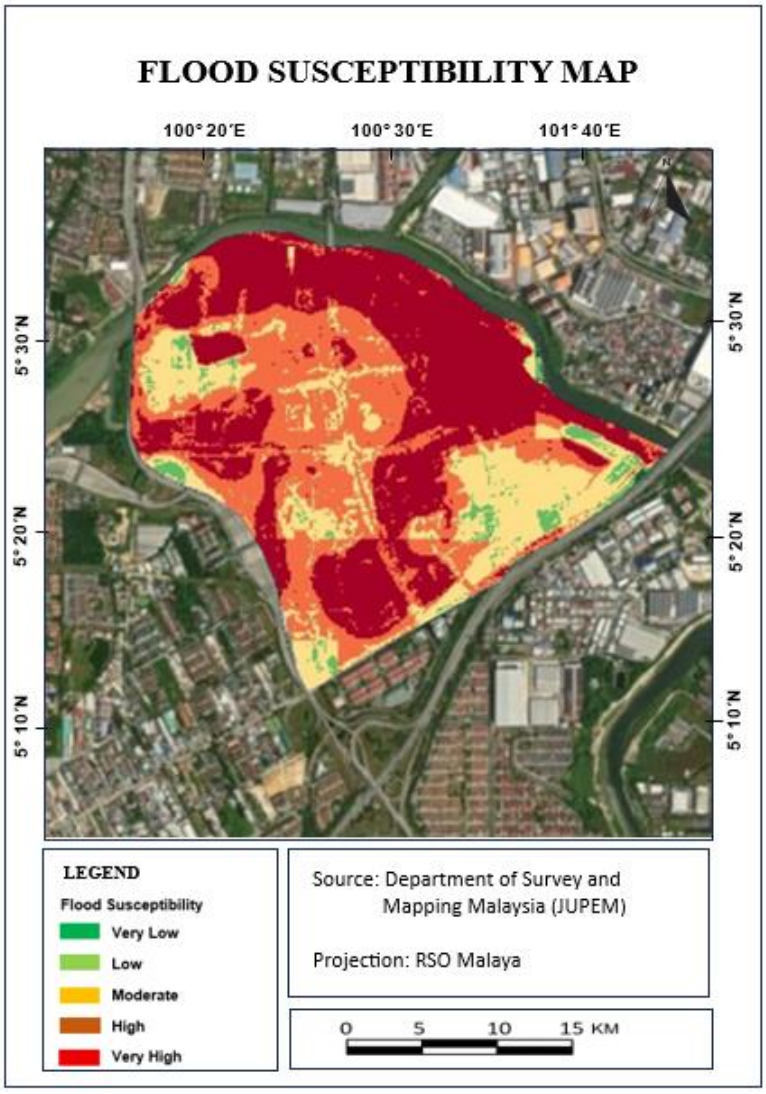


Figure 4.8 Flood Susceptibility Map of Taman Sri Muda

4.3.2 Spatial Concentration of High-Risk Zones

High and Very High susceptibility zones are predominantly concentrated in the northern and central sections of Taman Sri Muda. These areas correspond closely with low-elevation terrain, shallow groundwater zones, and proximity to the main river channel. The clustering of high-risk areas near river-adjacent corridors confirms the strong influence of fluvial processes on flood exposure patterns.

In contrast, peripheral and boundary zones, particularly in the southern sections, are generally classified as Low to Very Low susceptibility categories. These areas exhibit relatively better drainage conditions and slightly higher elevations. The spatial pattern confirms that flood vulnerability is concentrated in central and northern low-lying neighbourhoods, where multiple conditioning factors converge.

4.3.3 Dominant Contributing Factors

The final AHP weights reveal clear differentiation in the relative influence of the seven flood-conditioning factors. The relative influence of each flood-conditioning factor is summarised in Table 4.1. Distance to the river emerged as the most influential factor (19%), underscoring its dominant role in shaping flood exposure in Taman Sri Muda. Areas closer to the river channel consistently exhibit higher susceptibility.

Rainfall (18%) and elevation (17%) follow closely as secondary contributing factors, reflecting the importance of precipitation intensity and low-lying terrain in generating runoff and facilitating water accumulation. Water level (14%) and slope (13%) further highlight the significance of hydrodynamic conditions and flat terrain in prolonging inundation duration. Land Use/Land Cover (11%) reflects the impact of urban impervious surfaces on runoff processes, while drainage density (8%) exhibits the lowest relative contribution among the selected factors.

Collectively, the weighting structure confirms that flood susceptibility within Taman Sri Muda is primarily governed by proximity to rivers, with rainfall intensity and terrain characteristics as supporting factors.

Table 4.1
Final AHP Weights Assigned to Each Flood-Conditioning Factor.

Flood Criteria	Unit	Class	Susceptibility Class Ranges	Susceptibility Ratings (X_i)
Slope	degree	< 1	Very Low	5
		1.1 – 3	Low	4
		3.1 – 5.9	Moderate	3
		6 – 10.9	High	2
		>11	Very High	1
Elevation	m	0-5	Very Low	5
		5.1-10	Low	4
		10.1-15	Moderate	3
		15.1-20	High	2
		20.1-30	Very High	1
Rainfall	mm/year	0-10	Very Low	1
		11-30	Low	2
		31-60	Moderate	3
		61-100	High	4
		>101	Very High	5
		0.02-3.34	Very Low	1
		3.35-3.87	Low	2

Water Level	m	3.88-4.25	Moderate	3
		4.26-4.93	High	4
		>4.94	Very High	5
LULC	Level	Barren Land	Very Low	1
		Forest	Moderate	3
		Development	High	4
		Water Body	Very High	5
Distance to River	m	0.01-159.83	Very Low	5
		159.84-339.16	Low	4
		339.17-510.69	Moderate	3
		510.7-693.91	High	2
		693.92-994.08	Very High	1
Drainage Density	m	0.01-1.82	Very Low	1
		1.83-5.04	Low	2
		5.05-7.67	Moderate	3
		7.68-10.54	High	4
		10.55-14.94	Very High	5

4.4 Interpretation of Flood Risk Patterns

The spatial distribution of flood susceptibility in Taman Sri Muda shows a clear concentration of elevated risk in the northern and central portions of the research area. Rather than being randomly distributed, high- and very-high-susceptibility zones form contiguous clusters, indicating that flood vulnerability is structurally embedded. This pattern reflects the interaction of terrain, hydrological proximity, and urban surface conditions rather than isolated environmental triggers.

A strong relationship is evident between topographic characteristics and flood risk intensity. Areas identified as highly susceptible correspond closely with low-elevation terrain and gentle slope gradients. These conditions reduce the efficiency of gravitational drainage, allowing water to accumulate more readily during periods of intense rainfall or elevated river levels. In contrast, slightly elevated peripheral zones exhibit comparatively lower susceptibility due to improved runoff dispersal capacity. The spatial alignment between low-lying areas and high-risk classes confirms the critical influence of topography in shaping flood exposure.

The observed pattern also highlights the research area's physical vulnerability. Extensive built-up surfaces, combined with limited vegetative cover, further constrain infiltration capacity and amplify runoff accumulation in already low-lying zones. When

high rainfall intensity coincides with elevated river stages, these areas are more likely to experience prolonged inundation. The Flood Susceptibility Map, therefore, reflects not only environmental exposure but also the structural characteristics of urban development that intensify physical vulnerability within Taman Sri Muda.

These findings align with the problem statement presented in Chapter 1, which identified flood risk in Taman Sri Muda as a significant concern, particularly given its geographical location and the growing urban development in flood-prone zones.

The identification of spatial flood risk has important implications beyond hazard assessment, particularly for residential property valuation and investment decision-making. Flood susceptibility influences buyer perceptions, lenders' assessment of collateral risk, insurance considerations, and long-term investment confidence. Properties in areas of elevated flood exposure may experience reduced market demand or require price discounts to offset perceived risk. In contrast, properties in lower-risk locations may maintain stronger market performance. Consequently, integrating flood risk assessment into property valuation provides a more comprehensive understanding of housing market behaviour. It supports evidence-based decision-making by valuers, investors, financial institutions, and urban planners. The Flood Susceptibility Map developed in this research, therefore, serves not only as an environmental assessment tool but also as an important input for evaluating the economic consequences of flood exposure.

4.5 Property Value Analysis

The spatial flood susceptibility results presented in the preceding sections serve as an environmental risk indicator and are subsequently incorporated into the hedonic valuation analysis. By linking these spatial risk patterns to residential property transaction data, the research examines how flood exposure influences housing market prices.

A total of 198 residential property transactions were included in the analysis. These observations represent properties with varying locational settings and environmental conditions across the research area. Examining the dataset's statistical characteristics allows the research to identify the range of housing prices, the level of market variation, and any observable patterns associated with spatial flood exposure.

The analysis is divided into two parts. The first examines the distribution of transaction prices, focusing on minimum, maximum, and average values to understand overall price variation within the neighbourhood. The second part analyses how property prices are distributed across different flood susceptibility zones derived from the GIS-based flood risk assessment. These descriptive comparisons provide preliminary insight into potential relationships between flood exposure and housing prices before the formal regression analysis.

4.5.1 Descriptive Statistics of Property Transactions

Descriptive statistics were used to summarise the key characteristics of the residential property transaction dataset. This analysis provides an overview of the price distribution within the research area and allows preliminary identification of variations associated with property characteristics and environmental conditions.

The dataset comprises 198 residential property transactions recorded within Taman Sri Muda. These transactions represent properties located across different parts of the neighbourhood, providing sufficient variation in price levels for subsequent econometric analysis.

4.5.2 Transaction Price Distribution

The transaction prices range from RM 49,000 to RM 145,000, with an average price of approximately RM 97,000. This spread indicates moderate variability within the residential market of Taman Sri Muda. While most transactions cluster around the mid-range price band, lower-priced properties are found in certain areas, suggesting possible differences in structural size, locational attributes, and environmental exposure.

In addition to price variation, structural characteristics such as land size (mean of approximately 78.036 sq. ft) show relatively limited dispersion, suggesting homogeneity in housing typology. This relative uniformity allows clearer assessment of locational and environmental influences on price differences.

4.5.3 Distribution by Flood Risk Zone

When transaction prices are examined across different flood-susceptibility zones, variation emerges. Properties in higher-flood-risk areas, particularly those closer

to river corridors, tend to have lower transaction values than properties in lower-risk zones.

Although this descriptive comparison does not establish statistical causality, it suggests an initial negative association between flood exposure and property prices. These preliminary observations provide a foundation for the subsequent regression analysis, which formally tests whether flood-related variables significantly influence residential property values.

4.6 Hedonic Pricing Model Results

This section presents the regression results examining the determinants of residential property values in Taman Sri Muda. The analysis evaluates the effects of structural and locational variables on transaction prices, with particular attention to flood-related factors.

4.6.1 Model Performance

The regression model produced a coefficient of determination (R^2) of 0.0213, indicating that approximately 2.13% of the variation in property prices is explained by the included explanatory variables. The Adjusted R^2 of 0.0062 suggests limited explanatory power given the number of predictors.

Despite the relatively low R^2, the model is statistically significant overall. The F-statistic of 10.08 with a p-value of 0.0000 indicates that the independent variables jointly explain variation in residential property prices. This suggests that, while the magnitude of explained variance is modest, the model provides statistically meaningful insights into property price determinants.

Although the coefficient of determination ($R^2 = 0.0213$) is relatively low, this outcome is not unexpected in residential property valuation studies, where transaction prices are influenced by numerous behavioural, structural, financial, and neighbourhood factors beyond the scope of the present model. Variables such as renovation quality, interior condition, accessibility, financing arrangements, and buyer preferences may contribute substantially to price variation but were not included in this analysis. Therefore, the primary objective of the model is not to maximise predictive accuracy but to evaluate whether selected flood-related variables exhibit measurable economic effects on residential property values.

Table 4.2 presents the regression results for the HPM. The coefficients indicate the direction and magnitude of each independent variable's effect on property prices, while statistical significance is assessed through p-values and t-statistics.

Table 4.2
Estimation for the Hedonic Pricing Model

Variable	Coefficients	Standard Error	t Stat	P-value
β_0	-36721173.73	36710143.1765	-1.0003	0.3184
$Land\ Size_i$	472946.73	470464.5354	1.0053	0.3160
$Distance\ to\ Retention\ Pond_i$	-5.53	24.5972	-0.2247	0.8225
$Distance\ to\ River_i$	-13.24	7.2415	-1.8281	0.0691
ANOVA	F Stat	10.08	P-value	0.0000
R^2	0.0213			
Adjusted R^2	0.0062			

4.6.2 Regression Coefficients

i) Structural Variable

Land size exhibits a positive coefficient (β = 472,946.73), indicating that larger land parcels are associated with higher property values. However, the relationship is not statistically significant (p = 0.3160), suggesting that land size does not exert a strong independent influence on price variation in the research area. This may reflect the relative homogeneity of property types in Taman Sri Muda.

ii) Locational Variables

The distance to the retention pond also shows a negative coefficient (β = –5.53), but the relationship is not statistically significant (p = 0.8225). This indicates that proximity to retention ponds does not meaningfully influence property values within the research area.

iii) Environmental Variables

Seven flood-conditioning variables derived from the GIS–AHP framework were incorporated into the regression model: rainfall intensity, river water level, elevation, slope gradient, land use/land cover (LULC), drainage density, and distance to river. Each variable represents a distinct spatial dimension of flood vulnerability at the

property level.

Among the seven environmental variables tested, only distance to the river was statistically significant. The coefficient for distance to river (β = –13.24) was negative and marginally significant at the 10% level (p = 0.0691), indicating that properties located closer to the river tend to exhibit lower transaction values. The negative coefficient for distance to the river suggests that properties located closer to river channels tend to command lower transaction prices, reflecting buyers' perception of increased flood exposure. Although the relationship is only marginally significant at the 10% level, it provides empirical evidence that observable environmental risk is partially capitalised into residential property values. The result implies that proximity to rivers serves as a visible indicator of flood vulnerability, influencing market behaviour more directly than less observable hydrological variables.

The remaining flood-conditioning variables, rainfall intensity, water level, elevation, slope, land use, and drainage density did not show statistical significance in the regression model. This indicates that while these factors contribute to physical flood susceptibility, they may not be directly perceived or economically internalised by market participants when forming property prices.

The absence of statistical significance for land size and distance to the retention pond suggests that these variables do not independently explain substantial variation in residential property prices within Taman Sri Muda. The relatively homogeneous housing typology across the research area may reduce structural variation associated with land size. At the same time, the presence of retention ponds may not be sufficiently recognised by buyers as an indicator of flood protection or neighbourhood value. Consequently, these factors appear to have limited influence on market price formation compared with more directly observable environmental characteristics.

Table 4.3
Summarises the Regression Coefficients for the Key Explanatory Variables in the Hedonic Pricing Model (HPM)

Variable	Coefficient (β)	p-value	Interpretation
Land Size	472,946.73	0.3160	Not significant
Distance to Pond	–5.53	0.8225	Not significant
Distance to River	–13.24	0.0691	Significant at 10% level

Table 4.3 presents the estimated coefficients for the key explanatory variables included in the hedonic pricing model. Land size exhibits a positive coefficient, indicating that larger land parcels are associated with higher property values; however, the relationship is not statistically significant. Similarly, distance to the retention pond shows a negative but statistically insignificant effect on price variation.

In contrast, distance to the river demonstrates a negative coefficient and is marginally significant at the 10% level. This suggests that properties located closer to the river tend to command slightly lower transaction values. The result indicates that river proximity, which represents observable flood exposure, has a modest influence on residential property prices within the research area.

4.7 Economic Interpretation of Regression

The regression results indicate that flood-related variables negatively affect residential property values. In particular, the statistically significant relationship between distance to the river and property price suggests that environmental risk is partially capitalised into housing market values after controlling for other property attributes. This finding supports the proposition of Hedonic Pricing Theory that environmental disamenities may reduce buyers' willingness to pay and, in turn, influence residential property values.

From a spatial perspective, integrating flood susceptibility modelling with property transaction data further reveals that areas with higher environmental vulnerability tend to have lower market valuations. However, the low coefficient of determination ($R^2 = 0.0213$) indicates that only a small proportion of price variation is explained by the variables included in the model. This spatial correspondence between environmental risk exposure and property value depreciation reinforces the importance of incorporating flood risk indicators into property valuation frameworks.

Residential property prices are influenced by numerous structural, financial, behavioural, and macroeconomic factors that were not incorporated into the model, such as renovation quality, interior condition, buyer sentiment, financing conditions, and broader market cycles. The relatively homogeneous housing type in Taman Sri Muda (predominantly double-storey terrace houses) may also reduce observable variation in structural characteristics, thereby limiting explanatory power.

Furthermore, these findings are consistent with previous international studies demonstrating the capitalisation of environmental risk in housing prices. However, the present research contributes additional empirical evidence by demonstrating how spatially continuous flood susceptibility indicators, derived through GIS and AHP modelling, can be systematically incorporated into econometric property valuation analysis.

4.8 GIS Integration

Following the development of the Flood Susceptibility Map in Section 4.3.1, the next step is to integrate it with property value data from the Hedonic Pricing Model (HPM) regression results. The integration of flood susceptibility modelling and hedonic pricing estimation constitutes the final analytical stage of the research framework, generating a combined Flood Risk–Value Indicator Map. This map merges flood susceptibility zones with property transaction data, providing a clear visual representation of how flood risk correlates with property values across Taman Sri Muda. GIS identifies the spatial distribution of flood risk, while the Hedonic Pricing Model (HPM) quantifies its influence on residential property values. The integration of these approaches provides a spatially informed valuation framework that links environmental risk assessment with property market analysis.

The integration of Geographic Information Systems (GIS) and the Analytical Hierarchy Process (AHP) provide a systematic framework for evaluating flood susceptibility by combining spatial analysis with structured multi-criteria decision-making. GIS enables the processing, visualisation, and spatial representation of environmental variables, while AHP objectively quantifies the relative importance of each flood-conditioning factor through pairwise comparison and consistency assessment. The combined approach enhances analytical reliability by reducing subjective bias in weighting decisions and producing a spatially explicit flood susceptibility surface that can be integrated with property valuation analysis. This interdisciplinary framework strengthens the robustness of the research by linking environmental hazard assessment with economic evaluation within a unified analytical platform.

4.8.1 Flood Risk–Value Spatial Overlay

This section presents the empirical results of integrating flood susceptibility with residential property transaction data. The spatial overlay enables examination of how environmental vulnerability corresponds with observed market prices across Taman Sri Muda.

4.8.1.1 Spatial Correlation Pattern

The spatial overlay reveals a general inverse relationship between flood risk and property value. High and Very High flood susceptibility zones, primarily located in the northern and river-adjacent sections, tend to correspond with comparatively lower transaction prices. This indicates that areas exposed to greater flood vulnerability are associated with reduced market performance.

However, the correlation is not uniformly consistent across all locations. Certain moderate-risk areas display relatively stable property values, suggesting that additional locational advantages or neighbourhood characteristics may offset perceived flood exposure. These exceptions demonstrate that flood risk influences property values in a spatially differentiated manner rather than uniformly depreciating all high-risk zones.

Overall, the overlay results suggest a moderate but observable spatial alignment between environmental exposure and economic outcome.

4.8.1.2 Identification of Flood-Exposed Property Concentrations

Spatial concentrations further clarify the spatial–economic relationship. The most affected property concentrations are located in the northern and central low-lying zones near the river system. These areas exhibit both high flood susceptibility classifications and comparatively lower transaction prices, indicating convergence between physical exposure and economic vulnerability.

In contrast, more resilient spatial groupings are observed in the southern and peripheral areas of Taman Sri Muda. These locations display lower flood susceptibility levels and relatively stronger price performance. The separation between vulnerable and resilient zones highlights the uneven distribution of flood risk and its associated economic sensitivity within the neighbourhood.

These findings demonstrate that flood exposure is geographically concentrated and that its economic imprint is most visible in river-adjacent areas.

4.9 Flood Risk–Value Indicator Map

Figure 4.9 presents the Flood Risk–Value Indicator Map, which spatially overlays residential transaction prices onto the classified flood-susceptibility surface for Taman Sri Muda. The map illustrates the spatial relationship between flood exposure levels and observed housing prices across the research area.

A clear spatial pattern is evident in the northern and north-western sections, where clusters of properties fall within High and Very High flood susceptibility zones (darker-shaded areas). Within these zones, a noticeable concentration of lower-priced transactions (RM 49,000–105,000 and RM 105,001–145,000) is evident. This spatial configuration reflects a “High Risk – Low Value” pattern, in which greater flood exposure corresponds to comparatively lower property values.

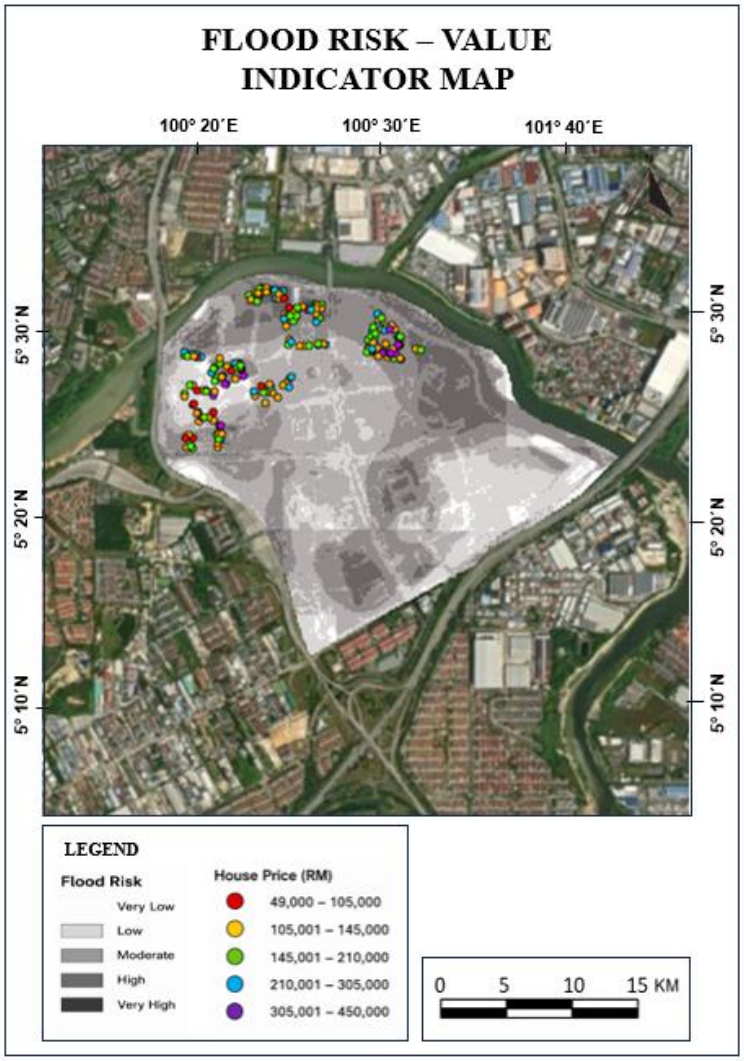


Figure 4.9 Flood Risk–Value Indicator Map

In contrast, properties located in lighter-shaded zones representing Low and Very Low flood susceptibility generally exhibit relatively higher transaction prices. Several medium- to higher-value units (RM 210,001–305,000 and RM 305,001–450,000) are distributed within these lower-risk areas. This indicates a "Low Risk – Higher Value" pattern, suggesting that reduced environmental vulnerability contributes positively to market performance.

Table 4.4 summarises the relationship between flood susceptibility levels and residential property value ranges identified from the Flood Risk–Value Indicator Map (Figure 4.9). The colours correspond to the flood risk classification and property price categories presented in the map legend.

Table 4.4
Summary of Flood Risk–Property Value Relationship in Taman Sri Muda

Flood Risk Level	Risk Colour (Map)	Property Price Range (RM)	Price Colour	Observed Pattern	Interpretation
Very High	Dark Grey	49,000 – 105,000	Red	High Risk – Low Value	High flood exposure associated with lower property values
High	Grey	105,001 – 145,000	Yellow	High Risk – Lower Value	Flood risk contributes to price depreciation
Moderate	Light Grey	145,001 – 210,000	Green	Mixed Pattern	Property prices influenced by both flood risk and neighbourhood factors
Low	Very Light Grey	210,001 – 305,000	Blue	Lower Risk – Higher Value	Reduced environmental risk supports stronger market values
Very Low	White / Lightest	305,001 – 450,000	Purple	Low Risk – Higher Value	Lowest flood exposure associated with higher property values

Nevertheless, the relationship is not perfectly uniform. Some moderate-risk zones still contain mid-range property values, indicating that other locational and neighbourhood characteristics influence pricing alongside flood exposure. The spatial pattern, therefore, suggests that while flood risk contributes to observable differences in property values, it is not the sole determinant of housing market outcomes. The Flood Risk–Value Indicator Map, therefore, provides a spatial representation of how environmental flood risk corresponds to residential property valuation patterns across the research area.

The results presented in this chapter provide empirical evidence of the spatial and economic relationships between flood susceptibility and residential property valuation within the research area. Through the integration of GIS-based flood susceptibility modelling and econometric property valuation analysis, the findings highlight how exposure to environmental risk can influence housing market dynamics in flood-prone urban environments. While this chapter has focused on presenting and interpreting the analytical results, the following chapter synthesises these findings in relation to the research objectives established in Chapter 1. It discusses their broader implications for urban planning, property valuation practices, and flood risk management strategies.

4.10 Summary

This chapter has presented the empirical results of the integrated GIS–AHP–HPM framework applied to Taman Sri Muda. The findings collectively demonstrate a coherent relationship between physical flood vulnerability, economic valuation, and spatial distribution patterns.

From a physical perspective, flood susceptibility is not uniformly distributed across the research area. High-risk zones are concentrated predominantly in low-lying, river-adjacent areas, particularly in the northern and central portions of Taman Sri Muda. Elevation, river distances, and hydrological conditions collectively contribute to this spatial concentration of vulnerability, confirming that topography remains a primary determinant of flood exposure.

From an economic perspective, the regression analysis indicates that flood-related variables exert a measurable influence on residential property values. Although the model's explanatory power is modest, proximity to the river shows a marginally significant negative effect on price. This suggests that observable flood exposure contributes to market discounting, reflecting the economic internalisation of environmental risk.

Spatially, the integration of flood susceptibility mapping and transaction data reveals a clear geographic alignment between high-risk zones and lower-value properties. The Flood Risk–Value Indicator Map confirms the presence of identifiable "High Risk – Low Value" and "Low Risk – Higher Value" patterns within the neighbourhood. These results demonstrate that environmental vulnerability leaves a discernible spatial imprint on housing market outcomes.

The findings presented in this chapter demonstrate how spatial flood susceptibility influences residential property values within the research area. These empirical results provide important insights into the economic implications of environmental risk in urban housing markets. The following chapter synthesises these findings in relation to the research objectives and discusses their broader implications for property valuation and urban flood risk management.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The empirical findings presented in Chapter 4 demonstrate how spatial flood susceptibility interacts with residential property valuation patterns within the research area. Building upon these analytical results, this chapter provides a comprehensive synthesis of the research findings in relation to the objectives established in Chapter 1. The chapter further discusses the broader implications of integrating geospatial flood risk modelling with property valuation analysis, identifies the research's limitations, and outlines directions for future research.

This chapter summarises the key findings of the research. It evaluates their implications for flood risk–informed property valuation by integrating the theoretical foundations, methodological framework, and empirical findings discussed in the preceding chapters. Chapter 1 introduced the research problem by highlighting the growing need to understand how environmental hazards, particularly flooding, influence residential property values in rapidly urbanising regions. The chapter also established the research objectives and outlined the analytical approach.

Subsequently, Chapter 2 reviewed the existing literature on flood risk assessment, geospatial technologies, and environmental property valuation. The literature review identified a key research gap in the limited integration between spatial flood-susceptibility modelling and econometric property valuation frameworks. Addressing this gap required developing an analytical framework that links environmental risk indicators to housing market behaviour.

Chapter 3, therefore, developed a methodological framework that integrates Geographic Information Systems (GIS), the Analytical Hierarchy Process (AHP), and the Hedonic Pricing Model (HPM). This framework enabled the systematic examination of how spatial flood susceptibility interacts with residential property valuation patterns. The empirical findings presented in Chapter 4 subsequently demonstrated the spatial and economic relationships between flood-risk exposure and housing market behaviour within the Taman Sri Muda research area.

Building on these findings, this chapter summarises the key conclusions of the research and discusses their implications for urban planning, property valuation practice, and flood risk management.

5.2 Objective Achievement

This research was guided by three objectives, formulated in Chapter 1, to examine the relationship between flood susceptibility and residential property values in a flood-prone urban environment.

The first objective was to identify key environmental and spatial factors contributing to flood susceptibility using GIS and Remote Sensing techniques. Through the integration of multiple environmental datasets and the Analytical Hierarchy Process (AHP), the research successfully developed a Flood Susceptibility Model incorporating seven flood-conditioning factors: rainfall intensity, river water level, elevation, slope gradient, land use and land cover (LULC), drainage density, and distance to river. The resulting Flood Susceptibility Map provides a spatial representation of flood vulnerability across Taman Sri Muda and identifies areas with varying levels of exposure to flooding.

The second objective was to estimate the influence of flood-risk exposure on residential property values using the Hedonic Pricing Model (HPM). Incorporating flood-related variables from the GIS analysis into the econometric framework indicates that environmental risk exposure has a measurable influence on housing market behaviour. Among the variables examined, distance to river was the only flood-related variable that demonstrated statistical significance ($\beta = -13.24$, $p = 0.0691$), indicating that properties located closer to river channels tend to exhibit lower transaction values. Although the model exhibited relatively low explanatory power ($R^2 = 0.0213$), the findings provide empirical evidence that observable flood-related characteristics are partially capitalised in residential property values within the study area.

The third objective was to develop an integrated GIS–AHP–HPM framework for producing a Flood Risk–Value Indicator (FRVI) Map. This objective was successfully achieved by integrating flood susceptibility modelling outputs and hedonic pricing results in a GIS environment. The resulting FRVI Map provides a spatially explicit representation of the relationship between flood vulnerability and residential

property values, enabling the identification of areas characterised by high flood risk and relatively lower property values.

Collectively, the results demonstrate that the integrated GIS–AHP–HPM framework developed in this research successfully achieved the research objectives and provides a systematic approach for assessing the economic implications of flood risk within urban residential property markets.

5.3 Conclusion of the Research

The findings demonstrate that flood risk has a measurable impact on residential property values in flood-prone urban areas. The spatial modelling results indicate that flood susceptibility within Taman Sri Muda is shaped by the interaction of multiple environmental and topographic conditions, including terrain characteristics, hydrological proximity, and urban land development patterns.

From a housing market perspective, the econometric analysis indicates that environmental risk exposure is internalised within residential property markets through market behaviour and risk perception. Flood susceptibility, therefore, functions as an environmental disamenity that influences buyer decision-making and contributes to observable variations in property values.

These findings are consistent with the theoretical perspectives discussed in Chapter 2, particularly the principles of hedonic pricing theory, which suggest that environmental attributes and disamenities are capitalised into housing prices through market mechanisms. By integrating spatial flood risk modelling with econometric valuation analysis, the research demonstrates how environmental risk indicators can be translated into measurable economic outcomes within residential property markets.

More importantly, the integrated GIS–AHP–HPM framework developed in this research makes a methodological contribution by linking spatial flood-susceptibility modelling to property-valuation analysis within a unified analytical framework. This integration offers a more comprehensive approach for understanding how environmental hazards influence housing market dynamics in flood-prone urban areas.

5.4 Research Contributions

This research contributes to the existing body of knowledge through theoretical, conceptual, knowledge-based, and methodological advancements in flood risk

assessment and property valuation.

5.4.1 Theoretical Contribution

Theoretically, this research extends the application of Hedonic Pricing Theory to flood-prone urban environments. The findings provide empirical support for the proposition that environmental hazards function as negative externalities, partially capitalised into residential property values. The research demonstrates that flood-related characteristics, particularly proximity to river systems, influence housing market behaviour through risk perception and willingness to pay. This contributes to the growing literature on environmental risk valuation by providing evidence from a Malaysian urban context.

This study contributes theoretically by supporting the proposition that flood risk is capitalised into residential property values through risk-adjusted market behaviour. The findings demonstrate that environmental risk factors influence buyer perceptions and willingness to pay, thereby affecting residential property values in flood-prone urban areas.

5.4.2 Knowledge and Conceptual Contribution

From a knowledge perspective, the research contributes new empirical evidence regarding the relationship between flood susceptibility and residential property values in Taman Sri Muda, Shah Alam. While previous studies have commonly examined flood risk assessment and property valuation separately, this research demonstrates how spatial flood vulnerability and housing market behaviour can be analysed within a unified framework.

Conceptually, the research introduces the Flood Risk–Value Indicator (FRVI) framework, which integrates flood susceptibility information with residential property valuation outcomes. The FRVI provides a spatially explicit conceptual approach for interpreting the interaction between environmental vulnerability and housing market performance.

5.4.3 Methodological Contribution

Methodologically, the research develops an integrated GIS–AHP–HPM framework that combines spatial flood susceptibility modelling with econometric

property valuation analysis. Geographic Information Systems (GIS) were utilised to process and visualise flood-conditioning variables, while the Analytical Hierarchy Process (AHP) was used to weight environmental factors based on expert judgement systematically. The resulting flood susceptibility outputs were subsequently incorporated into the Hedonic Pricing Model (HPM) to evaluate their influence on residential property values.

This integrated approach addresses a methodological gap identified in the literature by linking environmental risk assessment and property valuation within a single analytical framework. The reliability of the methodology was supported by a Consistency Ratio (CR) value of 0.019 for the AHP model and statistically significant regression diagnostics for the HPM model.

5.5 Limitations of the Research

Several limitations should be considered when interpreting the findings. Firstly, the research focuses on a specific geographical area, which may limit the generalisability of the findings, Taman Sri Muda in Shah Alam. Although this location provides a relevant context for analysing flood-related property valuation dynamics, the findings may not fully represent conditions in other flood-prone urban regions.

Secondly, the flood susceptibility model developed in this research is based primarily on environmental and spatial datasets available for the research area. While these variables provide a meaningful representation of flood vulnerability, incorporating additional hydrological parameters such as flood depth, flood duration, and drainage system capacity could further improve the precision of flood risk modelling.

Thirdly, the hedonic pricing analysis relies on available property transaction data within the research area. Limitations in data availability, particularly regarding detailed structural characteristics and long-term transaction records, may influence the precision of econometric estimation.

Furthermore, the Hedonic Pricing Model yielded a relatively low coefficient of determination ($R^2 = 0.0213$), indicating that a substantial proportion of the variation in residential property values is attributable to factors not included in the model. Variables such as access to amenities, neighbourhood characteristics, financing conditions, market sentiment, and buyer preferences may also significantly influence housing

market behaviour. Consequently, the findings should be interpreted as evidence of the marginal influence of flood-related variables rather than a complete explanation of residential property value formation.

Recognising these limitations provides important context for interpreting the research findings and highlights opportunities for methodological refinement in future studies.

5.6 Recommendation for Future Research

Future research could apply the integrated GIS–AHP–HPM framework developed in this research to other flood-prone urban areas. Comparative studies across different geographical regions would provide broader insights into how flood susceptibility influences residential property markets under varying environmental, socio-economic, and urban development conditions. Such comparative analyses would also enhance the generalisability of the findings beyond the context of Taman Sri Muda.

Another potential direction is the application of advanced Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) techniques in flood susceptibility and flood prediction modelling. Techniques such as Random Forest (RF), Support Vector Machine (SVM), Artificial Neural Networks (ANN), and Convolutional Neural Networks (CNN) models may improve predictive accuracy by capturing complex nonlinear relationships among hydrological, meteorological, and environmental variables. Integrating these approaches with geospatial datasets could contribute to more robust and dynamic flood-risk assessment frameworks.

Future studies may also explore the temporal dynamics of flood-induced changes in residential property values by analysing housing market responses before and after major flood events. Longitudinal analyses would provide a deeper understanding of how risk perception, market confidence, and property values evolve following flood occurrences.

In addition, future research could incorporate spatial econometric techniques, such as Spatial Lag Models (SLM) and Geographically Weighted Regression (GWR), to account for spatial dependence and spatial heterogeneity in residential property values. These approaches may provide a more accurate estimation of flood-risk effects by recognising that property values are influenced not only by individual property characteristics but also by neighbouring properties and surrounding spatial conditions.

Finally, future research could incorporate additional socio-economic indicators, including household income levels, insurance coverage, educational background, and community resilience measures, to further examine how environmental risks interact with broader socio-economic dynamics within urban housing markets. The inclusion of these variables may provide a more comprehensive understanding of the economic and social consequences of flood vulnerability.

Future studies may integrate machine learning techniques, climate change projections, and spatial econometric models to improve predictive capability. Advanced approaches such as Random Forest, Support Vector Machine, Artificial Neural Networks, Geographically Weighted Regression, and Spatial Lag Models may enhance the accuracy of flood susceptibility assessment and provide deeper insights into the spatial and temporal dynamics of changes in flood-related property values.

5.7 Summary

In conclusion, this research contributes to the existing literature by demonstrating how spatial flood susceptibility modelling can be integrated with econometric valuation methods to quantify environmental risk within urban property markets. By integrating GIS-based flood susceptibility modelling with the Analytical Hierarchy Process and the Hedonic Pricing Model, the research provides a comprehensive analytical framework that translates spatial environmental risk indicators into measurable outcomes in the property market. The findings highlight how environmental vulnerability shapes housing market behaviour through risk perception and price adjustments, particularly within flood-prone urban environments. As climate variability and rapid urbanisation intensify flood risks in many metropolitan regions, the adoption of spatially informed valuation approaches is increasingly important for supporting resilient urban planning and risk-sensitive property market decision-making.

Furthermore, the research contributes to SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) by supporting flood-risk-informed planning, resilient housing markets, and sustainable urban development.

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APPENDICES

APPENDIX A

Bil	Daerah	Luas (mp)	Jenis Bangunan	Bil. Tingkat	Alamat	Kawasan	Balasan (Rm)
1	Klang	78.036	Rumah Teres Tengah	2	52, Jalan Jasa 25/27 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
2	Klang	78.036	Rumah Teres Tengah	2	52, Jalan Jasa 25/27 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
3	Klang	78.036	Rumah Teres Tengah	2	39, Jalan Waja Satu 25/13a , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
4	Klang	78.036	Rumah Teres Tengah	2	27, Jalan Bakti Satu 25/15a, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	105,000
5	Klang	78.036	Rumah Teres Tengah	2	90, Jalan Bakti 25/15, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	133,000
6	Klang	78.036	Rumah Teres Tengah	2	52, Jalan Mahir 25/44 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
7	Klang	78.036	Rumah Teres Tengah	2	15, Jalan Harapan 25/29, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	130,000
8	Klang	78.036	Rumah Teres Tengah	2	2, Jalan Waja Satu 25/13a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	180,000
9	Klang	78.036	Rumah Teres Tengah	2	31, Jalan Mahir Satu 25/44a , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	148,000

10	Klang	78.036	Rumah Teres Tengah	2	26, Jalan Wangi 25/19, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
11	Klang	78.036	Rumah Teres Tengah	2	37, Jalan Mahir Dua 25/44b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	155,000
12	Klang	78.036	Rumah Teres Tengah	2	11, Jalan Harum 25/49 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	118,000
13	Klang	78.036	Rumah Teres Tengah	2	11, JALAN BAHAGIA 25/17, TMN SRI MUDA, SEK. 25 SHAH ALAM, SELANGOR, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	180,000
14	Klang	78.036	Rumah Teres Tengah	2	90, Jalan Impian 25/33, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	160,000
15	Klang	78.036	Rumah Teres Tengah	2	18, Jalan Jasa Satu 25/27a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	130,000
16	Klang	78.036	Rumah Teres Tengah	2	22, Jln Jasa Dua 25/27b , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
17	Klang	78.036	Rumah Teres Tengah	2	21, Jln Mahir Satu 25/44a , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	156,000
18	Klang	78.036	Rumah Teres Tengah	2	69, Jalan Cermat 25/36 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	160,000
19	Klang	78.036	Rumah Teres Tengah	2	26, Jalan Nyaman 25/20, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
20	Klang	78.036	Rumah Teres	2	33, Jalan Srikandi 25/14, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	130,000

			Tengah			25 Shah Alam	
21	Klang	78.036	Rumah Teres Tengah	2	16, Jalan Perkasa Satu 25/16a , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	115,000
22	Klang	78.036	Rumah Teres Tengah	2	76, Jalan Impian 25/33 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	170,000
23	Klang	78.036	Rumah Teres Tengah	2	79, Jalan Mahir 25/44, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	220,000
24	Klang	78.036	Rumah Teres Tengah	2	25, Jalan Harum 25/49, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	170,000
25	Klang	78.036	Rumah Teres Tengah	2	24, Jalan Jasa Dua 25/27b , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	185,000
26	Klang	78.036	Rumah Teres Tengah	2	9, Jalan Jujur Dua 25/30b , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	185,000
27	Klang	78.036	Rumah Teres Tengah	2	5, Jalan Harapan 25/29, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	138,600
28	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Wangi 25/19 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	165,000
29	Klang	78.036	Rumah Teres Tengah	2	27, Jalan Harapan 25/29 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
30	Klang	78.036	Rumah Teres Tengah	2	56, Jalan Tekun 25/43 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	170,000

31	Klang	78.036	Rumah Teres Tengah	2	20, Jalan Cekal 25/34 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	280,000
32	Klang	78.036	Rumah Teres Tengah	2	20, Jalan Jasa Dua 25/27b, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	250,000
33	Klang	78.036	Rumah Teres Tengah	2	53, Jalan Geliga 25/12, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	300,000
34	Klang	78.036	Rumah Teres Tengah	2	69, Jalan Harapan 25/29, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000
35	Klang	78.036	Rumah Teres Tengah	2	8, Jalan Wangi 25/19 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	250,000
36	Klang	78.036	Rumah Teres Tengah	2	71, Jln Mahir Dua 25/44b , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	380,000
37	Klang	78.036	Rumah Teres Tengah	2	57, Jalan Wangi 25/19 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	300,000
38	Klang	78.036	Rumah Teres Tengah	2	19,Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	400,000
39	Klang	78.036	Rumah Teres Tengah	2	5, Jalan Perkasa Satu 25/16a , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000
40	Klang	78.036	Rumah Teres Tengah	2	14, Jln Jasa Dua 25/27b, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	88,000
41	Klang	78.036	Rumah Teres	2	56, Jalan Mahir Satu 25/44a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	88,000

			Tengah			25 Shah Alam	
42	Klang	78.036	Rumah Teres Tengah	2	87, Jalan Tertib 25/32 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
43	Klang	78.036	Rumah Teres Tengah	2	16, Jalan Bakti Satu 25/15a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
44	Klang	78.036	Rumah Teres Tengah	2	42, Jalan Teladan 25/22 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
45	Klang	78.036	Rumah Teres Tengah	2	148, Jalan Tokoh 25/28, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	165,000
46	Klang	78.036	Rumah Teres Tengah	2	24, Jalan Cekal 25/34, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	130,000
47	Klang	78.036	Rumah Teres Tengah	2	45, Jalan Cermat 25/36, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	160,000
48	Klang	78.036	Rumah Teres Tengah	2	30, Jalan Tokoh Dua 25/28b , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	188,000
49	Klang	78.036	Rumah Teres Tengah	2	31, Jalan Tokoh Dua 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	300,000
50	Klang	78.036	Rumah Teres Tengah	2	32, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	320,000
51	Klang	78.036	Rumah Teres Tengah	2	39, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	250,000

52	Klang	78.036	Rumah Teres Tengah	2	37, Jalan Mahir 25/44, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	80,000
53	Klang	78.036	Rumah Teres Tengah	2	79, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	127,500
54	Klang	78.036	Rumah Teres Tengah	2	20, Jalan Jasa 25/27 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
55	Klang	78.036	Rumah Teres Tengah	2	19, Jalan Geliga 25/12, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	130,000
56	Klang	78.036	Rumah Teres Tengah	2	12, Jalan Jasa Empat 25/27d, Seksyen 25 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
57	Klang	78.036	Rumah Teres Tengah	2	27, Jalan Budi Satu 25/21a , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
58	Klang	78.036	Rumah Teres Tengah	2	134, Jalan Tokoh 25/28, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	98,000
59	Klang	78.036	Rumah Teres Tengah	2	26, Jalan Mahir Satu 25/44a, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	130,000
60	Klang	78.036	Rumah Teres Tengah	2	14, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	123,000
61	Klang	78.036	Rumah Teres Tengah	2	51, Jalan Harapan 25/29, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
62	Klang	78.036	Rumah Teres	2	73, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	167,000

			Tengah			25 Shah Alam	
63	Klang	78.036	Rumah Teres Tengah	2	24, Jalan Mahir Dua 25/43b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	49,000
64	Klang	78.036	Rumah Teres Tengah	2	26, Jalan Tekun 25/43, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
65	Klang	78.036	Rumah Teres Tengah	2	13, Jalan Khidmat Dua 25/35b , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	230,000
66	Klang	78.036	Rumah Teres Tengah	2	27, Jalan Srikandi 25/14, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	180,000
67	Klang	78.036	Rumah Teres Tengah	2	15, Jalan Teladan Satu 25/22a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	165,000
68	Klang	78.036	Rumah Teres Tengah	2	43, Jalan Tokoh Dua 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	260,000
69	Klang	78.036	Rumah Teres Tengah	2	13, Jalan Budi Satu 25/21a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	205,000
70	Klang	78.036	Rumah Teres Tengah	2	58, Jalan Tekun 25/43, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	178,000
71	Klang	78.036	Rumah Teres Tengah	2	65, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	260,000
72	Klang	78.036	Rumah Teres Tengah	2	58, Jalan Impian 25/33, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	315,000

73	Klang	78.036	Rumah Teres Tengah	2	44, Jalan Tabah 25/24, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	300,000
74	Klang	78.036	Rumah Teres Tengah	2	33, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	290,000
75	Klang	78.036	Rumah Teres Tengah	2	13, Jalan Waja Dua 25/13b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	400,000
76	Klang	78.036	Rumah Teres Tengah	2	56, Jalan Cekap 25/45 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	230,000
77	Klang	78.036	Rumah Teres Tengah	2	42, Jalan Bahagia 25/17, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	400,000
78	Klang	78.036	Rumah Teres Tengah	2	11, Jalan Mahir 25/44, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	115,000
79	Klang	78.036	Rumah Teres Tengah	2	63, Jalan Harapan 25/29 , Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	122,000
80	Klang	78.036	Rumah Teres Tengah	2	33, Jalan Bahagia 25/17, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
81	Klang	78.036	Rumah Teres Tengah	2	9, Jalan Jasa Dua 25/27b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	75,000
82	Klang	78.036	Rumah Teres Tengah	2	35, Jalan Cermat 25/36, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
83	Klang	78.036	Rumah Teres	2	38, Jalan Impian 25/33 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	130,000

			Tengah			25 Shah Alam	
84	Klang	78.036	Rumah Teres Tengah	2	19, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
85	Klang	78.036	Rumah Teres Tengah	2	49, Jalan Harapan 25/29, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	135,000
86	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Jasa Dua 25/27b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	165,000
87	Klang	78.036	Rumah Teres Tengah	2	30, Jalan Tabah 25/24, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	118,000
88	Klang	78.036	Rumah Teres Tengah	2	57, Jalan Mahir Dua 25/44b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
89	Klang	78.036	Rumah Teres Tengah	2	72, Jalan Impian 25/33, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	155,000
90	Klang	78.036	Rumah Teres Tengah	2	67, Jalan Cermat 25/36, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	210,000
91	Klang	78.036	Rumah Teres Tengah	2	42, Jalan Tekun 25/43, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
92	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Teladan 25/22a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	210,000
93	Klang	78.036	Rumah Teres Tengah	2	26, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	290,000

94	Klang	78.036	Rumah Teres Tengah	2	18, Jalan Tekun 25/43, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	263,000
95	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Waja Satu 25/13a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	250,000
96	Klang	78.036	Rumah Teres Tengah	2	48, Jalan Tokoh Dua 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
97	Klang	78.036	Rumah Teres Tengah	2	45, Jalan Mahir 25/44, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	135,000
98	Klang	78.036	Rumah Teres Tengah	2	9, Jalan Budi Satu 25/21a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
99	Klang	78.036	Rumah Teres Tengah	2	53, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
100	Klang	78.036	Rumah Teres Tengah	2	20, Jalan Tekun 25/43, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	90,000
101	Klang	78.036	Rumah Teres Tengah	2	139, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	132,000
102	Klang	78.036	Rumah Teres Tengah	2	15, Jalan Bahagia 25/17, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
103	Klang	78.036	Rumah Teres Tengah	2	32, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	123,000
104	Klang	78.036	Rumah Teres	2	27, Jalan Mahir Dua 25/44b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	190,000

			Tengah			25 Shah Alam	
105	Klang	78.036	Rumah Teres Tengah	2	12, Jalan Teladan Dua 25/22b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	220,000
106	Klang	78.036	Rumah Teres Tengah	2	17, Jalan Jasa Empat 25/27d, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
107	Klang	78.036	Rumah Teres Tengah	2	44, Jalan Budi 25/21, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
108	Klang	78.036	Rumah Teres Tengah	2	67, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
109	Klang	78.036	Rumah Teres Tengah	2	38, Jalan Nyaman 25/20, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	230,000
110	Klang	78.036	Rumah Teres Tengah	2	73, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000
111	Klang	78.036	Rumah Teres Tengah	2	80, Jalan Impian 25/33, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	200,000
112	Klang	78.036	Rumah Teres Tengah	2	26, Jalan Bahagia 25/17, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
113	Klang	78.036	Rumah Teres Tengah	2	11, Jalan Sri Kandi 25/14, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	102,000
114	Klang	78.036	Rumah Teres Tengah	2	15, Jalan Jasa Dua 25/27b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000

115	Klang	78.036	Rumah Teres Tengah	2	25, Jalan Tokoh 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	130,000
116	Klang	78.036	Rumah Teres Tengah	2	71, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	200,000
117	Klang	78.036	Rumah Teres Tengah	2	30, Jalan Bahagia 25/17, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	260,000
118	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Jasa Empat 25/27d, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
119	Klang	78.036	Rumah Teres Tengah	2	9, Jalan Bakti Satu 25/15a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	250,000
120	Klang	78.036	Rumah Teres Tengah	2	146, Jalan Tokoh 25/28, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	100,000
121	Klang	78.036	Rumah Teres Tengah	2	26, Jalan Mahir Tiga 25/44c , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	280,000
122	Klang	78.036	Rumah Teres Tengah	2	24, Jalan Mahir Satu 25/44a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	260,000
123	Klang	78.036	Rumah Teres Tengah	2	46, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
124	Klang	78.036	Rumah Teres Tengah	2	10, Jalan Impian 25/33, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
125	Klang	78.036	Rumah Teres	2	21, Jalan Tokoh Dua 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	95,000

			Tengah			25 Shah Alam	
126	Klang	78.036	Rumah Teres Tengah	2	14, Jalan Nyaman 25/20, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
127	Klang	78.036	Rumah Teres Tengah	2	27, Jalan Tokoh Dua 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	82,500
128	Klang	78.036	Rumah Teres Tengah	2	29, Jalan Tabah 25/24, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
129	Klang	78.036	Rumah Teres Tengah	2	21, Jalan Sri Kandi 25/14, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	76,000
130	Klang	78.036	Rumah Teres Tengah	2	4, Jalan Waja Dua 25/13b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	155,000
131	Klang	78.036	Rumah Teres Tengah	2	62, Jalan Mahir Satu 25/44a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
132	Klang	78.036	Rumah Teres Tengah	2	44, Jalan Impian 25/33, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	113,400
133	Klang	78.036	Rumah Teres Tengah	2	10, Jalan Tekun 25/43, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	138,000
134	Klang	78.036	Rumah Teres Tengah	2	42, Jalan Geliga 25/12, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	160,000
135	Klang	78.036	Rumah Teres Tengah	2	24, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	230,000

136	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	256,000
137	Klang	78.036	Rumah Teres Tengah	2	27, Jalan Tokoh Satu 25/28a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	200,000
138	Klang	78.036	Rumah Teres Tengah	2	102, Jalan Bakti 25/15, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	230,000
139	Klang	78.036	Rumah Teres Tengah	2	1, Jalan Budi Dua 25/21b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	250,000
140	Klang	78.036	Rumah Teres Tengah	2	14, Jalan Teladan Dua 25/22b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	230,000
141	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Khidmat Dua 25/35b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	300,000
142	Klang	78.036	Rumah Teres Tengah	2	7, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	222,000
143	Klang	78.036	Rumah Teres Tengah	2	16, Jalan Jasa Satu 25/27a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	450,000
144	Klang	78.036	Rumah Teres Tengah	2	27, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	157,000
145	Klang	78.036	Rumah Teres Tengah	2	38, Jalan Cekap 25/45, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	84,000
146	Klang	78.036	Rumah Teres	2	1, Jalan Cekap 25/45, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	170,000

			Tengah			25 Shah Alam	
147	Klang	78.036	Rumah Teres Tengah	2	5, Jalan Cekap 25/45, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
148	Klang	78.036	Rumah Teres Tengah	2	71, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	135,000
149	Klang	78.036	Rumah Teres Tengah	2	5, Jalan Teladan Satu 25/22a , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
150	Klang	78.036	Rumah Teres Tengah	2	16, Jalan Mahir Dua 25/44b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	105,000
151	Klang	78.036	Rumah Teres Tengah	2	72, Jalan Tekun 25/4, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
152	Klang	78.036	Rumah Teres Tengah	2	7, Jalan Waja Dua 25/13b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	170,000
153	Klang	78.036	Rumah Teres Tengah	2	32, Jalan Mahir Tiga 25/44c, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
154	Klang	78.036	Rumah Teres Tengah	2	17, Jalan Mahir 25/44, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	170,000
155	Klang	78.036	Rumah Teres Tengah	2	22, Jalan Jasa Dua 25/27b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	140,000
156	Klang	78.036	Rumah Teres Tengah	2	46, Jalan Geliga 25/12, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	300,000

157	Klang	78.036	Rumah Teres Tengah	2	126, Jalan Tokoh 25/28, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	350,000
158	Klang	78.036	Rumah Teres Tengah	2	39, Jalan Mahir 25/44, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	250,000
159	Klang	78.036	Rumah Teres Tengah	2	123, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam , Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
160	Klang	78.036	Rumah Teres Tengah	2	8, Jalan Tokoh Dua 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	130,000
161	Klang	78.036	Rumah Teres Tengah	2	8, Jalan Cekal 25/34, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
162	Klang	78.036	Rumah Teres Tengah	2	30, Jalan Tokoh Satu 25/22a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000
163	Klang	78.036	Rumah Teres Tengah	2	28, Jalan Budi Satu 25/21a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
164	Klang	78.036	Rumah Teres Tengah	2	72, Jalan Bakti 25/15, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	115,000
165	Klang	78.036	Rumah Teres Tengah	2	9, Jalan Teladan Dua 25/22b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	160,000
166	Klang	78.036	Rumah Teres Tengah	2	64, Jalan Bakti 25/15, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	155,000
167	Klang	78.036	Rumah Teres	2	135, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	112,500

			Tengah			25 Shah Alam	
168	Klang	78.036	Rumah Teres Tengah	2	19, Jalan Mahir 25/44 , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
169	Klang	78.036	Rumah Teres Tengah	2	13, Jalan Jujur Satu 25/30a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	235,000
170	Klang	78.036	Rumah Teres Tengah	2	61, Jalan Tertib 25/32, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	280,000
171	Klang	78.036	Rumah Teres Tengah	2	14, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	305,000
172	Klang	78.036	Rumah Teres Tengah	2	29, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	100,000
173	Klang	78.036	Rumah Teres Tengah	2	10, Jalan Budi Dua 25/21b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	135,000
174	Klang	78.036	Rumah Teres Tengah	2	22, Jalan Teladan 25/22, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
175	Klang	78.036	Rumah Teres Tengah	2	8, Jalan Teladan Dua 25/22b , Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	124,000
176	Klang	78.036	Rumah Teres Tengah	2	16, Jalan Waja Satu 25/13a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
177	Klang	78.036	Rumah Teres Tengah	2	43, Jalan Cekap 25/45, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000

178	Klang	78.036	Rumah Teres Tengah	2	38, Jalan Mahir Tiga 25/44c, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000
179	Klang	78.036	Rumah Teres Tengah	2	30, Jalan Impian 25/33, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	150,000
180	Klang	78.036	Rumah Teres Tengah	2	58, Jalan Mahir Satu 25/44a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	187,000
181	Klang	78.036	Rumah Teres Tengah	2	5, Jalan Tabah 25/24, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	155,000
182	Klang	78.036	Rumah Teres Tengah	2	25, Jalan Nyaman 25/20, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
183	Klang	78.036	Rumah Teres Tengah	2	53, Jalan Jujur 25/30, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	136,000
184	Klang	78.036	Rumah Teres Tengah	2	58, Jalan Nyaman 25/12, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	135,000
185	Klang	78.036	Rumah Teres Tengah	2	3, Jalan Tokoh Dua 25/28b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	120,000
186	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Budi Dua 25/21b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	145,000
187	Klang	78.036	Rumah Teres Tengah	2	15, Jalan Nyaman 25/20, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	190,000
188	Klang	78.036	Rumah Teres	2	56, Jalan Mahir Satu 25/44a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek.	165,000

			Tengah			25 Shah Alam	
189	Klang	78.036	Rumah Teres Tengah	2	42, Jalan Cekap 25/45, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	320,000
190	Klang	78.036	Rumah Teres Tengah	2	22, Jalan Cekap 25/45, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	350,000
191	Klang	78.036	Rumah Teres Tengah	2	6, Jalan Mahir Dua 25/44b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	342,000
192	Klang	78.036	Rumah Teres Tengah	2	36, Jalan Nyaman 25/20, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	333,000
193	Klang	78.036	Rumah Teres Tengah	2	32, Jalan Jasa Dua 25/27b, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	160,000
194	Klang	78.036	Rumah Teres Tengah	2	9, Jalan Cermat 25/36, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	125,000
195	Klang	78.036	Rumah Teres Tengah	2	41, Jalan Teguh 25/25, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	110,000
196	Klang	78.036	Rumah Teres Tengah	2	32, Jalan Jasa Satu 25/27a, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	153,000
197	Klang	78.036	Rumah Teres Tengah	2	61, Jalan Mahir 25/44, Tmn Sri Muda, Sek. 25 Shah Alam, Selangor, 40400, Malaysia	Tmn Sri Muda, Sek. 25 Shah Alam	95,000

AUTHOR'S PROFILE



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