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ANALYSING NEIGHBOURHOOD SAFETY FOR CHILDREN IN SHAH ALAM, MALAYSIA USING FUZZY-AHP AND GIS

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Abstract

Children could be vulnerable to being victims of kidnapping cases due to their cognitive level in perceiving safety. Until September 2023, 4,471 missing persons were reported all around Malaysia. As there is a growing concern regarding children's safety, this study was conducted throughout the Shah Alam region as it is one of the biggest cities in Selangor, which has several factors contributing to kidnapping cases towards children. However, does every section in Shah Alam have a high level of safety and is suitable for children? Geographic Information System (GIS) and Fuzzy-Analytic Hierarchy Process (AHP) are used as the main processes in decision-making when identifying the Neighbourhood Safety for Children in Shah Alam, Selangor, Malaysia. Based on previous studies, five (5) main criteria were selected, i.e., Perceived Safety, Transportation Accessibility, Land-Use, Public Facilities and Population Density. They were represented on the ground using the sub-criteria. Spatial data was collected, and 15 criterion maps were established, undergoing editing, rasterisation and reclassification. A pairwise comparison matrix was created to determine the weightage of these criteria, and Weighted Overlay Analysis was used to identify the safety level for each section. The results showed moderate neighbourhood safety (index level 5 or 6) for children in Shah Alam, with southern and western areas having worse safety levels (index value 4) compared to the middle and eastern parts. The safety index exhibits a random pattern (Moran I: -0.3333), indicating that it is spatially independent and unaffected by nearby sections. This index could help local authorities improve safety measures in the area.

Keywords: children safety, fuzzy-ahp, GIS, MCDA, spatial analysis

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INTRODUCTION

In Malaysia, children make up 27.1% of the population, with Selangor having the highest number of children under 18 (DOSM, 2021). Childhood is regarded as the most crucial time for social, physical and mental growth. Even depriving children of their nourishment, healthcare, education and affection for a short period can give them long-term and permanent effects. Therefore, child protection is crucial in creating a safe environment for children. Neighbourhood safety among the residents should be analysed, especially in Shah Alam, to make sure that the environment is safe and that all measures are calculated for children's safety.

In September 2022, Malaysia experienced an increase in kidnapping cases in school areas, causing concern for parents' safety, which may affect children's mental, physical and social development. Neighbourhood safety is crucial for improving child safety, particularly in playgrounds, surrounding areas and education selection. Addressing these issues is essential for ensuring the safety of children in Malaysia. Kidnapping cases could be influenced by several factors that are related to the poor neighbourhood safety for children, such as there is poor walkability around the area, poor lighting sources, a high number of crime cases, low constant police presence, a lot of abandoned houses and storefronts and lack access to well-maintained recreation areas (Kallus, 2015).

Kidnapping cases could be influenced by several factors that are related to the poor neighbourhood safety for children, such as there is poor walkability around the area, poor lighting sources, a high number of crime cases, low constant police presence, a lot of abandoned houses and storefronts and lack access to well-maintained recreation areas (Montréal, 2015). The factors that influenced neighbourhood safety among the children were identified by using GIS technology, and the data was translated into the GIS database for spatial analysis. Neighbourhood Safety for Children in Malaysia is a very less common topic to be studied based on the findings of previous research and studies related to GIS. Nonetheless, the concept of the GIS Index Model may be used to assess it.

Multi-Criteria Decision Analysis (MCDA) technique, AHP especially, was frequently used in GIS models to make the best decision depending on the criteria. The rise in kidnapping cases necessitates a better technique for identifying neighbourhood safety for children using Spatial-MCDA. In spite of that, using the AHP method has some limitations due to uncertainty or fuzzy information. Thus, Fuzzy-AHP was introduced to address the uncertainty issue. Therefore, this study used Fuzzy-AHP and GIS to evaluate safety for children in Shah Alam, Selangor. The factors influencing safety were determined and used for the evaluation to categorize the study area into the safest to least safe neighborhoods. The findings suggest the need for further research on neighborhood safety measures using MCDA.

LITERATURE REVIEW

Neighbourhood Safety for Children

Neighbourhoods are residential areas within towns or cities, designed for development and social issues (Gokumen, 2018). They include structures, roads, public areas and walkways, providing opportunities for physical activities. City planners, architects and urban designers focus on neighbourhoods as remedies for urban social issues, often based on preindustrial cities' interactions (Gheda & Ilmi, 2019).

Children's growth is affected by their neighborhood environment (Yusuf et al., 2021). It can be said that difficulties regarding the safety of children occur, especially in nearby industrial and developed cities (Gheda & Ilmi, 2019). Studies suggested that most children clearly preferred to be involved in outdoor activities such as play and learning outside of the housing area (Jacobs, 1961; Gemmel et al., 2023). However, the neighbourhood area could be less safe for the children.

A crime against children has often been heard and talked about either on social media or in person. The topic has frequently been read and listened to on the radio, in newspapers, on gadgets, and on television, which brings fear to all parents (Jain, 2011). Children's safety is one of the most important things to be identified, handled and taken into account. Children normally tend to enjoy physical activity, whether it is around the neighbourhood area, in the park or in other places, as long it is outside of their houses. Therefore, the safety of the children around the neighbourhood area must be considered. Due to the high exposure to danger that has been brought about by modern development, there might no longer be freedom for children to roam around while enjoying outdoor activities without feeling paranoid and anxious about their safety (Jacobs, 1961).

The development and design of a neighbourhood play a huge role in producing a safe community to overcome parental fear (Lueder, 2007). Safety is described as one of the methods to protect a person or group of people against any accident that might be harmful to others. If some precautions were taken, unnecessary accidents could be avoided, and safety measures could be identified and carried out. Compared to an untrained city street, a well-used city street is more likely to be a safe street (Ali, 2020). Hence, to design a safe neighbourhood, there is a need to consider the number of shops and public areas dispersed along the sidewalks, which comply with the concept of Crime Prevention through Environmental Design (CPTED) that is widely used these days.

Neighborhood safety for children is influenced by factors such as residential density, public transit density, and crime density. Residential density impacts walkability and environment, while public transit density increases the risk of accidents and crimes involving children. Land-use crime density, including residential, commercial, educational, industrial, and recreational facilities, also affects safety. High crime density in these areas poses significant

dangers to children, making it crucial to consider these factors when assessing child-friendly environments.

Table 1: Criteria Influencing Children's Safety in a Neighbourhood

Author(s)	Perceived Safety	Transportation Accessibility	Land Use	Public Facilities	Population Density
Zougheibe et al., 2021	✓	✓		✓	✓
Azmi et al., 2015	✓	✓	✓	✓	✓
Ogneva-Himmelberger et al., 2019	✓		✓	✓	✓
Ilmi et al., 2018	✓		✓	✓	✓
Rakhimova et al., 2022	✓		✓	✓	✓
Azlan and Naharudin, 2020	✓	✓	✓		
Tappe et al., 2013	✓	✓	✓	✓	✓
Ilmi et al., 2018	✓		✓	✓	✓
Tupenaite et al., 2018			✓	✓	✓
Lueder, 2007	✓	✓	✓	✓	✓
Brown et al., 2019	✓		✓	✓	✓

Source: Authors (2024)

Spatial-MCDA in Measuring Neighbourhood Safety for Children

GIS and non-GIS methods can be used to assess neighbourhood safety for children. One of the GIS methods, is GIS index model that is related to the mathematical or computation model, which combines multiple criteria in order to produce an index value for the purpose of representation of specific data, such as for suitability index map or phenomena (Chang, 2016; Roslan & Naharudin, 2023). There are several index models that are normally used in a multi-criteria analysis, such as the Weighted Linear Combination method, which is divided into two index models: the vector-based index model and the raster-based index model. The vector-based index model refers to creating a ranking by aggregating the attribute based on the features such as points, lines and polygons, while a raster-based index model is the data that are represented as a grid of cells where each cell has its own value.

GIS index model uses the concept of MCDA including AHP (Saaty, 1980; Malczweski & Rinner, 2015; Elhosni & Faiz, 2021). Spatial-MCDA is a general decision theory and analysis that often implemented in decision-making by integrating geographical details (Malczweski & Rinner, 2015; Vogdrup-Schmidt et al., 2019). It is also known as the combination of GIS data processing combined with the process and capabilities of MCDA decision-making. The combinaton is very useful for data collection, keeping, processing, interpretation and analysis.

The decision-making phase in AHP involves overlapping criteria and can be divided into three levels: hierarchy, pairwise comparisons, and uncertainty

(Ruslan et al., 2023). The uncertainty of MCDA in the weighting method is the confidence in assuming that the decision maker has the capabilities to make an accurate analysis (Malczweski & Rinner, 2015). This uncertainty is often mistaken for the MCDA model, as the information gathered is incomplete or imprecise, resulting in inaccurate decision-making. This causes preference error, a term of preference uncertainty, which defined as the difference between assessed weight and real value criteria.

The Fuzzy-AHP method is an enhanced analytical methodology developed from classical AHP, which is used to solve the uncertainty of both quantitative and qualitative criteria in MCDM problems. This technique aims to overcome the fuzziness problem in decision-making, which can cause imprecise judgments when using conventional AHP approaches (Malczweski & Rinner, 2015). Fuzzy sets provide a smooth transition between elements and non-elements, allowing decision-makers to focus on crucial factors. With that, Fuzzy-AHP ignores less significant criteria, giving equal weighting to each other, enabling evaluation of uncertainty.

RESEARCH METHODOLOGY

Figure 1 illustrates the flow of methodology used in this study that implement a combination of Fuzzy-AHP and GIS. The former was used to calculate the weightage for each criterion and its sub-criteria, while the latter was utilised to create all spatial data and measure the safety level for children in a neighbourhood.

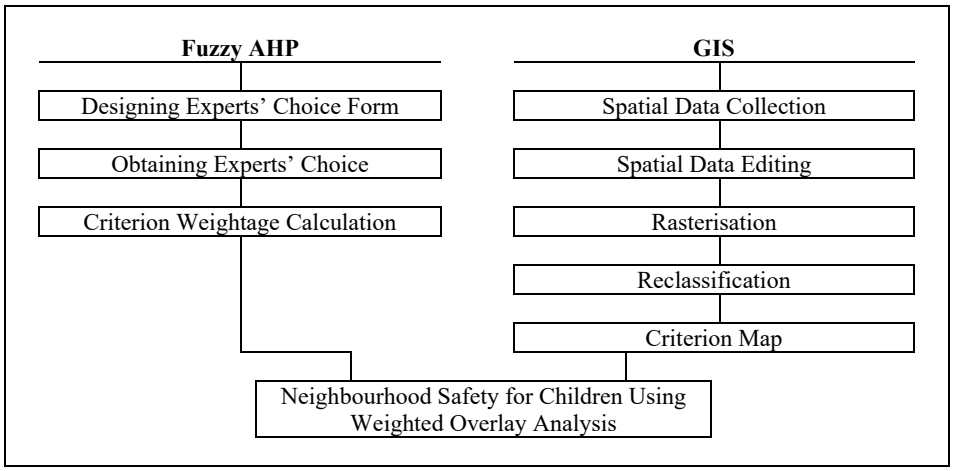

Figure 1: Research Methodology Flowchart
Source: Authors (2024)

Fuzzy-AHP to Determine Weightage of Criteria and Subcriteria

Figure 2 shows the hierarchical structure that was used to represent criteria and sub-criteria and their dependencies in the decision-making. The first level of the hierarchical structure was identified by the goal of the study, which is the Neighbourhood Safety for Children. The second level of the hierarchy is the criteria that was chosen to determine the level of safety in the neighbourhood for children, and the third level consists of the sub-criteria of each main criteria.

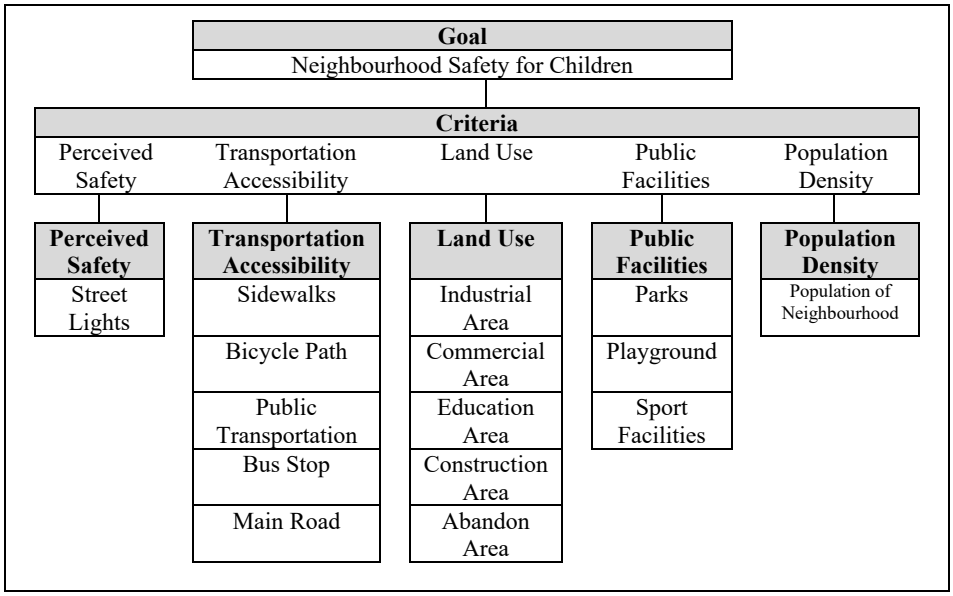

Figure 2: Hierarchical Structure
Source: Authors (2024)

The experts' choice form (Figure 3) was designed according to the dependencies in the hierarchical structure. Each node in the same cluster was compared to each other in a pair. Thus, in this case, all main criteria and subcriteia were compared to each other in a pair. A brief description and example of how experts (Table 2) can give their judgement on the pairwise comparison was included in the form to enhance familiarity in answering the questions.

Table 2: Experts' for Pairwise Comparison Survey

Expert(s)		Description
Academician	A1	Professor in Local University
	A2	Professor in Local University
Industrial	I1	Expert from local authority
	I2	Expert from crime perspective
	I3	Expert from child welfare agency

Source: Authors (2024)

Pairwise Comparison of Main Criteria

	Extremely Importance (9,9,9)	Intermediate Value (7,8,9)	Very Strong Important (6,7,8)	Intermediate Value (5,6,7)	Strong Important (4,5,6)	Intermediate Value (3,4,5)	Moderate Important (2,3,4)	Intermediate Value (1,2,3)	Equal Importance (1,1,1)	Intermediate Value (1,2,3)	Moderate Important (2,3,4)	Intermediate Value (3,4,5)	Strong Important (4,5,6)	Intermediate Value (5,6,7)	Very Strong Important (6,7,8)	Intermediate Value (7,8,9)	Extremely Importance (9,9,9)	
Perceived Safety	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Transportation Accessibility
Perceived Safety	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Land-Use
Perceived Safety	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Public Facilities
Perceived Safety	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Population Density
Transportation Accessibility	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Land-Use
Transportation Accessibility	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Public Facilities
Transportation Accessibility	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Population Density
Land-Use	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Public Facilities
Land-Use	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Population Density
Public Facilities	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Population Density

Pairwise Comparison for subcriteria of Transportation Accessibility

	Extremely Importance (9,9,9)	Intermediate Value (7,8,9)	Very Strong Important (6,7,8)	Intermediate Value (5,6,7)	Strong Important (4,5,6)	Intermediate Value (3,4,5)	Moderate Important (2,3,4)	Intermediate Value (1,2,3)	Equal Importance (1,1,1)	Intermediate Value (1,2,3)	Moderate Important (2,3,4)	Intermediate Value (3,4,5)	Strong Important (4,5,6)	Intermediate Value (5,6,7)	Very Strong Important (6,7,8)	Intermediate Value (7,8,9)	Extremely Importance (9,9,9)	
Sidewalks	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Bicycle Path
Sidewalks	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Public Transport
Sidewalks	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Bus Stop
Sidewalks	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Main Road
Bicycle Path	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Public Transport
Bicycle Path	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Bus Stop
Bicycle Path	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Main Road
Public Transport	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Bus Stop
Public Transport	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Main Road
Bus Stop	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Main Road

Pairwise Comparison for subcriteria of Landuse

	Extremely Importance (9,9,9)	Intermediate Value (7,8,9)	Very Strong Important (6,7,8)	Intermediate Value (5,6,7)	Strong Important (4,5,6)	Intermediate Value (3,4,5)	Moderate Important (2,3,4)	Intermediate Value (1,2,3)	Equal Importance (1,1,1)	Intermediate Value (1,2,3)	Moderate Important (2,3,4)	Intermediate Value (3,4,5)	Strong Important (4,5,6)	Intermediate Value (5,6,7)	Very Strong Important (6,7,8)	Intermediate Value (7,8,9)	Extremely Importance (9,9,9)	
Industrial Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Commercial Area
Industrial Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Education Area
Industrial Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Construction Area
Industrial Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Abandon Area
Commercial Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Education Area
Commercial Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Construction Area
Commercial Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Abandon Area
Education Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Construction Area
Education Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Abandon Area
Construction Area	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Abandon Area

Pairwise Comparison for subcriteria of Public Facilities

	Extremely Importance (9,9,9)	Intermediate Value (7,8,9)	Very Strong Important (6,7,8)	Intermediate Value (5,6,7)	Strong Important (4,5,6)	Intermediate Value (3,4,5)	Moderate Important (2,3,4)	Intermediate Value (1,2,3)	Equal Importance (1,1,1)	Intermediate Value (1,2,3)	Moderate Important (2,3,4)	Intermediate Value (3,4,5)	Strong Important (4,5,6)	Intermediate Value (5,6,7)	Very Strong Important (6,7,8)	Intermediate Value (7,8,9)	Extremely Importance (9,9,9)	
Parks	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Playground
Parks	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Sport Facilities
Playground	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	Sport Facilities

Figure 3: Pairwise Comparison
Source: Authors (2024)

The experts' choice was based on the Fuzzy-AHP method as the expert's choices are very important as it helps to identify the weight of the criteria based on the scale in the fuzzy scale of (1,1,1) to (9,9,9). Therefore, the experts

identified the importance of the criteria in determining the safety of the children in the neighbourhood area. From the experts' choice that was obtained, the weightage of the criteria was calculated using Microsoft Excel software, which was then used to determine the safety in the study area. The pairwise comparison matrix for each criterion and their subcriteria is shown in Figure 3.

GIS in Measuring Neighbourhood Safety for Children

This study involves two (2) types of data collection, which are primary and secondary data collection as described in Table 3. Primary data collection is based on the process of gathering the information and data that are related to the study through surveys, while secondary data collection is based on the data that was collected from other sources such as government agencies and open sources.

Table 3: Data Collected in the Study

Data			**Type**	**Source(s)**	**Reason(s)**
Rating of Criteria and Subcriteria			Table	Experts' Choice – Primary Data Collection	To determine the weightage of criteria and their subcriteria
Spatial Data of Subcriteria	Perceived Safety	Street Lights	Table in Excel	Primary Data Collection	Represent criteria in the spatial environment
	Transportation Accessibility	Sidewalks	Shapefile	Open Street Map	
		Bicycle Path	Shapefile		
		Public Transport	Scanned Data	City Council	
		Bus Stop	Shapefile	Open Street Map	
		Main Road	Shapefile		
	Land Use	Industrial Area	Shapefile		
		Commercial Area	Shapefile		
		Education Area	Table in Excel	Ministry of Education	
		Construction Area	Shapefile	Primary Data Collection	
		Abandon Area	Shapefile		
	Public Facilities	Parks	Shapefile	Open Street Map	
		Playground	Shapefile		
		Sport Facilities	Shapefile		
	Population Density	Population of Neighbourhood	Table in Excel	Department of Statistics	

Source: Authors (2024)

The process of spatialising the data involves georeferencing images, digitising features and checking topological data. This process uses software tools

to convert scanned images into digital formats or maps. However, errors are common in editing, affecting the quality of GIS data. To eliminate errors, topology editing is used to improve data quality. Topology editing includes adding rules to digitise data, with ten available for error identification. According to the study, one (1) data was obtained in a scanned format data that required to go through this process, which was the data on public transportation, while several data were collected in a digital format, which is in a shapefile format. This data was represented by point, polygon, or line features. The education area is represented in tabular data. To display it in ArcGIS Pro software, the tabular data are converted to a shapefile format. Geocoded tools were used to automatically identify the location of the education centre using its addresses in the tabular data and represented in point features.

Next, the rasterisation process was completed to convert the data to raster data. The rasterisation process in Shah Alam was automated using Modelbuilder software from ArcGIS Pro. Automation in GIS processing aims to reduce human errors and mistakes, as processing may involve multiple tasks. The process involved extracting raw data into various feature classes and population data for each boundary of sections. The output was then used for the next process. Reclassification processes are completed to process the data by using the technique of Weighted Overlay Analysis. The reclassification was done in the reclassify table, and the final output is for the Criterion Map for each of the sub-criteria of this study.

Criterion maps were created after processing GIS operations, representing each criterion as a map layer in the GIS database. These maps represent the evaluation criteria for alternative decisions. A criterion map represents the spatial dataset of criteria for this study, and the steps for creating a criterion map and geographic database are similar. The process of creating a criterion map was conducted using Euclidean Distance, creating a raster of each criterion. Then, the raster values were reclassified to create a standard scale value from 1-9 according to the Saaty scale. These maps are utilised to determine neighbourhood safety for children using Weighted Overlay Analysis.

The neighbourhood safety for children was modelled and measured using Weighted Overlay Analysis (WOA). Generally, WOA is the most popular approach used in identifying site suitability, but in this study, it was used to identify the safety of the neighbourhood area. This is because using WOA can determine the quantitative and qualitative data. Therefore, in this study, the weight was calculated based on the criteria that have been determined by the experts. The expert's weightage for each sub-criteria was assigned in the Influence tabular column based on the percentage of weightage. It was also classified into nine classes where the determination of the value of the weightage was classified and changed according to the parameter needed.

After that, the Spatial Autocorrelation of neighbourhood safety for children in Shah Alam was conducted as part of the analysis to identify the statistical relationship of the distribution of safety through every section in Shah Alam that has been obtained from the result of WOA. In this study, it is used to identify whether the distribution of the safety index is dispersed, random or clustered. The final map of the safety index was verified by an expert from the local authority. This stage is important to validate the method used and verify the results found to be similar to those of the real world. For this stage, the expert from the local authority was interviewed.

RESULTS AND ANALYSIS

Weightage of Criteria for Neighbourhood Safety for Children

Table 4: Overall Priorities of Criteria and Sub-Criteria

Main Criteria	Sub-Criteria	Weightage	Overall Priority	Percentage (%)
Perceived Safety	Streetlight	0.133	0.133	13
Transportation Accessibility	Sidewalks	0.089	0.013	1
	Bicycle Path	0.187	0.027	3
	Public Transport	0.250	0.036	4
	Bus Stop	0.191	0.028	3
	Main Road	0.282	0.041	4
Land Use	Industrial Area	0.307	0.083	8
	Commercial Area	0.152	0.041	4
	Education Area	0.138	0.037	4
	Construction Area	0.124	0.034	3
	Abandon Area	0.278	0.075	8
Public Facilities	Parks	0.321	0.060	6
	Playground	0.234	0.044	5
	Sport Facilities	0.445	0.083	8
Population Density	Population of Neighbourhood	0.264	0.264	26

Source: Authors (2024)

Table 4 shows the weightage of the criteria and its sub-criteria for overall priorities, which helps represent the final output of Neighbourhood Safety for Children in Shah Alam. The results indicate that the most influential criterion for children's safety in a neighbourhood is Land Use, with a weightage of 0.271, followed by Population Density (0.264), Public Facilities (0.187), Transportation Accessibility (0.145), and Perceived Safety (0.133). Notably, there is a significant gap between the second and third criteria, Population Density and Public Facilities, with a difference of 0.077. The smallest gap is between the first and second criteria, Land Use and Population Density, with a difference of only 0.0068. Land Use is considered the most critical due to children's frequent presence in educational areas. Population Density poses risks such as accidents

and limited outdoor spaces. Public Facilities, though generally safe, can have hazards like poor maintenance and lack of supervision. Transportation Accessibility is influenced by factors such as traffic accidents and pollution. Perceived Safety is the least influential, likely because street lighting is commonly present in urban areas, enhancing perceived safety.

For subcriteria, the least influential sub-criteria referring to the expert's choice is the sidewalks, which are under the main criteria of Transportation Accessibility with a percentage of 0.013. The most influential subcriteria is the presence of streetlights (0.133), which is undoubtedly important for the safety of children. The findings revealed that proximity to certain land uses is the second most influential factor for safety, such as to industrial areas and abandoned areas, which is in line with previous literature by Gheda & Ilmi (2019).

Neighbourhood Safety for Children in Shah Alam

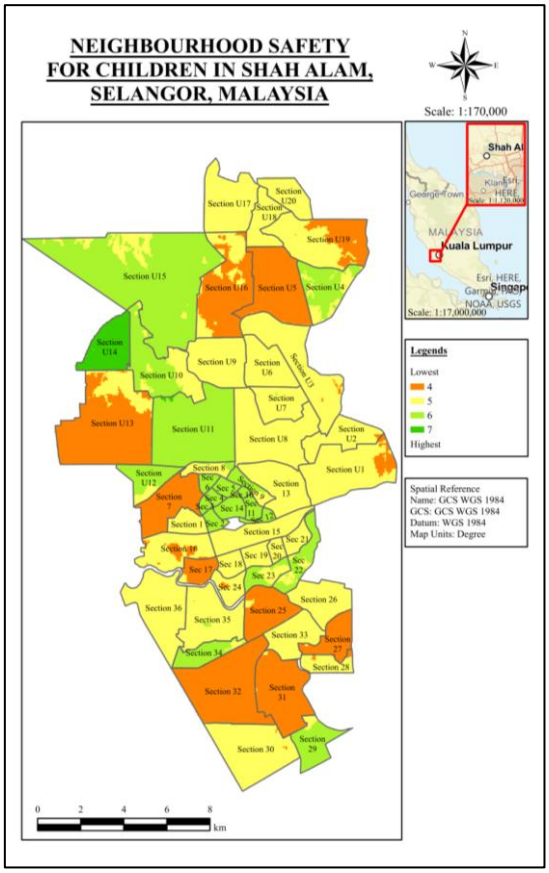

Figure 4: Map of Neighbourhood Safety for Children in Shah Alam
Source: Authors (2024)

Figure 4 illustrates the map of Neighbourhood Safety for Children in Shah Alam, Selangor. Section U14 has the highest level of safety, influenced primarily by its low population of 998, which accounts for 26% of the weightage. This suggests that higher populations correlate with decreased safety. The findings, verified by experts, also reveal that 17 sections exhibit low safety levels. Factors contributing to these low safety levels include proximity to abandoned areas, construction sites, and industrial zones, supporting the hypothesis that greater distances from such areas increase safety.

A comparison of the sections with the lowest safety levels identified population density and streetlight presence as critical parameters, with high population density (26% weightage) and low streetlight presence significantly impacting safety. This underscores the importance of managing population density and enhancing street lighting to improve neighbourhood safety for children. Table 5 summarises how each factor plays a role in the safety index by comparing results for two (2) sections.

Table 5: Comparison of Parameters

Section 7 (Least Safe)	Parameters	Weightage (%)	Section U5 (Safe)
15	Industrial Area	8	1371
162	Commercial Area	4	782
5	Construction Area	3	3
4	Abandon Area	8	2
43,200	Population Density	26	59,760
2798	Street Light	18	6257

Source: Authors (2024)

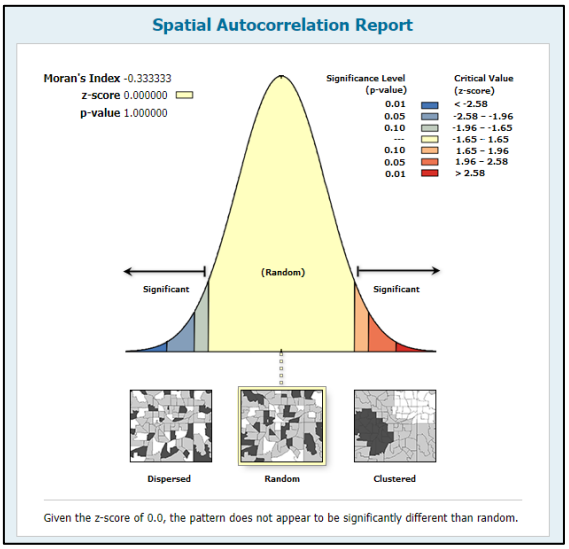

Figure 5: Spatial Autocorrelation of Neighborhood Safety for Children
Source: Authors (2024)

To understand the pattern of safety in the neighbourhood for children, Spatial Autocorrelation Analysis was used to identify the pattern of the distribution of safety throughout every section in Shah Alam, whether it is dispersed, random or clustered. The spatial autocorrelation results shown in Figure 5 show that the level of safety for children around Shah Alam is distributed randomly indicating that the level of safety for children is spatially independent and is not influenced or affected by other nearby sections. It may be caused by several factors, such as different sections having different criteria.

The final output was verified by using two different methods and approaches where the first verification was completed with the help of Shah Alam's experts, who are from a local government agency, and the second method of verification was made by field verification. It helps to avoid and reduce any inaccurate or imprecise data measurement that may affect the quality of the GIS analysis.

CONCLUSION

The study aims to analyse the neighbourhood safety for children in Shah Alam, Selangor, Malaysia, using the Fuzzy-AHP and GIS methods. First, Fuzzy-AHP was used to determine the weightage of criteria, such as perceived safety, transportation accessibility, land use, public facilities, and population density and then GIS was used to develop a model that measures the level of safety in each neighbourhood area. The study finds that land use is the most important criterion for neighbourhood safety for children, followed by population density, while perceived safety is the least important. The study also finds that the level of safety in Shah Alam is average, with some areas being safer than others. The study uses spatial autocorrelation to identify the factors that influence the level of safety and finds that the distribution of safety is random. The study concludes that a safe neighbourhood is crucial for protecting children and contributes to the field of GIS by introducing a novel approach to addressing neighbourhood safety for children in Shah Alam. For future improvement of this study, it is recommended that more criteria such as crime rate and speed limits could be added to be evaluated as the method that has been chosen is Fuzzy-AHP. Other than that, a spatial relationship analysis can be conducted to identify the relationship between the final safety level results and real crime cases such as kidnapping cases.

The research contributes in introducing a novel approach to analysing neighbourhood safety for children by Fuzzy-AHP with GIS. This combination leverages the strengths of Fuzzy-AHP in handling the inherent uncertainties and subjectivities in evaluating safety criteria while utilising GIS for precise spatial analysis and visualisation. By applying Fuzzy-AHP, the study enhances the accuracy of weighting diverse safety factors reflecting their true impact on neighbourhood safety. GIS enables the detailed mapping and spatial analysis of these weighted criteria, providing a comprehensive and visual representation of

safe and unsafe areas for children. This innovative methodology not only improves the reliability of safety assessments but also offers urban planners and policymakers a robust tool for making informed decisions to create child-friendly environments.

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