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Determining Land Suitability for New Primary Schools in Seremban, Malaysia: An Exploratory Study with the GIS-MCDA Approach

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ABSTRACT

Schools serve as community cornerstones, offering education and a platform for adult learning, healthcare services, and civic engagement. Recognising this vital role, this study uses a GIS multi-criteria decision analysis (MCDA) approach to identify suitable land for a new primary school in Seremban, Negeri Sembilan. The MCDA approach assesses various critical criteria for optimal school placement, including population density, land use, school, clinic, land size, and topography or slope. The result shows that most of the land suitable for developing new schools is in the Seremban city centre due to development suitability, particularly the high population density and public facility availability. However, the study's findings also suggest that the location of the newly proposed primary schools should prioritise student accessibility and community integration in Nilai and Senawang. Ultimately, the identified land will contribute to a strong sense of community spirit and enhance the overall well-being of the area, providing valuable insights for urban planners, policymakers, and educators.

INTRODUCTION

Primary education is a fundamental foundation for human development, crucial for nation-building and maximising human life potential. Establishing primary schools is fundamental to the growth and development of communities. Schools serve as educational institutions and pivotal centres for adult education, healthcare, and civic engagement (Smith & Brown, 2021). Given their multi-faceted role, it is crucial to carefully select locations for new schools to maximise their positive impact on communities.

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Carefully selecting school locations is crucial for maximising community impact by ensuring accessibility, enhancing social integration, and supporting local development. Effective site selection can also improve educational outcomes, reduce transportation costs, and foster community cohesion (Smith & Brown, 2021; Thompson & Lee, 2022). The public facility's location directly impacts quality of life for inhabitants and others, while land selection is crucial for students' safety and security from potential disasters like soil erosion and wind.

Globally, the demand for land to develop educational infrastructure is rising due to urbanisation and population growth. In Malaysia, the challenge is amplified by land scarcity and urban sprawl, especially in regions like Seremban. Integrating Geographical Information Systems (GIS) and multi-criteria decision analysis (MCDA) has become crucial in efficiently determining land availability, considering factors like accessibility, land use, and environmental impact. Recent studies, such as Hashim et al. (2023) and Abdullah & Chan (2024) in the Asia-Pacific Planning Review, emphasise the need for advanced geospatial techniques to optimise site selection. Local studies have also proven that GIS can help in a better decision-making of public facilities data management (Abdullah et al., 2024; Mustapha et al., 2023; Mohd Hasmizi et al., 2020; Jalil et al., 2018)

This study leverages the capabilities of MCDA within GIS software to identify optimal land availability for the development of a new primary school as utilised by previous researchers (Wilson et al., 2021; Ahmed & Wang, 2022; Garcia & Martinez, 2020). MCDA is a robust decision-making tool that evaluates multiple criteria, balancing various factors to make the best decision. The study examines several vital criteria essential for ideal school placement. These criteria include population density, student age distribution, types of land use, and the proximity of potential sites to residential areas. In Malaysia, determining land for primary school development is guided by PlanMalaysia's National Physical Planning guidelines. It mandates assessing factors like population density, accessibility, and land use compatibility, according to Rahman et al. (2022) in the Urban Policy.

By employing MCDA in a GIS framework, the study seeks to prioritise the accessibility and integration of the new school in the community. This approach ensures that the chosen location will be easily reachable for students and harmoniously integrated into the community, fostering a vibrant and supportive learning environment (Thompson & Lee, 2022). The aim is to select a site that enhances community spirit and contributes to the overall well-being of the area, thereby underscoring the significant role schools play beyond their educational mandate. This comprehensive approach to site selection underscores the importance of strategic planning in educational infrastructure, aiming to meet the community's current needs and future demands. As a pilot study, this spatial research uses the GIS-MCDA method to identify suitable land for a new primary school in Seremban, Negeri Sembilan, based on PlanMalaysia's guidelines.

METHODOLOGY

This study aims to identify the land suitability for developing a new primary school based on PlanMalaysia's requirements. The study used the GIS-MCDA method to identify an accurate area based on the criteria listed by the guidelines, including community facilities, agriculture, open space, vacant land, and housing (Figure 1).

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Fig. 1. Research Flowchart to Identify Land Suitability for Primary School

Source: Authors (2024)

Study Area

The Seremban area was chosen as the study area because it is rapidly developing. Seremban, the state capital of Negeri Sembilan, is rapidly developing because Seremban is a Malaysian Vision Valley 2045 (MVV) study (Figure 2). Therefore, much of the planning is focused on improving the economy and providing affordable housing areas for the residents of Negeri Sembilan. In planning the development of the housing area, community facilities are essential to making the area sustainable and harmonious. This is because the facilities provided are a communication medium between the surrounding residents. The study aims to identify suitable areas to provide adequate community facilities for the residents of Seremban. These findings will show an example of identifying a suitable area to develop a primary school because providing primary schools is the basis for the development of the population.

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Fig. 2. Study Area Located in Seremban, Negeri Sembilan

Source: https://www.google.com/maps/place/Seremban

Preliminary Study

A preliminary study has been conducted to find references about the factors that prepare the primary school area. These factors have been stated in the community facility area planning guide published by PLAN Malaysia. In addition, preliminary research found the need to provide primary schools in certain areas. Among the factors that contribute to the provision of schools are the population density, the distribution of existing schools, the type of land, the condition of the land, the distance between the school and housing, and aspects of safety in the area.

Data Collection

Process data collection for this study using secondary data. The data is from PLANMalaysia@Negeri Sembilan, an open source for joint studies. The data types used in this study are shapefile, tiff, and polygon. This data is obtained from QGIS to obtain open-source data such as the contour and slope of the study area. In addition, shapefile data in polygon type is obtained from Government agencies.

Data Analysis and Mapping

Most of this study's data is in polygon shapefile (shp) obtained from PLANMalaysia@Negeri Sembilan. The data is a land use layer for the Seremban area. Accordingly, the land use data is essential for identifying suitable areas for developing primary schools. The data used include house radius, facility radius, school radius, land use layer, and land area. In addition, topography data is taken through OpenTopograpfy DEM in the raster layer. The analysis carried out in this study is using the MCDA method. This analysis combines various factors according to the level highly related to the purpose of the study.

Data extraction and data classification are the main tasks in data analysis. In data extraction, the primary sources of land use are extracted to the required features class. The data required is land use for community facilities, agriculture, open space, vacant land, and housing (Figure 3). These four layers can be gazetted as school areas according to land conditions. Other land use layers, such as commercial areas and factories, are not suitable for use as school areas because schools are not suitable close to the area.

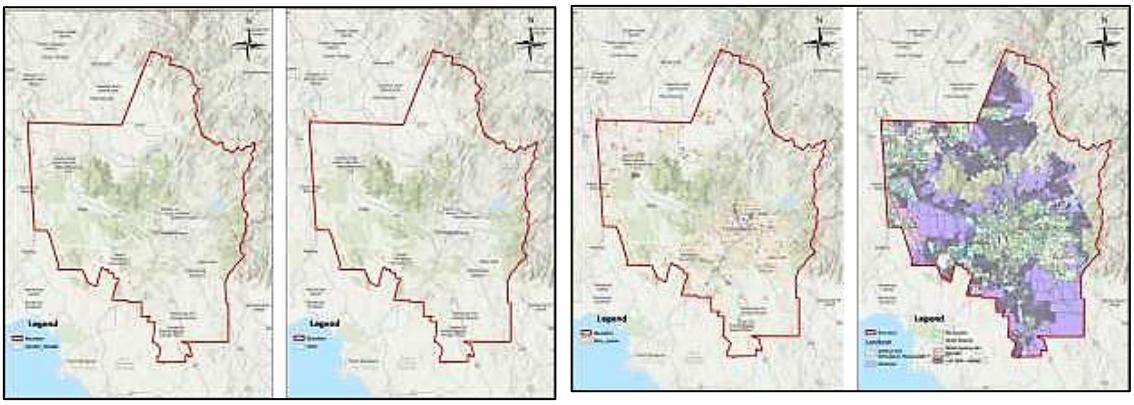

Fig. 3. Layer Extraction for School, Clinic, Housing and Land Use Area

Source: Authors (2024)

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Data classification of the layers was then categorised based on the requirements of the "Kemudahan Masyarakat" Guidelines. The information was used to classify the level factor for weightage overlay tools, as shown in Table 1. Several fundamental overly analyses were applied to conduct the classification, such as buffering and clip process. This buffer will use a clip tool to ensure all the buffers are inside the boundary study. This buffer will be classified as a raster layer before using weightage overlay tools.

For example, the GIS buffering analysis in Table 1 evaluates land use suitability for a new primary school based on different land use types. Each land use type is assigned a suitability level: Facility (Most Suitable, Level 5), Empty Land (Suitable, Level 4), Open Land (Moderate, Level 3), Housing (Less Suitable, Level 2), Agriculture (Not Suitable, Level 1). This ranking system helps prioritise areas for school development, with facilities and empty land being the most favourable, while agricultural land is considered unsuitable.

Another significant criteria ranking is Housing Density (Number of Houses per Unit Area). This criterion refers to the number of houses present in a given area. The suitability of a location for a new primary school depends on the number of houses around it, which is a proxy for the population that would potentially send children to the school. Based on the Suitability Ratings, 1 (Not Suitable) - 6250 Houses, this density indicates an extremely high number of houses in the area, leading to potential overcrowding. It may also suggest that existing schools are already present, making it unnecessary or challenging to establish a new one. While 5 (Most Suitable) - 5000 Houses indicate that this density represents an optimal number of houses, suggesting a high population density. It indicates a strong need for a new school with a sizeable potential student base and an ideal balance between demand and overcrowding.

Table 1. Proposed Criteria for Primary School Placement in Seremban

Criteria/ factor (Unit)	Sub-criteria	Level	Rank
Land use (Types)	Housing	Less Suitable	2
	Facility	Most Suitable	5
	Agriculture	Not Suitable	1
	Empty Land	Suitable	4
	Open Land	Moderate	3
School (number)	400	Less Suitable	2
	800	Most Suitable	5
	1200	Suitable	4
	1600	Moderate	3
	2000	Not Suitable	1
Clinic (number)	400	Less Suitable	2
	800	Most Suitable	5
	1200	Suitable	4
	1600	Moderate	3
	2000	Not Suitable	1
Size Land (Area)	0 – 2 acres	Moderate	2
	2 – 3 acres	Suitable	3
	3 – 4 acres	Most Suitable	4
	4 – 5 acres	Less Suitable	1
Density- Housing- (Number)	1250	Less Suitable	2
	2500	Moderate	3
	3750	Suitable	4
	5000	Most Suitable	5
	6250	Not Suitable	1
Topography - slope (Degree)	5	Most Suitable	5
	10	Suitable	4
	15	Moderate	3
	20	Less Suitable	2
	25	Not Suitable	1

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Source: Authors (2024)

RESULTS AND DISCUSSIONS

Spatial Criteria for Optimal Primary School Placement in Seremban

Figure 4 shows the spatial criteria for optimal primary school placement in Seremban as required by the Kemudahan Masyarakat guidelines by PLAN Malaysia. The criteria are ranked according to five Likert scale: 1 shows the lowest preference, and 5 is the highest suitability. For housing, the proximity to residential areas is evaluated, with areas close to housing being less suitable due to potential congestion, while more open or non-residential areas are preferred. Regarding slopes, areas with flatter terrain are more suitable for development, while steeper slopes are less suitable due to construction challenges and safety concerns.

Land Area is another critical criterion influencing the school placement: larger land parcels, mainly those three to four acres, are considered most suitable for primary school development, ensuring adequate space for infrastructure and future expansion. Another factor is that land suitability use that is categorised by its current use. Facilities and empty land are preferred, while agricultural and highly residential areas are less suitable.

Proximity to existing schools is a critical factor for new schools. To avoid oversaturation, new schools should not be too close to existing ones but should remain within an accessible distance for underserved areas. Similarly, for the clinic availability, proximity to clinics is considered, with areas close to healthcare facilities being more suitable, ensuring that the school is integrated into a community with essential services. These criteria ensure that the selected site for a new primary school in Seremban is accessible, safe, and conducive to both learning and community integration, following the strategic planning guidelines of LAN Malaysia.

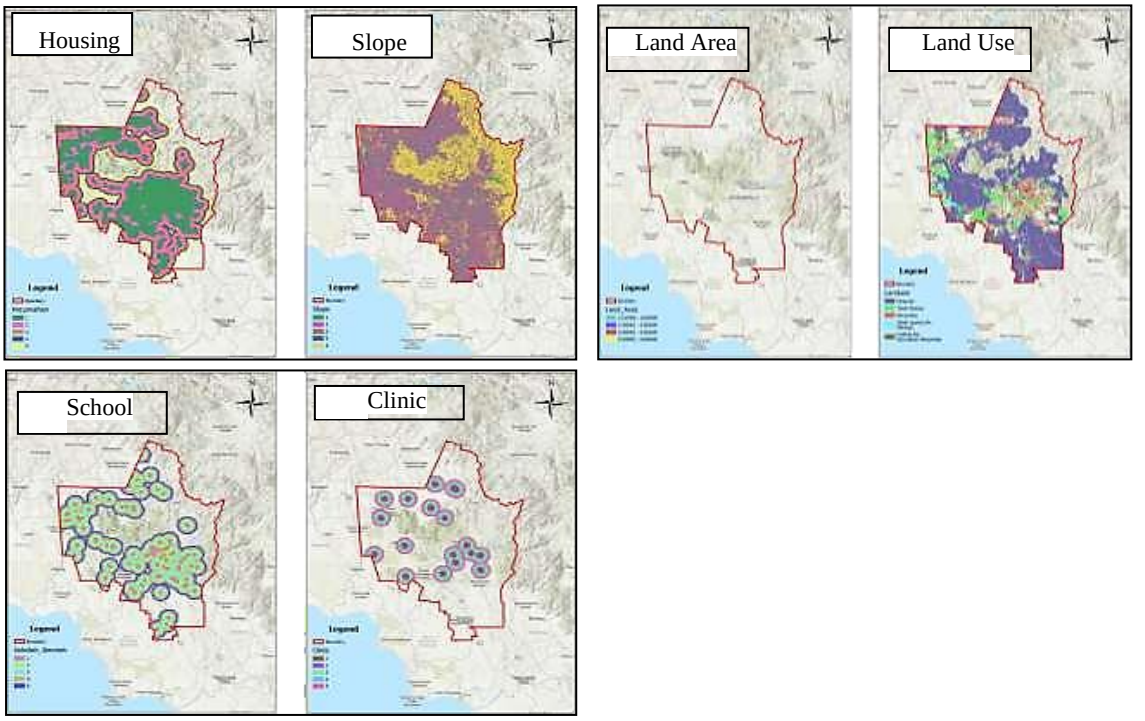

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Fig. 4. The Criteria for Optimal Primary School Placement in Seremban

Source: Authors (2024)

Site Suitability for Proposed Primary Schools in Seremban

Based on the resulting map shown in Figure 5, the GIS-MCDA identified a suitable area to develop the new school in Seremban. As mentioned above, this criterion is MCDA, which uses factors that contribute to developing schools in Malaysia. The criteria were chosen based on the Kemudahan Masyarakat guidelines of PLAN Malaysia. This guideline has been used for all states in Malaysia and has been revised every five years. The result shows that most of the land suitable for developing new schools is in the Seremban city centre. That area is suitable for development because it meets all the criteria listed in this study. Furthermore, the area had the highest population density. The high population density required new residential areas and public facilities such as schools. Besides that, there are several identified lands for the development of schools.

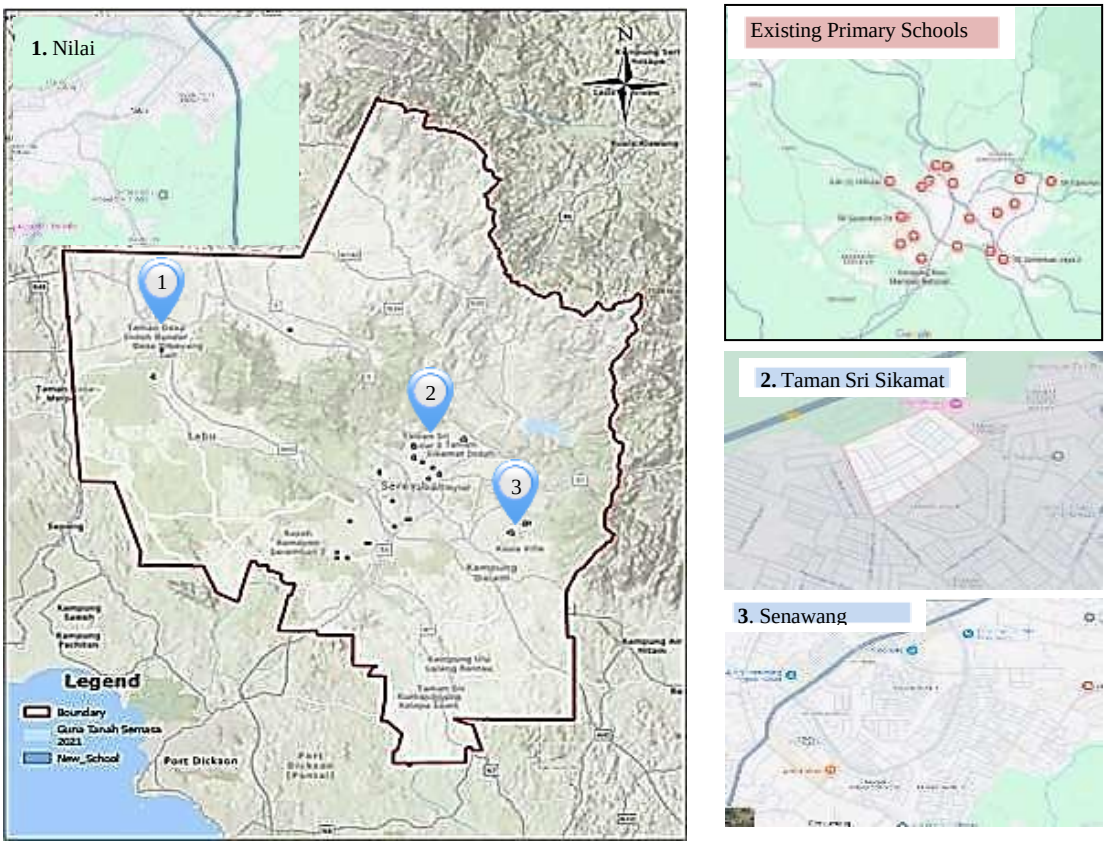

Fig. 5. Site Suitability for Proposed Primary Schools in Seremban

Source: Authors (2024)

The GIS-MCDA also identified the area because schools within the area need easy access to the residential. The requirement for access range school is stated in the guidelines as being within 800 meters of the residential area. The area is rural; the existing school cannot capture all the residential areas. The MCDA indicates that the area can be developed based on the criteria listed. However, it must indicate how

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many schools should be developed in the area. Further study has been conducted to identify how many schools are needed. This study has leveraged the capabilities of MCDA within GIS software to identify optimal land availability for the development of a new primary school (Wilson et al., 2021; Ahmed & Wang, 2022; Garcia & Martinez, 2020).

Assessing where to build new primary schools in Malaysia using the GIS-MCDA approach brings many advantages. It helps make informed decisions by considering land use, accessibility, and the environment. This ensures that schools are placed in locations that best serve the community and enhance educational access (Rahman & Ismail, 2022; Tan et al., 2023). For example, building new primary schools in Nilai and Senawang is crucial as these areas multiply. As more people move in, the need for schools is rising. Strategically placing new schools will make education more accessible, prevent overcrowding, and contribute to the overall well-being and development of the community (Ahmad & Rahman, 2021; Lim & Tan, 2023).

CONCLUSION

This study aims to identify land availability to develop a primary school by using the GIS-MCDA approach. By identifying the critical factors contributing to developing primary school placements, MCDA analysis has shown the overall suitable map result of proposed primary schools in Seremban. The influential criteria comprised land use, school, clinic, land size, density and topography or slope. This study has identified the main factors and the land availability for primary schools in Seremban, especially in the Nilai and Senawang. These places are increasing, and placing new schools will make education more accessible, prevent overcrowding, and contribute to overall well-being. The study also demonstrated the capabilities of GIS-MCDA in identifying optimal land availability for developing a new primary school. Future research could look into using real-time data, considering additional factors, and studying the long-term effects on community growth to improve decision-making and sustainability.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest regarding this article's research, authorship, and publication.

AUTHOR'S CONTRIBUTION

Amirul Asraf A Renzi conducted the research, including data collection and analysis, and wrote the article. Abdul Rauf Abdul Rasam conceptualised the central research idea, reviewed the article, supervised the research progress, and approved the article's submission.Saiful Anuar Jaafar @ Ibrahim presented the paper in the ICON BEE and revised the article in the context of GIS-MCDM analysis.Daniel Ugih and Anak Echoh have revised the article to address school site siting planning and policy.

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