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Analyzing Projections of Cemetery Land Utilization: A Case Study of Perlis State

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ABSTRACT

Cemetery land scarcity is becoming a notable urban planning challenge, particularly in land-constrained regions such as Perlis, Malaysia. In this state, local communities often wish to donate (waqf) their land for cemetery purposes. However, authorities tend to encourage these donations to be allocated for other uses, as they believe current cemetery capacity is sufficient. Without clear and transparent evidence to support this belief, differences in perception can arise between communities and authorities. Perlis Technical Report estimate sufficiency until 2035, but these are based on limited assumptions and methods, which may not capture the full range of possible scenarios. This study re-examines cemetery land longevity in Perlis using three projection models: (1) a constant average demand model based on annual cemetery land requirements from 2019–2023, (2) a demand estimation model derived from average population and mortality rates, and (3) a surplus estimation model projecting land sufficiency by balancing burial needs against existing capacity over a 30-year horizon. Projections were carried out both at the state level and for individual districts (Kangar, Arau, Kuala Perlis, and Padang Besar). The results consistently show that cemetery land sufficiency extends far beyond the 2035 estimate, with some districts such as Kangar, projected to sustain capacity up to 48 years beyond 2025. These findings demonstrate the importance of applying multiple methodological approaches to produce more reliable and adaptive cemetery land forecasts. Data-driven assessments not only provide stronger evidence for policymakers but also help reconcile differences in perception between authorities and communities, thereby preventing premature land acquisition and supporting more sustainable land management strategies.

Keywords: Cemetery land management, Burial space projection, Waqf land management

INTRODUCTION

Urban cemetery planning in Malaysia faces mounting pressure from urbanization, population growth, and competing land uses that intensify land scarcity, particularly in metropolitan areas (Mohamad et al., 2023; Bani et al., 2023). In Islamic contexts such as Perlis, these challenges are compounded by religious and cultural requirements for dedicated grave plots of specific dimensions, with no reuse permitted for 30 years (PLANMalaysia, 2023). While these customs ensure the dignity of burial practices, they also constrain land allocation flexibility. This situation demands proactive, evidence-based projections to prevent both premature shortages and inefficient land management.

The Perlis technical report (2018) estimated that existing cemetery land would be sufficient until 2035. However, this projection does not account for variations in mortality rates, population growth, or district-level land supply. Furthermore, studies indicate that some regions, including Perlis, may face an oversupply of endowed (waqf) land that is poorly aligned with zoning needs, leading to inefficient land use (Noor et al., 2023). Simplified projections that overlook these nuances risk costly planning mistakes and undermine the effectiveness of land management policies. A significant challenge also lies in the lack of systematic management and poor data integration between religious and planning authorities, which hinders effective long-term planning (Noor et al., 2023; Daud et al., 2013).

This disconnect often creates a difficult dynamic between communities and authorities. Local communities frequently wish to donate (waqf) land for cemetery use as a charitable act. In contrast, authorities may encourage these donations toward other purposes, believing cemetery capacity is adequate. Without transparent, data-driven projections, these differing perceptions can erode trust in official planning processes.

Existing research on cemetery planning typically relies on either demand-side or supply-side models. Demand-based approaches often use constant per-capita burial rates, failing to capture spatial or demographic shifts, while supply-side assessments focus on current capacity without integrating future pressures. Although the adoption of Geographic Information Systems (GIS) is improving site selection and management (Mohamad et al., 2023; Asni et al., 2020), a gap remains in applying integrated demand–supply projection frameworks in the Malaysian context. Government studies have generally used single-scenario forecasts without providing district-level analysis or alternative timelines.

This study seeks to address these gaps through three interrelated objectives: (1) to project cemetery land sufficiency for Perlis and its primary planning blocks using three distinct projection methods (two demand-based and one surplus-based); (2) to compare the results across these methods, evaluating their sensitivity to demographic trends and land-supply assumptions; and (3) to provide updated, evidence-based guidance for sustainable cemetery land allocation. The contributions to the literature are threefold: the introduction of an integrated demand–supply projection framework tailored to cemetery planning in an Islamic context; the provision of revised sufficiency timelines that, in some instances, extend well beyond prior estimates; and the delivery of district-specific insights to support targeted land allocation policies.

To achieve these objectives, the study applies three complementary methods. Method 1 employs a constant-demand model based on the average annual cemetery land requirement from 2019 to 2023. Method 2 calculates a constant demand value by applying the average mortality rate (2019–2023) to the average population over the same period. Method 3 adopts a surplus estimation approach, projecting land sufficiency by integrating burial demand with current land availability over a 30-year horizon, following the seminal work of Coutts et al. (2011). By estimating both the earliest and latest potential depletion timelines, the study produces a more comprehensive evidence base to strengthen data-driven policy, enhance dialogue between stakeholders, and promote sustainable land management.

This paper is organised as follows: the dataset is presented in Section 2; Section 3 details the projection models; Section 4 summarises the findings; and the conclusion is presented in Section 5.

DATA

This study employs demographic, mortality, and cemetery land-use data to project cemetery land requirements in Perlis. The baseline supply of cemetery land was obtained from the Perlis Technical Report (2018), which documents 66.06 hectares distributed across four planning blocks (Noor & Sabir, 2023). Population and mortality statistics for the years 2019–2023 were sourced from the Department of Statistics Malaysia (DOSM, 2023a, 2023b). These datasets were complemented with planning parameters from the Islamic Cemetery Planning Guidelines (PLANMalaysia, 2023), specifying an average grave lot size of 8.36 m² (including supporting facilities and landscaping) and a reuse cycle of 30 years.

Table 1 presents the demographic and mortality data for Perlis from 2019 to 2023. The population increased steadily from 254,000 in 2019 to 293,100 in 2023, with the Malay population forming the majority and growing from 217,700 to 251,100 over the same period. This steady growth is critical because Malay-Muslims are the primary users of Islamic cemeteries in the state (PLANMalaysia, 2023). The death rate, however, fluctuated during this period, ranging from a low of 6.8 per 1,000 population in 2020 to a peak of 8.4 in 2022, before slightly declining to 7.4 in 2023 (DOSM, 2023a). These variations provide the basis for calculating the average mortality rate of 7.66 per 1,000, which is used in cemetery land demand projections.

Table 2 outlines the distribution of cemetery land supply across Perlis in 2018. Kangar holds the largest share with 29.87 hectares, while Arau, Kuala Perlis, and Padang Besar have more modest allocations of around 12 hectares each. When compared against estimated demand, each planning block shows a deficit, with Kangar experiencing the largest shortfall of 13.77 hectares. The combined state-level shortage is projected at 22.73 hectares (Noor & Sabir, 2023). This imbalance highlights the urgency of long-term cemetery land planning, particularly in high-population areas such as Kangar.

The dataset therefore integrates demographic growth trends, mortality patterns, and land supply baselines to inform projections of cemetery land demand. While the data are robust, limitations include reliance on 2018 supply figures, potential under-reporting of burial migration (residents interred outside Perlis), and assumptions of constant growth and mortality rates in projections.

Table 1: Population and Death Rate in Perlis (2019–2023)

Year	Total Population (‘000)	Malay Population (‘000)	Death Rate (per 1,000)
2019	254.0	217.7	7.9
2020	284.9	245.9	6.8
2021	287.6	248.0	7.8
2022	289.8	249.5	8.4
2023	293.1	251.1	7.4

Source:Department of Statistics Malaysia (2023a, 2023b).

Table 2: Cemetery Land Supply in Perlis

Planning Block	Population (2018)	Supply (ha)	Demand (ha)	Surplus/Deficit (ha)
Kangar	80,481	29.87	16.10	-13.77
Arau	48,444	12.30	9.69	-2.61
Kuala Perlis	44,901	11.56	8.98	-2.58
Padang Besar	42,839	12.33	8.57	-3.76
Total	216,665	66.06	43.34	-22.73

Source: Perlis Technical Report (2018); Noor & Sabir (2023).

METHODOLOGY

This study applies quantitative forecasting to estimate cemetery land demand and identify the year of full utilization in Perlis. The analysis combines demographic, mortality, and land supply data with planning formulas and extrapolation techniques.

The formula used as follows:

1. Cemetery Land Requirement Formula

The demand for cemetery land in year *t* is calculated using the formula from the Islamic Cemetery Planning Guidelines (PLANMalaysia, 2023):

The equation is as follows:

$$C_t = P_t \times M_r \times S_z \times R_g \tag{1}$$

where C_t represents the output variable, and P_t , M_r, S_z, and R_g are multiplying factors.

- C_t = Required cemetery land in year *t*
- P_t = Population in year *t*
- M_r = Mortality rate per 1,000 individuals
- S_z = Average grave lot size (8.36 m², inclusive of facilities and landscaping)
- R_g = Grave reuse cycle (30 years)

2. Population Projection

Future population was projected using the extrapolation method by following Sadigov(2022):

$$P_t = P_0 \times (1 + r)^t \tag{2}$$

r: average population growth rate
P_t: projected population on year, t
P_0: population at the beginning of the forecast period
t: forecast period

In this study, r is Perlis average annual growth rate which is 2.19% according to (Noor & Sabir, 2023).

3. Cemetery Land Surplus or Deficit

Long-term sufficiency of cemetery land was assessed using the model of Coutts et al. (2011):

Table 3: Parameters in the formula used to calculate required cemetery acreage by Coutts et al. (2011)

Variable	Variable symbol	Variable note
Land needed or excess	L	Acres of capacity
Burial need	B	$B = d - c - bm$
Deaths	d	Deaths likely to occur over the projected period. Recommended 30 years.
Cremation or other alternative burial	c	People who contribute to local death rate but who will not require a burial plot.
Burial migration	bm	Persons who will be buried or otherwise disposed of elsewhere.
Excisting capacity	ec	Number of plots available to accommodate those choosing burial.
Plots per acre	p	Plots per acre in a typical cemetery.

Table 3 defines the variables that are involved in cemetery land surplus or needed calculation. Taking all the variables into account, it is now possible to estimate the amount of land needed for burial space. Table 3 explains the variables in the following equation:

$$L = \frac{ec - B}{p} \tag{3}$$

where burial need is

$$B = d - c - bm \tag{4}$$

A positive result reveals that capacity exceeds demand, and L is the land in acres exceeding demand for the projection period. A negative result reveals that demand exceeds capacity, and L is the land in acres needed to meet demand for the projection period.4.

4. Analytical Methods

For robustness, three methods were used:

Method 1:Constant Average Annual Demand (2019–2023):
Cemetery land demand was calculated yearly for 2019–2023 using (1), then averaged to provide a constant projection value.

Method 2: Demand from Average Population and Mortality:
This approach estimates constant cemetery land demand by multiplying the average population and average mortality rate (from 2019–2023) with Sz and Rg:

$$Ct = \overline{P_t} \times \overline{M_r} \times Sz \times Rg$$

Unlike Method 1's averaged results, this method smooths out annual variation by directly applying mean demographic data.

Method 3 :Acreage-Based Land Sufficiency:

The procedures for the method is as follows:

a. An initial land surplus (L) is calculated for the 30-year period from 2019 to 2048 using the Coutts et al. (2011) model.
b. This surplus is treated as the available land supply from the year 2049 onwards.
c. This supply is then depleted annually using the constant demand figure from Method 1 until it reaches zero, which determines the final year of full utilization.

5. Assumptions and Limitations

The methods assume:

i. Mortality and growth rates remain constant throughout the forecast period.
ii. The average grave lot size (8.36 m^2) is uniformly applied.
iii. Burial migration and cremation are negligible in the Perlis context.

Limitations include reliance on 2018 land supply data, exclusion of cultural variations in burial practices, and the inherent uncertainties of long-term demographic forecasting.

To enhance the robustness of projections, three complementary methods were applied. Each method varies in how cemetery demand is estimated, either through annual averages, smoothed averages, growth-adjusted dynamics, or acreage-based sufficiency analysis. The key differences between these methods, including their formulas, assumptions, and data inputs, are summarized in Table 4 below.

Table 4: Key Differences Between Each Method

Method	Description	level	Formula Applied	Key Data Inputs	Assumption	Reference	Projection Iteration
Method 1	Cemetery land demand calculated yearly for 2019 to 2023 and averaged	State	$t = 2019, \ldots, 2023$ $C_t = P_t \times M_r \times S_z \times R_g$	Population by year, P_t Annual mortality rate, M_r	For the next calculation, the averaged land demand, $\bar{C}_t$ from year 2019 to 2023 is constantly used as land demand for each year, t	(PLANMalaysia, 2023)	$t = 2019, 2020, \ldots, 2023$ $\text{surplus}_\text{t} = \text{supply}_\text{t} - \text{demand}_\text{t}$ $\text{supply}_{t+1} = \text{surplus}_\text{t}$
		District	$t = 2019, \ldots, 2023$ $P_t = P_{2018} \times (1 + 0.0219)^t$ $C_t = P_t \times M_r \times S_z \times R_g$	Extrapolation method applied Population by year, P_t Annual mortality rate, M_r			
Method 2	population and mortality rate (2019–2023) are averaged and multiplied with Sz and Rg	State	$t = 2019, \ldots, 2023$ $C_t = \overline{P_t} \times \overline{M_r} \times S_z \times R_g$	Average population (2019-2023), $\overline{P_t}$ Average death rate (2019-2023), $\overline{M_r}$	For the next calculation, land demand is the C_t computed after averaging the population and		
		District	$t = 2019, \ldots, 2023$ $P_t = P_{2018} \times (1 + 0.0219)^t$ $C_t = \overline{P_t} \times \overline{M_r} \times S_z \times R_g$	Extrapolation method applied Average population (2019-2023), $\overline{P_t}$ Average death rate (2019-2023), $\overline{M_r}$			

						mortality rate (2019-2023)		
Method 3	land surplus is determined using the model of Coutts et al. (2011)	State and district	Land surplus or deficit	$L = \frac{ec - B}{p}$	Area of land available in 2018 Average death rate (2019-2023), $\overline{M_r}$ Extrapolation method applied Average size of 1 plot	L is the land supply starting 30 years after 2019 while land demand is same as in method 1	(Coutts et al., 2011)	Using demand from Method 1, $t = 2049, 2050, 2051, \ldots$ $\text{surplus}_\text{t} = L_t - \text{demand}_\text{t}$ $L_{t+1} = \text{surplus}_\text{t}$
			Burial need	$B = d - c - bm$				
			Existing capacity	$ec = \frac{\text{available acres for burial}}{\text{acreage per plot}}$				
			Plots per acre	$p = \frac{1 \text{ acre}}{\text{acreage per plot}}$				
			Deaths	$d = \text{resident} \times \overline{M_r} \times 30 \text{ years}$				

RESULT AND DISCUSSION

1. State-Level Projections

The projection results for cemetery land depletion in Perlis reveal a high degree of consistency between Method 1 and Method 2. Both models forecast that the available land will be fully utilized by the year 2061, affording a 36-year operational lifespan from 2025 (Table 6). The convergence of these two distinct methods strengthens the reliability of this 2061 projection.

Conversely, Method 3 presents a more conservative estimate, forecasting land depletion by 2064, which is three years later than the other projections. This later date suggests that the variables or assumptions inherent in Method 3 (e.g., lower mortality rate projections, higher land-use efficiency) result in a slower rate of land consumption. Figure 1 visually contrasts these timelines, clearly depicting the consensus between the first two methods and the more optimistic, extended timeline projected by Method 3.

Table 5: Summary of projected cemetery land depletion year for Perlis

Method	Depletion Year	Years from 2025
Method 1	2061	36
Method 2	2061	36
Method 3	2064	38

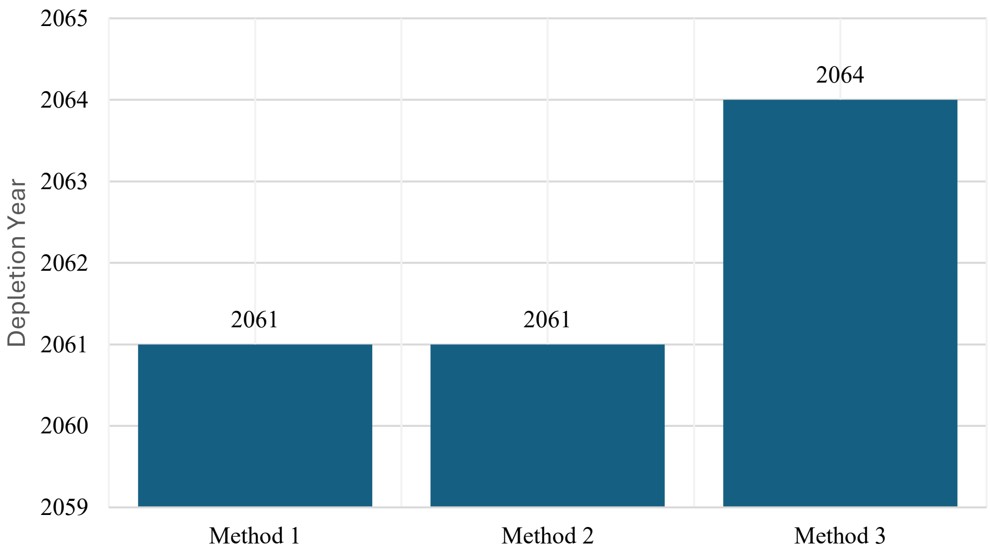

Figure 1: Projected cemetery land depletion year for Perlis

2. District-level projections

In Method 1, the demand for cemetery land was estimated and projected to determine when each district would fully utilize its burial space. The results from Table 6 show that Kangar is expected to have the longest usage period, with its land lasting until 2073 (48 years from 2025). Padang Besar is estimated to reach full capacity by 2061, which gives them another 36 years of usage. Meanwhile, Arau and Kuala Perlis are projected to run out of cemetery land earlier, by 2056, giving them only 31 more years.

Table 6: District level result for Method 1

District	Demand, $\overline{C_t}$ (acre)	Depletion Year	Years from 2025
Kangar	1.360147	2073	48
Arau	0.818715	2056	31
Kuala Perlis	0.758837	2056	31
Padang Besar	0.723989	2061	36

Method 2 produces results identical to Method 1, indicating consistency in the assumptions or calculations used between these two approaches. According to Table 7, the year of full utilization and demand estimates for all districts remain the same which is Kangar by 2073**,** Perlis and Padang Besar by 2061**,** and Arau and Kuala Perlis by 2056.

Table 7: District level result for Method 2

District	**Demand, C_t (acre)**	**Depletion Year**	**Years from 2025**
Kangar	1.360147	2073	48
Arau	0.818715	2056	31
Kuala Perlis	0.758837	2056	31
Padang Besar	0.723989	2061	36

Method 3 incorporates both demand and supply to assess land sufficiency, making it the most comprehensive method. It confirms a surplus of cemetery land in all four districts after 30 years of projection. The analysis reveals that each district will still have significant remaining land after 30 years based on year 2018.

Based on Table 8, Kangar will still have around 34.8306 acres remaining, Arau and Kuala Perlis will each retain 6.9050 acres and 6.812 respectively, and Padang Besar will have roughly 9.7066 acres of cemetery land left after 30 years.

As a result, the land is expected to last until 2074 for Kangar. Arau and Kuala Perlis are expected to last until 2057 while Padang Besar will last up to year 2062. This method emphasizes that there is no critical shortage of land. Plus, the current cemetery areas are enough to meet future needs for at least the next few decades.

Table 8: District level result for Method 3

District	**Supply, L (acre) after 2047**	**Surplus/ Needed**	**Demand, $\overline{C_t}$ (acres)**	**Depletion Year**	**Years from 2025**
Kangar	34.8306	Surplus	1.360147	2074	48

Arau	6.9050	Surplus	0.818715	2057	31
Kuala Perlis	6.812	Surplus	0.758837	2057	31
Padang Besar	9.7066	Surplus	0.723989	2062	36

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In summary, the study was conducted at the district level, revealing significant differences in the lifespan of cemetery land among the districts in Perlis. As presented in Table 10, the projections from the three methods are highly consistent. For every district, Method 1 and Method 2 predict the same depletion year, while Method 3 consistently predicts a depletion year that is one year later. This consistency across the models suggests the overall forecast is reliable.

The most important finding is the large difference in land availability between the districts. Kangar shows the highest sustainability, with its cemetery land projected to be sufficient until 2073 or 2074, which provides local authorities with a long planning period of nearly 50 years. In contrast, the situation in Arau and Kuala Perlis is more urgent, as both share the earliest projected depletion dates of 2056-2057. This indicates their land will be fully utilized in approximately 31 years, highlighting an immediate need for strategic land management. The forecast for Padang Besar is intermediate between these extremes, with land depletion expected in 2061-2062.

These differences are visually represented in Figure 2. In conclusion, this district-level analysis successfully identifies specific localities namely Arau and Kuala Perlis in which require urgent attention and planning from policymakers to prevent a future shortage of burial land.

Table 9: Projected cemetery land depletion year by district and method

District	Method 1	Method 2	Method 3
Kangar	2073	2073	2074
Arau	2056	2056	2057
Kuala Perlis	2056	2056	2057
Padang Besar	2061	2061	2062

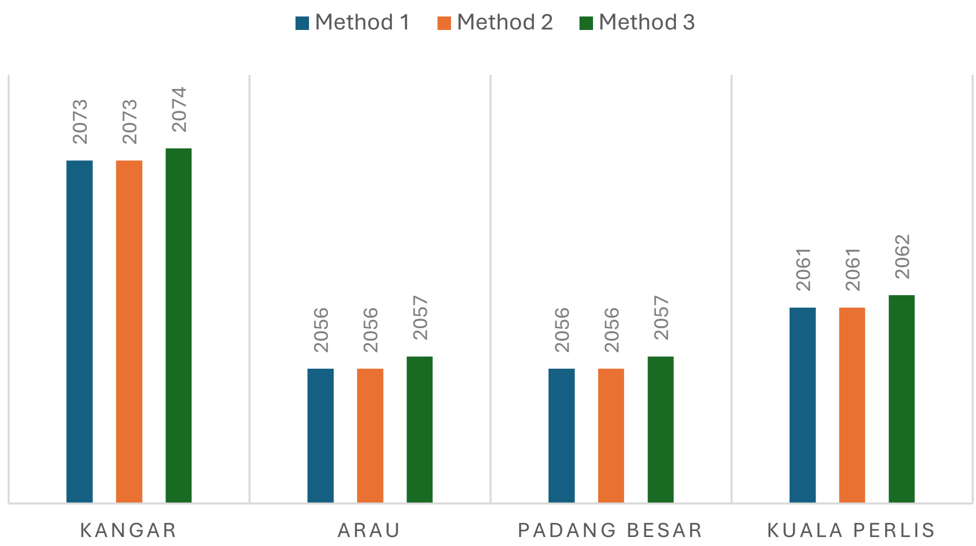

Figure 2: Projected cemetery land depletion year (district level)

CONCLUSIONS

This study re-examined cemetery land sufficiency in Perlis using three complementary projection methods that combined demographic, mortality, and land supply data. The results consistently indicate that existing cemetery land can sustain burial needs well beyond the 2035 depletion year estimated in earlier official reports. At the state level, the sufficiency horizon extends to at least 2061 under demand-based methods and up to 2064 under surplus-based projections, offering between 36 and 38 years of capacity from 2025. District-level analyses reveal important variations: Kangar shows the most sustainable outlook with capacity lasting until 2073–2074, while Arau and Kuala Perlis are projected to face depletion earlier, by 2056–2057. Padang Besar falls in between, with sufficiency until 2061–2062.

These findings underscore two key insights. First, cemetery land sufficiency in Perlis is more secure than previously assumed, reducing the urgency for immediate land acquisition or diversion of waqf donations for burial purposes. Second, district-level disparities highlight the need for localized planning, as certain areas may face earlier constraints despite overall state-level adequacy.

By employing multiple projection approaches, this study demonstrates the value of robust, data-driven methods in enhancing the transparency and reliability of cemetery land forecasts. Such evidence not only supports sustainable land management but also helps bridge the perception gap between local communities and authorities. Future research should incorporate updated land supply data, dynamic mortality trends, and cultural practices to further refine projections and strengthen long-term cemetery planning strategies.

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REFERENCES

Asni, F., Mahamud, M., & Sulong, J. (2020). Socio-economics and management of Muslim cemetery waqf using istibdal and GIS method in Penang state. *Journal of Islamic Accounting and Business Research*, **11(7)**: 1343–1362.

Bani, N., Azman, M., Rosli, N., Soffian, N., Ahmad, A., & Arip, M. (2023). Land availability and requirement on Islamic cemetery at Kampung Tokai, Pendang. *International Journal of Law, Government and Communication*, **8(32)**: 101–112.

Coutts, C., Basmajian, C., & Chapin, T. (2011). Projecting landscapes of death. *Landscape and Urban Planning*, **102(4)**: 254–261.

Daud, M., Shafiqah, N., Sulaiman, N., & Ahmad, M. A. (2014). Issues and challenges in Muslim cemetery management (MCM) in Malaysia. In *Proceedings of the International Real Estate Research Symposium 2014*. National Institute of Valuation.

Department of Statistics Malaysia. (2023a). *Population dashboard (Perlis, 2019-2023)*. https://open.dosm.gov.my/dashboard/population/pls

Department of Statistics Malaysia. (2023b). *Population by state and ethnicity (Perlis, 2019-2023)*. https://open.dosm.gov.my/data-catalogue/population

Mohamad, F., Maulud, K., & Taib, A. (2023). Modelling of geospatial data through multi criteria analysis for cemetery land management. *IOP Conference Series: Earth and Environmental Science*, **1167(1)**: 012051.

Noor, N. B. M., & Sabir, N. S. K. (2023). Geospatial technologies approach for cemetery management solutions: A review. *Jurnal Planologi*, **20(2)**: 105–118.

PLANMalaysia. (2018). *Draft Kangar Municipal Council Local Plan 2035 (Replacement)*. Author.

PLANMalaysia. (2023). *Islamic Cemetery Planning Guidelines*.

Sadigov, R. (2022). Rapid growth of the world population and its socioeconomic results. *The Scientific World Journal*, *2022*, Article 8110229. https://doi.org/10.1155/2022/8110229