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Spaces for the living and the dead: Optimising cemeteries as sustainable urban green spaces

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Abstract: Being one of the major cities in Indonesia, Makassar is experiencing rapid growth but struggles to meet the statutory minimum requirement of 20% public green open space, achieving only 5.95%. At the same time, there is a pressing need for cemetery land, with projections indicating a shortage from 2023 to 2027. Cemeteries, as integral components of urban green space, present an opportunity to address both green space and burial land needs. This study examines the physical and spatial conditions, community opinions, and government regulations regarding Makassar's cemeteries. The analysis aims to develop strategies for enhancing traditional burial system cemeteries, reflecting the faith of the majority, as functional green spaces, while at the same time increasing their burial capacity. Findings reveal that vegetation cover across all cemeteries in Makassar is only 25.5%, and 29.2% for government-managed ones, both far below the required 80%. This necessitates urgent need to increase vegetation. To maximise green space, the study suggests specific planting patterns that enable the addition of the most trees and provide the highest potential vegetation cover. For Islamic cemeteries, a regular planting pattern using medium-sized trees placed every two rows of graves is recommended to maintain order and symmetry. In contrast, for Christian cemeteries, a more random planting pattern is advised to reflect diversity. Small trees are suggested along roadways and pathways, while large trees should be planted wherever space allows. Implementing these patterns in government-managed cemeteries could increase vegetation cover in Makassar's public cemeteries from 29.2 to 57.5%. Additionally, the careful selection of appropriate vegetation types is crucial to achieving these goals.

Keywords: graveyard capacity, graveyards, green open spaces, planting pattern, vegetation cover

INTRODUCTION

An increase in population results in a growing demand for urban infrastructure to fulfil cities' physical, economic, and social needs (Iswoyo, Dariati and Junardi, 2020). As a result, land use is shifting from green open spaces to built-up areas (Gauk, Yudono and Umar, 2009; Iswoyo *et al.*, 2018; Iswoyo *et al.*, 2019; Iswoyo *et al.*, 2020). Being the largest city in eastern Indonesia, with a population of 1,474,393 living in the total area of 175.77 km^2 (Yafendi (ed.), 2023), Makassar experiences the common challenge of growing cities in the developing world (Busrah, Robert and Lululangi, 2019). The availability of urban green open space has an important role, as it affects environmental quality (Wolch, Byrne and Newell, 2014), helps to shape city structure (Mawardah and Mutfianti, 2013), and serves important ecological functions (Jim and Chen, 2006; Iswoyo *et al.*, 2018; Juita, Lumangkun and Dewantara, 2016; Santoso and Astuti, 2019). It also contributes to maintaining the harmony and balance of urban environmental ecosystems (Adiyanta, 2018), and supports the balance between the natural and built environments in urban areas (Mahendra, 2022). Green spaces not only make cities healthier and more liveable place but also enhances their beauty,

cleanliness, and overall comfort (Hamrun and Prianto, 2007; Zaznobina, 2023; Chen and Filzani, 2024).

Most cities in Indonesia, including Makassar, have not been able to fulfil the obligation of allocating 30% of their area to green space, consisting of 20% public and 10% private greenspaces (Hidayansyah, 2007; Undang-Undang, 2007; Iswoyo, Vale and Bryant, 2011). In Makassar, the area of public green space is only 1,044.98 ha, accounting for approximately 5.95% of the city's total area (Kurnianti, 2020; Yanti, 2022).

One form of green open space in urban areas is public cemeteries (Peraturan, 2007). In Makassar, the City Parks and Cemetery Service manages seven public cemeteries, covering a total area of 367,452 km^2 (Nukmawati, Mappamiring and Mone, 2017). However, these public cemeteries have not been optimally utilised as green spaces (Peraturan, 2015; Fahmiah, 2022). The demand for burial space in Makassar is quite high due to population growth, which is directly proportional to the number of deaths (Kartini, As and Surur, 2019). This issue is common across public cemeteries in Indonesia, where the high density of graves often leaves little space for trees (Fahlevi, 2013). As a result, the open space in cemeteries is generally left barren or planted with only a few types of vegetation (Wulandari, 2014), limiting the landscape potential to function effectively as urban green space (Zain *et al.*, 2020).

The optimisation of cemeteries as green spaces is a concern not only in developing countries like Indonesia but also in developed nations such as Canada. Despite their vegetative characteristics, cemeteries are often overlooked in discussions on green space planning and management (Quinton and Duinker, 2019). Similar neglect has been observed in Budapest (Sallay *et al.*, 2023). However, initiatives to integrate cemeteries into green open space planning have emerged in the United States (Rae, 2021), whereas in Istanbul, the cemeteries have been considered an important sanctuary for plant diversity (Yılmaz, Kuşak and Akkemik, 2018; Itescu and Jeschke, 2024).

Cemeteries are complex spaces that carry a multitude of meanings and functions (Rae, 2021). In Indonesia, cemeteries primarily provide a culturally sacred places where the living can honour and remember the deceased (Hidayatulloh, 2022). Cemeteries are important historical and cultural landscapes, imbued with sacred and social meanings that allow for multi-functional community use (Harvey, 2006; McClymont, 2016). As such, cemeteries hold historical, cultural, personal, social, and sacred value within a community (Rae, 2021).

Previous studies have examined aspects of the availability of public cemeteries as green open spaces (Alam and Warlina, 2019). With increasing population density, cemeteries can provide valuable green spaces in urban environments (Wulandari, 2014; Adriyanto, 2016). Harvey (2006) explained that cemeteries can be developed into multipurpose landscapes supporting urban ecological functions. Rae (2021) examines the potential of cemeteries as one of practical solutions for green open space in highly built-up areas. Triharto (2021) and Adryanto (2016) discussed the suitability of locations for the development of public cemeteries. In addition to these spatial studies, policy aspects have also been highlighted in several studies related to cemeteries. Various government and regional regulations have regulated public cemeteries (Fernando, 2016; Alam and Warlina, 2019). Some other examine the implementation of public policies in the management of public cemeteries (Riswan, 2023), related to retribution paid (Larasti, 2017), to strategies for stabilising the cemetery's position as a green open space (Fahrul, Siregar and Sukendi, 2020).

Additionally, several studies have highlighted cemeteries as part of green open space, while also addressing various problems, such as increasingly limited land availability (Hapsari, Windya and Krisdianto, 2016; Resal and Soemardiono, 2022), and the negative public perceptions they carry (Loho, Siregar and Egam, 2017). Cemeteries are often viewed as a "spooky" places (Hapsari, Windya and Krisdianto, 2016), which contributes to general reluctance among Indonesians to consider them as recreational spaces (Sudiro and Suhardjo, 2020). Instead, they are rather associated with spiritual purposes (Rosada and Wawansyah, 2018; Hikmah, 2022; Sari and Sari, 2024). Due to their designated status as greenspace, the ecological function of cemeteries becomes increasingly relevant. Nevertheless, efforts are being made in Indonesia to make cemeteries more attractive for public visitation, for example by integrating them with other attractions like museums (Pratama and Prijotomo, 2016), or introducing unique conceptual designs (Resal and Soemardiono, 2022).

Most previous studies have focused on the potential of cemeteries as green spaces. Similarly, this paper addresses that issue, with the added concern of the diminishing carrying capacity of cemetery land in major cities. This matter is taken into consideration in the development of strategies for revitalising public cemeteries through policy, spatial arrangement, and the use of vegetation. This paper provides an analysis of the potential of public cemeteries to enhance green open space while accommodating the demand for burial land. The expected outcome of this study is the formulation of recommendations for models/designs and appropriate strategies to maximise the public cemeteries in Makassar. This strategy is expected to produce management policy recommendations that are adaptive to various situations and conditions at public cemeteries in Makassar. However, modifying existing cemeteries, which are already densely occupied, presents significant challenges and substantial financial costs. Consequently, the suggestions put forth in this paper are more appropriate for implementation in newly designated cemetery sites through government planning, or as pilot projects within selected sections of existing cemeteries.

MATERIALS AND METHODS

RESEARCH DESIGN

This study employed an analysis of respondent data collected through questionnaires. Additionally, quantitative data related to the area size and vegetation cover at the study site are also presented. The physical aspects of each government-managed cemetery were assessed in detail to collect data on vegetation, cemetery layout, and the general physical condition of the tombs. Vegetation cover data were obtained for all cemeteries in Makassar, regardless of their management status. Secondary data were utilised to estimate the capacity and to project the carrying capacity of cemeteries. The analysis of vegetation and cemetery capacity focused specifically on government-managed cemeteries, as the policy recommendations derived from this study are intended for implementation within those cemeteries.

DATA COLLECTION, SOURCE, AND ANALYSIS

Data collection techniques included: 1) field observation, 2) interviews with relevant parties, in this case with the Makassar City Parks and Cemetery Service, the manager of the cemetery, and 3) distribution of questionnaires to residents of Makassar, both online and offline. Additional information was obtained and analysed from previous studies and government documents, including records on the number and total area of public cemeteries in Makassar.

The research included public cemeteries representing Muslims, Christians, and Chinese communities (Tab. 1). Interviews and focus group discussions were conducted with cemetery managers from the Makassar City Parks and Cemetery Service, managers of the selected cemeteries. Questionnaires were distributed to gather primary data. Population sampling was random, and the study administered questionnaires were administered to the selected respondents. Of the total population of 1,474,393, 89% are Muslims, 10% are Christian, and 1% are Buddhist, the latter group consisting predominantly of individuals of Chinese descent (Yafendi (ed.), 2023). The proportion of respondents from each group reflected this population distribution. However, since there are no government-managed Chinese cemeteries in the city, this study recommendations for the cemetery layout and policy apply only to Muslims and Christian cemeteries under government management.

Physical and biophysical data were analysed for problems and potential, vegetation needs in public cemeteries were analysed considering land area, cemetery density, and vegetation type. The spatial layout of public cemeteries was analysed using data from the Makassar city government and aerial photographs, which provided information on cemetery distribution and vegetation conditions. Vegetation analysis evaluated suitability for supporting green spaces (Wibowo, Krisdianto and Gunawan, 2017), ensuring that it would not damage existing tomb structures. The assessment focused on physical, aesthetic, and ecological aspects (Fahrul, Siregar and Sukendi, 2020).

The survey evaluated the implementation of government regulations related to cemetery design and maintenance. The study also sought community opinions on possible actions to enhance public cemeteries as functional and aesthetic green spaces. The projection analysis of Makassar city's cemetery needs aimed to assist government planning by analysing demand for cemetery land based on population growth and death rates. The goal is to ensure proper land allocation for cemeteries while complying with laws and regulations, and to help predict cemetery capacity based on population projections and mortality rates.

Furthermore, residents of Makassar city shared their opinions on the current condition of the public cemeteries. Satisfaction levels were analysed using a scoring system ranging between 1 (very unsatisfied) and 10 (very satisfied), and public preferences were evaluated based on their approval of various related aspects.

RESULTS AND DISCUSSION

SPATIAL COVERAGE OF PUBLIC CEMETERIES IN MAKASSAR CITY

Makassar city has seven public cemeteries managed by the city government, covering 363,200 m^2 across various sub-districts. The contribution of these cemeteries to Makassar city's green open spaces is detailed in Table 2 and shown in Figure 1.

Table 2 shows that, besides the seven public cemeteries managed by the Makassar City Government, there are other cemeteries managed by community groups, foundations, or families, based on location, ethnicity, religion, or family ties. Figure 1 indicates these that these cemeteries are evenly distributed throughout the city. When compared to the area of the entire city, the presence of these cemeteries contributes 0.5% to the city's green space. In terms of vegetation coverage within cemetery area, the average vegetation cover is 25.5% for all

Table 1. Data variables and collection in the study

Variable	Data source	Data collection and processing	Presented result
Cemetery location and area	government documentation	data retrieval/ extraction from government documentation	map and table of cemeteries data
Vegetation cover	geographic locations of the government-managed cemeteries	digitalisation of aerial photographs of all cemeteries in the city	vegetation cover data presentation
Types of vegetation	managers or operators of government-managed cemeteries	field survey	vegetation data table
Perception and preferences	Makassar dwellers as respondents	field survey	perception and preferences data table
Cemetery capacity consideration	previous study documentation	– capacity formulation based on existing and previous study – FGD with related stakeholder discuss option for capacity enhancement	– table of capacity – recommendation related to capacity enhancement
Planting layout	– previous study documentation – government standard – table of capacity	data and standard were used as basis for layouting the recommended siteplan	planting siteplan
Vegetation requirement	planting siteplan	data review	vegetation quantity table

Source: own elaboration.

Table 2. Names, areas, and locations of government and non-government public cemeteries in Makassar city

Cemetery in the city of Makassar	Cemetery area (m^2)	Vegetation cover area (m^2)	Vegetation cover (%)	District
Government-managed cemeteries				
Islam Sudiang Raya	115,900	34,000.0	29.3	Biringkanaya
Kristen Panaikang	52,000	13,600.0	26.2	Panakukang
Islam Paropo	50,600	17,100.0	33.8	Panakukang
Islam Beroanging	54,400	13,200.0	24.3	Tallo
Islam Maccini	11,100	4,500.0	40.5	Makassar
Islam Dadi Kel. Maricaya	45,500	13,000.0	28.6	Mamajang
Kristen Pannara	33,700	10,700.0	31.8	Manggala
Government cemeteries total	**363,200**	**106,100.0**	**29.2**	
Non-government cemeteries total	**573,363**	**132,953.2**	**23.2**	
Total cemeteries of the city	**936,563**	**239,053.2**	**25.5**	

Source: own study.

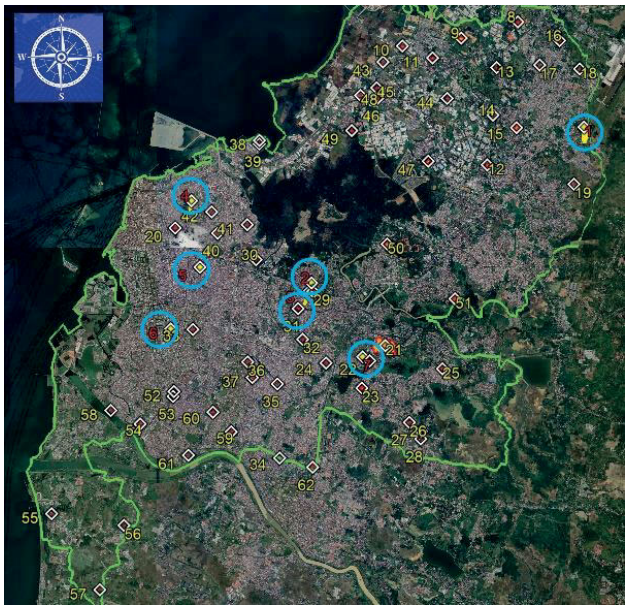


Fig. 1. Distribution of public cemeteries in Makassar city (blue circled are the government-managed cemeteries); source: own elaboration based on Google Earth – 2024

cemeteries and 29.2% for government-managed ones, both figures falling below the 80% minimum standard set by the Ministry of Public Works. The physical appearances of the three different faith-based cemeteries are shown in Photo 1.

OBSERVATION OF CEMETERIES PHYSICAL APPEARANCE

Based on field observations, the burial arrangements of the three religious groups – Islam, Christianity, and Chinese traditions – have distinct characteristics. Islamic cemeteries tend to have a relatively compact arrangement of graves and lower grave structures. In contrast, Christian and Chinese cemeteries have often larger grave sizes, and more elaborate structures, sometimes even including roofs over the graves (Photo 1). These differences in grave structure and spatial layout across Islamic, Christian, and Chinese cemeteries are influenced by religious teachings, socio-

Photo 1. Physical appearance of the cemeteries: a) Islamic, b) Christian, c) Chinese (photo: *H. Iswoyo*)

cultural practices, and economic factors. In Islamic tradition, simplicity in burial is emphasised. Muslims are discouraged from spending lavishly on memorial monuments, as excessive display of wealth in death contradicts the principle of humility promoted in Islam (Ismail *et al*., 2017). Omer (2008) further highlights that the construction of grand monuments over graves is viewed as wasteful and contrary to Islamic values. However, the degree to which these precepts are followed often depends on individual belief and intention, making grave styles a matter of personal choice. This general preference for modesty aligns well with the concept of memorial parks, where uniform and low-profile grave structures are more acceptable than in traditional public cemeteries (Reza and Alfa, 2018).

In contrast, Christian and Chinese (Buddhist) burial practices tend to exhibit a broader range of structural expressions. The construction of monumental grave structures is common across many cultures, including among Muslims, and is influenced not only by religious doctrine but also by socio-economic status (Francis, 2003). In Chinese cemetery traditions, the size, elevation, and design of graves are shaped by both spiritual beliefs and economic considerations. In some communities, elevated graves are believed to bring the deceased closer to the deities, thereby conferring spiritual merit. Simultaneously, the style and prominence of a grave often reflect the financial capacity of the deceased's family. The high cost of grave plots, particularly those located on elevated terrain, makes burial location and monument scale a marker of social status. Families with greater financial means are more likely to construct elaborate and elevated graves, whereas those with limited resources often resort to burying their loved ones in less prominent areas, such as the lower parts of hills (Ramli *et al.*, 2018). Historically, Chinese tombs were even designed to resemble houses, underscoring the connection between domestic space and the afterlife. This socio-spiritual stratification is further exemplified using *mingqi*, or bright utensils, which are specially crafted burial objects intended to serve the deceased in the afterlife. During early medieval China, *mingqi* practices were reinterpreted through a Buddhist lens, reflecting a synthesis of spiritual beliefs and material expressions. Among the most prominent were miniature architectural models, including multi-story towers, that featured intricate representations of wooden structural elements such as post-and-lintel frames and *dougong* brackets. These models, which were commonly found in tombs from the Eastern Han dynasty onward, have been interpreted as symbolic watchtowers, spaces for scenic enjoyment, or metaphoric representations of immortal dwellings, further illustrating how spiritual ideology and economic capacity jointly influenced burial traditions (Yu, 2021).

OBSERVATION ON VEGETATION TYPE AND COVER

Vegetation within cemetery areas is quite diverse as described in Table 3. The table presents an overview of the most common vegetation types found in Makassar's public cemeteries, highlighting their botanical names, growth characteristics, and functional benefits. It categorises trees and plants based on their projected crown width, optimal height, and their primary contributions to the landscape. These functions include shading, aesthetics, ecological benefits, and production, demonstrating how different species serve various roles in enhancing the cemetery environment. The table also indicates the suitability of each species for specific functions, marking them as either dominant or supportive in physical, aesthetic, and ecological aspects.

Table 3. Most common vegetation types and purposes in Makassar's public cemeteries

Botanical name	Projected crown width (m)	Optimal tree height (m)	Vegetated landscape function	Dominant suitability[1)]		
				physical	landscape/ aesthetics	ecological
Acacia auriculiformis	10–15	16–30	shading	+	+	
Pterocarpus indicus	12	16–30	shading		+	+
Bambusa vulgaris	6	15	conservation	+		
Neololeba atra	1.8–3.0	2.0–3.5	conservation		+	
Averrhoa bilimbi	3–6	10	production	+		
Bougainvillea glabra	1–1.5	3	aesthetics	+	+	
Lagerstroemia speciosa	12	20	shading, aesthetics	+	+	
Syzygium cumini	1–10	12–30	shading and production		+	
Syzygium aqueum	5–10	5–8	production	+	+	
Psidium guajava	3–6	10	production	+	+	
Citrus aurantifolia	2.4–3.6	2–4	production	+	+	
Plumeria sp.	4	7	aesthetics	+	+	
Plumeria obtusa	4.5–9.0	7–9	aesthetics	+	+	
Plumeria rubra	8–10	7–8	aesthetics	+	+	
Moringa oleifera	3.0–4.5	10	shading	+	+	
Bougainvillea glabra	1.0–1.5	3	aesthetics		+	

cont. Tab. 3

Botanical name	Projected crown width (m)	Optimal tree height (m)	Vegetated landscape function	Dominant suitability[1)]		
				physical	landscape/ aesthetics	ecological
Muntingia calabura	3–6	3–12	birds inviters	+	+	
Terminalia mantaly	10–15	10–20	shading		+	
Samanea saman	20–30	25	shading		+	+
Washingtonia robusta	5–7	15–30	aesthetics		+	
Swietenia macrophylla	15–20	40	aesthetics			+
Mangifera indica	10	30–35	production		+	
Musa paradisiaca	2–4	1–3	production		+	
Ceratonia siliqua	6	7–15	shading	+		
Ceiba pentandra	6–18	60	shading		+	+
Syzygium polyanthum	6	30	shading		+	
Mimusops elengi	10	15	shading	+	+	+
Alstonia scholaris	10	10–30	shading			+
Handroanthus chrysotrichus	7–8	6–15	aesthetics and shade	+	+	

[1)] **S**uitability prescribed by the government as general function of the plants as landscape element, not specifically for cemetery areas (Peraturan, 2008; Peraturan, 2022).
Source: own study.

The diversity of vegetation in these cemeteries plays a crucial role in creating a balanced and sustainable green space. Shade-providing trees like acacia (*Acacia auriculiformis*) and rain tree (*Samanea saman*) contribute to cooling and comfort, while ornamental plants such as *Bougainvillea glabra* and *Plumeria* sp. enhance visual appeal. Additionally, productive trees like mango (*Mangifera indica*) and guava (*Psidium guajava*) add practical value by yielding fruits. The inclusion of conservation-oriented species, such as bamboo (*Bambusa vulgaris*), further supports ecological stability, emphasising the importance of selecting appropriate vegetation to optimise both the functional and aesthetic qualities of public cemeteries in Makassar.

The suitability of the vegetation types presented in Table 3 was assessed based on their physical, ecological, and landscape/ aesthetic functions. From a physical standpoint, the vegetation is considered suitable as its placement in the cemetery does not result in structural issues, such as damage to pavement surfaces, roads, and buildings. Aesthetic suitability aligns with the known landscape function, which is specific vegetation characteristic. The vegetation landscape function presented in the study includes the functions of plants as mentioned in government standards (Peraturan, 2012; Peraturan, 2022) and is often taken into consideration while selecting plant species for landscapes (Schutzki, 2005).

The vegetation identified in study site provides basic environmental services, such as CO_2 sequestration (Iswoyo, Dariati and Herdijono, 2019; Ratag, 2017) and provision of oxygen (Sesanti, Kurniawan and Anggraeni, 2012), as well as shade that contributes to more comfortable microclimate, especially during hot tropical summer. Additionally, some tree species in study area produce fruit for local people as additional benefits. The role of vegetation and the green open spaces it forms have also been extensively studied in various countries, including the United States (Rae, 2021), Canada (Sallay *et al*., 2022), and Europe (Skår, Nordh and Swensen, 2018).

As green spaces, public cemeteries are expected to offer ecological benefits by providing vegetative cover that functions as the city' "lungs" through their photosynthetic oxygen production. To be able to carry out this function, regulations (Peraturan, 2008) stipulate that public cemeteries should have a minimum vegetation cover of 80%. However, in Makassar, the total vegetation cover across the 936,563 m^2 cemetery area is only 239,053.2 m^2, or 25.5%. In other countries, natural burials that incorporate traditional tombs, such as those found in the study area, are still considered to provide greater contributions to cultural ecosystem services (Clayden *et al*., 2018).

Vegetation cover in the study area is predominantly composed of tree species (Tab. 3). The structure of urban tree vegetation has been identified as the most significant contributor to essential ecological functions. In addition to serving as the city's lungs (Ruliyansyah and Fitrianingsih, 2013; Samsuri, Zaitunah and Rajagukguk, 2021), urban trees support biodiversity conservation (Kowarik *et al*., 2016) by providing semi-natural habitats (Sallay *et al*., 2023), and can even serve as remnants of urban forest ecosystems (Pirnat and Hladnik, 2016).

COMMUNITY PERCEPTIONS AND PREFERENCES

The respondent profile, as seen in Figure 2, shows the results of the community's assessment regarding public cemeteries managed by the Makassar City Government, as well as the Chinese public cemetery managed by a private foundation. The largest age group among the respondents was 26–40 years, accounting for

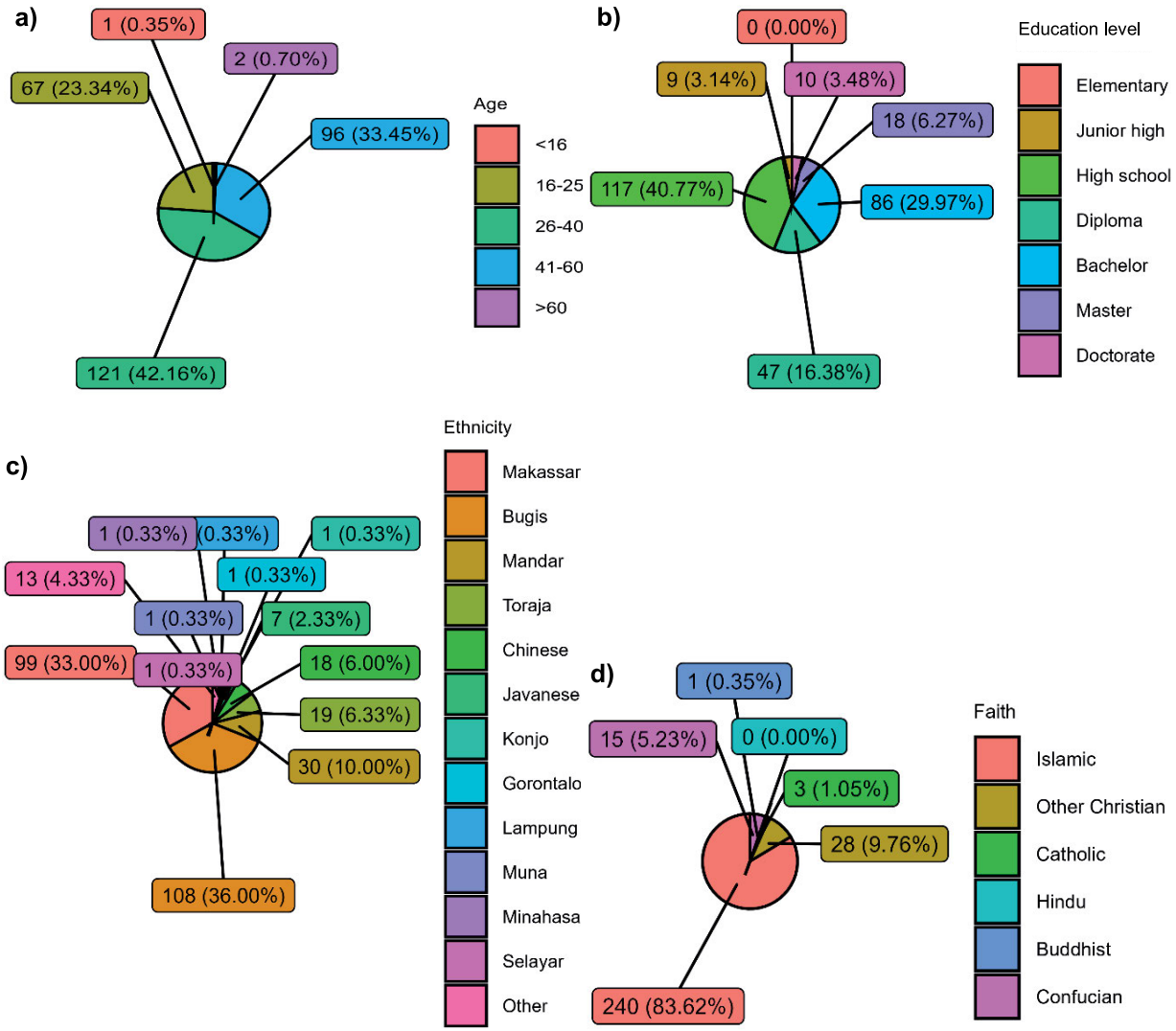


Fig. 2. Profile of respondents by: a) age, b) education, c) ethnicity, d) faith; source: own study

42.16% of the sample. In terms of education, the majority of respondents (40.77%) had completed high school. Furthermore, the Makassar ethnic group accounted for the largest representation at 33.00%, while Islam was the dominant religion among respondents, accounting for 83.62% of the total.

Table 4 reflects the respondents' perceptions of the functional attributes that support cemeteries as green spaces (Quinton and Duinker, 2019; Sallay *et al.*, 2022). Based on the findings, public satisfaction with government-managed cemeteries is relatively good, with an average rating of 6.80 out of 10. The highest satisfaction levels were recorded for parking facilities and footpaths. Although cemetery-related regulation of the Minister of Agrarian Affairs and Spatial Planning (Peraturan, 2022) cover technical details such as grave size, spacing, design, materials, and greening – these are not fully implemented in Makassar. For example, while the regulations prohibit hardening or piercing of graves, most graves in the city are still walled or paved. In addition, the study sought public opinion on proposed actions to develop cemeteries into functional and aesthetic green spaces, according to government guidelines. The results of these responses are summarised in Table 5.

Table 4. Community perceptions related to the performance of public cemeteries in Makassar city

Assessment parameter	Average satisfaction score
Ease of getting an area for parking	7.21
Ease of finding the tomb	6.81
Regularity of graves in cemetery	6.61
Shade in the cemetery area	6.52
Footpath condition at the cemetery	7.00
Cleanliness condition of the cemetery	6.66
Average of all parameters	**6.80**

Source: own study.

DEVELOPMENT OF PUBLIC CEMETERY GREEN SPACE AND BURYING CAPACITY

In Makassar, cemetery burying capacity can be projected based on population and mortality rates (Kartini, As and Surur, 2019). In 2022, cemetery land available was 0.93 ha. According to the

Table 5. Community preferences related to development and revitalisation plans for public cemeteries

Aspect preferences	Community approval (%)	Respondent justification
Addition of vegetation	96.2	To make it cooler, improve aesthetics, eliminate the impression of haunting, make the cemetery greener, and as a protector of grave land, so that it is not easy to landslide if rainfall is high.
Trail access development	98.6	In order to facilitate visitor access, it is not troublesome to find the tomb, does not step on the grave that is passed and makes the tomb more structured.
Uniformity of tombs/cemeteries	95.1	Creating a more organised atmosphere, maintaining visual balance, creating harmony, creating an aesthetic impression, and not wasting space.
Tomb shifting/moving	62.0	For the convenience of tomb users, it looks tidier, makes it easier to arrange tombs, maximises footpaths, and makes the cemetery environment better.
Action on old and abandoned tombs	82.2	In order for the cemetery land to function optimally, the location of the cemetery becomes more beautiful so that the area can be used by other graves.
Remodelling the graveyard to make it greener	59.2	Making the grave more organised with various notes, namely the shape of the headstone is easy to see and read, does not interfere with the initial headstone, coordination with the family, and there must be an officer who takes care of the grave.
Addition of facilities	100.0	The addition of different facilities at the cemetery based on community preferences includes parking lots, benches, paths, gazebos, lights, directional boards, and others (mashallah, flower vendors, restrooms).

Source: own study.

statistical board of the city, in 2030, the population of the city will increase by around 39,000 people (Yafendi (ed.), 2023). The estimation of cemetery land demand in Makassar for the next 15 years is presented by Kartini, As and Surur (2019). If 2.5×1.5-meter graves are allowed to become the norm, the city will run out of burial land by 2027. By reducing the size of graves to 2.0×1.0 m, by 2027 the city will have 0.25 ha of cemetery land. The capacity may increase if graves are stacked. If 2.5×1.5-meter graves are stacked, 0.424 ha will be available by 2027, to be exhausted in 2032. The most effective option is the use of 2.0×1.0 m graves with stacked burials, allowing two bodies per grave. Under this arrangement, approximately 0.246 ha of burial space would still be available by 2032. Based on these projections, several potential solutions were proposed through focus group discussions (FGDs) with relevant stakeholders to extend the capacity threshold of public cemeteries in Makassar City. These proposals are summarised in Table 6.

Table 6. Potential solutions related to efforts to optimise cemetery capacity in Makassar

Aspect	Conditions	Potential solution
Standardisation of tomb shape	The shape of the grave is stipulated in the heirs' approval letter. The approval letter only requires the tomb model; there is no regulation on dimensions, materials, etc.	A stronger set of rules than just a statement/consent letter from the heirs is needed. Regulations also standardise dimensions, materials, etc.
Standardisation of grave size and spacing	Provisions are still based on central government regulations, but not implemented locally.	A more localised and specific set of rules that comply with central government regulations.
Pavement and grave piercing	In general, graves in Makassar's public cemeteries are still walled up even though government regulations do not allow the walling of graves. Grave piercing and pavement, results in difficulties to achieve the required 70% green area in Makassar's cemeteries.	A social study followed by gradual socialisation prior to consistent application the provisions of graves without pavement/embankment. Need to regulate new cemetery areas to apply this provision consistently.
Stacking of corpses	Makassar's public cemetery, which is already full, stacking the bodies of those who are still related to the family. Based on the study, the Makassar's public cemetery capacity threshold is longer with a system of two bodies per grave.	For Islamic cemeteries, it could be considered to be more specific about the stacking of bodies, and not just because the grave is full. If there is a new public cemetery area, the stacking of bodies should be enforced more consistently. It may be necessary to conduct a social study for the possibility of a purely time-based accumulation of bodies without restrictions on family relationships (for example, as is done in Saudi Arabia).
Treatment to abandoned tombs and retribution arrears	There is information related to the provision that abandoned tombs, including those that do not fulfil retribution obligations, can be taken over by the government and used for new tombs or other uses, but this study was not able to find a specific set of rules governing this.	Abandoned tombs and those that are in arrears of retribution can be quite significant in number, thus requiring clear and legally based regulations that are specific and local in nature.

Source: own study.

INCREASING VEGETATION COVER IN PUBLIC CEMETERY AREAS

According to Peraturan (2022), public cemeteries are designated as urban green spaces and are required to serve multiple functions, including water catchment, social activities, and maintaining at least 70% green cover. Furthermore, Peraturan (2008) specifies that 80% of this green cover must consist of vegetation, rather than solely ground cover. A study in Jakarta by Hidayatulloh (2022), in line with government standards, proposed optimising cemetery planting through design strategies based on specific criteria, such as grave size (1.0×2.0 m), minimum grave spacing (0.5 m), pedestrian pathways (150–200 cm wide), and boundary treatments (hedges or fences). Based on these considerations and supported by site planning simulations of government-managed cemeteries, this study proposes several recommendations in relation to planting patterns to be implemented within the setting of government-managed cemeteries in the city (Tab. 7).

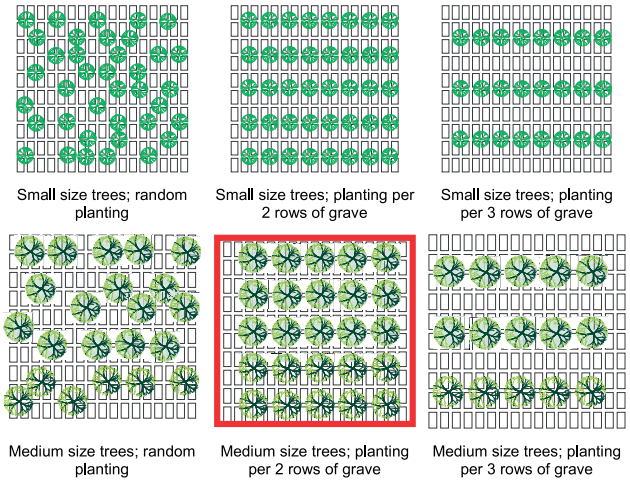
The condition of government public cemeteries in Makassar does not entirely meet the criteria set by the government. However, recommendations for improvement can be made to optimise vegetation enhancement. The physical form of cemeteries can affect their suitability as urban green spaces, particularly in terms of accessibility and management practices (Rae, 2021). Based on the findings of this study, specific tree planting pattern recommendations have been developed. An illustration of the proposed application of these recommendations is presented in Figure 3.

To maximise green space in government-managed public cemeteries, the planting pattern should be designed to optimise

Table 7. Recommended tree[1)] planting pattern and number of trees for government cemeteries in Makassar city

Tree pattern	Number of trees that can be accommodated		
	small tree	medium tree	large tree
Random tree planting	30–40 per 25× 5 m (625 m^2) burial plot (adjusted to the condition of the grave arrangement)	20–25 customised tomb setting conditions	it is not recommended to plant large trees in the space between graves
Trees on paths or between cemetery blocks	8 trees per 25 m length of grave walkway or grave block boundary	medium-sized trees are not recommended on footpaths or cemetery block boundaries	large trees are not recommended on walkways or cemetery block boundaries
Regularly planted trees per two rows of graves	40 trees per 25×25 m (625 m^2) burial plot	25 trees per 25×25 m (625 m^2) burial plot	it is not recommended to plant large trees in the space between graves
Orderly planting trees per three rows of graves	24 trees per 25×25 m (625 m^2) burial plot	15 trees per 25×25 m (625 m^2) burial plot, planted intermittently	it is not recommended to plant large trees in the space between graves
Trees on one side of the road	11 trees per 25 m road length	8 trees per 25 m road length	4 trees per 25 m road length
Trees on both sides of the road	22 trees per 25 m road length	it is not recommended to plant medium-sized trees on 2 sides, preferably combined with small trees on the other side	it is not recommended to plant large trees on 2 sides, preferably combined with small trees on the other side
Trees at the edge of the cemetery	12 trees per 25 m length of cemetery boundary edge	8 trees per 25 m length of cemetery boundary edge	4 trees per 25 m length of cemetery boundary edge

[1)] Tree type/size based on government classification (Peraturan, 2012).
Source: own elaboration based on Hidayatulloh (2022) adjusted to government standards (Peraturan, 2008) and proposals based on the general condition of government-managed cemeteries.



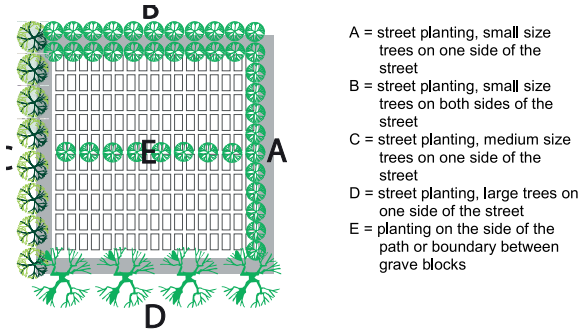


Fig. 3. Tree planting recommendations to optimise vegetation cover at the public cemeteries and the selected recommendation (red box) for the maximum planting and most vegetation coverage (top) and planting recommendations on the road green belt in the cemetery area (bottom); source: own study

tree capacity and vegetation cover. According to the Islamic tradition, graves are generally limited to tombstones with concrete borders, while Christian burial practices often involve more elaborate structures, such as roofed graves. Consequently, individual Christian graves occupy more space than Muslim ones. Additionally, the irregular size and layout of Christian graves make spatial organisation more difficult. For Islamic cemeteries, a regular planting pattern with medium-sized trees between rows of tombs is recommended. In contrast, a more random planting pattern is suitable for Christian cemeteries. Small trees should be planted along roads and pathways, while larger trees should be positioned where space allows. The projected vegetation cover for Makassar's public cemeteries, based on these planting patterns, is shown in Table 8.

If the proposed recommendations are implemented, in vegetation cover in the government-managed cemetery areas is projected to increase from 29.2 to 57.51%. To implement this, additional vegetation is required, as shown in Table 9. These projections are based on the assumption that the newly planted trees will reach their optimal size and crown width. It is estimated that this level of vegetation cover can be achieved within approximately 5–7 years.

The revitalisation of cemetery areas through planting recommendations proposed in this study significantly enhances the value of such spaces. In the context of the study area, typically perceived as a foreboding environment, this approach could transform cemeteries into a park-like and green spaces with added tourism value. Similar models have already been implemented in parts of Europe (Yılmaz *et al.*, 2018; Sallay *et al.*, 2022) and Canada (Quinton and Duinker, 2019).

The primary recommendation derived from this study is a quantitative estimation aimed at enhancing vegetation cover through additional plantings, thereby improving the cemetery's function as a green space. To achieve an increase in both vegetation cover and overall plant population, planting recommendations are proposed. The layout of these plantings is based on previous research conducted in the Indonesian capital, which has faced similar – if not more severe – challenges (Hidayatulloh, 2022). Furthermore, the proposed design and dimensions of individual tombs, which aim to improve burial capacity, are based on information from existing studies (Kartini, As and Surur, 2019).

The implementation of these recommendations is expected to achieve two key objectives: enhancing the role of cemeteries as green spaces by increasing vegetation cover, and expanding their burial capacity. These recommendations can be applied within existing cemeteries, either through site renovations or by planning within currently unoccupied cemetery areas. While renovation may incur significant costs, if such an approach is not

Table 8. Potential increase in vegetation cover after the addition of vegetation according to study recommendations in all government public cemeteries in Makassar

Cemetery location	Cemetery area (m^2)	Existing condition		Projected additions		Total projection after addition	
		vegetation cover area (m^2)	percentage cover (%)	projected increase in vegetation cover area (m^2)	percentage of additional cover (%)	projected total vegetation cover area after addition (m^2)	projected percentage of total vegetation cover after addition (%)
Islam Sudiang Raya	115,900	34,000	29.34	64,055.5	55.27	98,055.49	84.60
Islam Dadi	45,500	13,000	28.57	6,771.1	14.88	19,771.11	43.45
Islam Paropo	50,600	17,100	33.79	8,321.6	16.45	25,421.61	50.24
Kristen Panaikang	52,000	13,600	26.15	6,776.4	13.03	20,376.40	39.19
Islam Maccini	11,100	4,500	40.54	3,454.2	31.12	7,954.20	71.66
Islam Beroanging	54,400	13,200	24.26	8,976.3	16.50	22,176.27	40.77
Kristen Pannara	33,700	10,700	31.75	4,418.7	13.11	15,118.72	44.86
Total	**363,200**					**208,873.80**	**57.51**

Source: own study.

Table 9. Recommended increase in the number of tree to increase the area of vegetation cover in government public cemeteries in Makassar

Cemetery location	Small tree	Medium tree	Large tree
Islam Sudiang Raya	2,805	15,589	357
Islam Dadi	77	1,859	0
Islam Paropo	270	1,959	104
Kristen Panaikang	152	1,917	61
Islam Maccini	94	726	89
Islam Beroanging	653	1,958	83
Kristen Pannara	172	1,140	64
Total	**4,222**	**25,150**	**758**

Source: own study.

feasible, the findings of this study can serve as a basis for government regulations and policies applicable to the planning and establishment of new cemeteries.

CONCLUSIONS

In Makassar, besides the seven government-managed public cemeteries, there are other cemeteries managed by various community groups, foundations, and family associations. This research determined several attributes of these cemeteries.

1. These cemeteries contribute 0.5% to the city's green space.
2. The average vegetation cover is 25.5% for all cemeteries in the city and 29.2% for government-managed ones, all are below the 80% standard of Minister of Public Works (Peraturan Nomor 5 Tahun 2008).
3. With the current one-body per grave model, government cemeteries will run out of space by 2029. However, using a stacking system in 2.5×1.5 m graves could maintain 0.424 ha of land until 2027. Allowing 2.0×1.0 m graves with two bodies per grave would release additional 0.246 ha of land that will meet the demand until 2032.

Public satisfaction with Makassar's cemeteries is 6.80 out of 10, with the highest ratings for parking and pathways. To improve vegetation cover, recommended planting patterns and vegetation types should be followed:

- maximising cover involves regular and extensive tree planting in government-managed cemeteries and avoiding problematic vegetation types;
- to maximise green space in government-managed cemeteries, a planting pattern should be chosen to maximise the number of trees and vegetation cover; for Islamic cemeteries, it is recommended to use a regular pattern with medium-sized trees every two rows of graves; for Christian cemeteries, a random pattern;
- small trees should be planted along roads and pathways, while large trees should be used wherever possible;
- this approach could increase the land cover in Makassar's public cemeteries from 29.2 to 57.51%; the Makassar city government is advised to conduct a vegetation study based on recommended vegetation types and research findings to assess and improve existing vegetation in public cemeteries.

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CONFLICT OF INTERESTS

All authors declare that they have no conflict of interests.

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