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Clustering Analysis of Kutai Sultanate Tombs: Exploring Design Preference, Symbolism, and Social Hierarchy in East Kalimantan, Indonesia

Titin Agustin Nengsih [a,*], Muhammad Chawari [b], Irfanuddin Wahid Marzuki [b], Henki Riko Pratama [c], Imam Arifa'illah Syaiful Huda [d], Benny Agusti Putra [e], Wahyu Rizky Andhifani [f]

[a] Department of Statistic, Faculty of Science and Technology, UIN Sulthan Thaha Saifuddin Jambi, Jambi, 36363, Indonesia
[b] Research Centre for Prehistoric and History Archaeology, National Research, and Innovation Agency, Jakarta, 12510, Indonesia
[c] Research Centre for Archaeometry, National Research, and Innovation Agency, Jakarta, 12510, Indonesia
[d] Department of Geographic Information Science, Faculty of Science and Technology, UIN Sulthan Thaha Saifuddin Jambi, Jambi, 36363, Indonesia
[e] Department of History of Islamic Civilization, Faculty of Adab and Humanities, UIN Sulthan Thaha Saifuddin Jambi, Jambi, 36363, Indonesia
[f] Research Center of Prehistoric and History Archaeology. Archaeological, Language and Literature Research Organization National Research and Innovation Agency, Jakarta, 12510, Indonesia
* Corresponding author Email: nengsih@uinjambi.ac.id
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Abstract: Sultanate tombs are cultural artifacts that record various social, political, and symbolic information about past societies. In the context of the Kutai Kartanegara Sultanate, variations in tomb design and decoration are believed to reflect the hierarchical social structure and cultural values passed down across generations. However, previous studies have tended to be descriptive and visual, and have not developed an objective and systematic classification model. This study addresses this gap by applying an exploratory quantitative approach using a mixed-type clustering algorithm to identify patterns of design preference, symbolism, and social structure in the tomb complexes of the Kutai Kartanegara Sultanate in East Kalimantan, Indonesia. A total of 74 tombs were selected through purposive sampling based on the completeness of the inscriptions and the feasibility of visual data. Each tomb was analyzed based on the physical dimensions of the jirat and headstone, decoration, form, material, and the language of the inscription. The clustering results revealed three main groups: clusters with simple dimensions and ornaments (distant families), clusters with moderate proportions (close families), and clusters with monumental designs and complex ornaments (nuclear families and heads of the sultans). The findings suggest that cemetery architecture functions as an expression of social status and a means of preserving collective memories in Islamic royal societies. This study also offers a data-driven classification model that can be replicated in other digital archaeological research, as well as expanding methodological approaches in the study of death, identity, and power in Southeast Asia.

Keywords: Sultanate Tomb, Islamic Decorative Variety, Social Stratification, Multivariate Clustering, Digital Archaeology, Kutai Kartanegara.

1. Introduction

Sultanates have played a fundamental role in shaping social and cultural systems since the early civilization. Through hierarchical structures, sultanate societies place individuals based on social roles and status, political status to religious status as seen in the Sultanate of Malaysia (Muslim *et al.*, 2024), Deccan Sultanate (Fischel, 2020), Ottoman Sultanate (Özdalga, 2013), and Ayyubid Sultanate (Souadand & Ramdane, 2017). In Indonesia, there are many sultanates scattered across various regions, with more than 100 sultanates established. However, there are approximately 30-40 sultanates that are recognized. One of the oldest sultanates plays an important role in the social

and cultural organization of the archipelago, and the spread of Islam is the Kutai Kartanegara Sultanate (Burhanudin, 2018). This evidence is reinforced by a study of the tombs of the Sultan of Kutai Kartanegara, which reflects the history, social structure, and technological development of the community.

Several studies have been conducted on Islamic tombs in Indonesia, such as the study of the types and inscriptions of gravestones that contain life advice (Pinem, 2018), a reflection of the ornamental variety of the gravestones of the Palembang Sultanate, which shows a regional relationship with the Majapahit and Demak Kingdoms in Java. In the context of research on tombs in the Kutai Sultanate, Balkis and Uka (1998) discuss tomb ornaments that can be grouped based on their origin, namely Bugis, Makasar, Dayak, and Islamic ornaments. In a global context, many studies have shown that tomb attributes, such as size, decoration, and materials, are used to display social status (Baker, 2010; Kuznetsova, 2018; Yan *et al.,* 2024; Lipińska, 2022). However, tomb research using quantitative analysis methods has been conducted to reduce ambiguity, such as the classification of tombs by size and structure (Scalas, *et al.,* 2018). Quantitative analysis is intended to maximize the differences between groups and predictions based on individual and group characteristics (Barceló, *et al.,* 2015).

Although previous studies have provided important insights into historic tombs, there are still some shortcomings, especially in the use of quantitative approaches to explore design preferences, symbolism, and social hierarchy through tomb cluster analysis, particularly in Indonesia. Generally, previous studies are often subjective based on visual interpretation; therefore, the results obtained cannot always be retested objectively. In addition, the classification of tombs in the Kutai Kartanegara Sultanate also uses manual categorization that does not necessarily reflect structural and temporal relationships among tombs. Therefore, the use of quantitative methods, such as clustering, can support the systematic and accurate interpretation of classification, design preferences, symbolism, and social hierarchy.

This study has broad significance, particularly for archaeologists, academics, historians, and local governments, in terms of a deeper understanding of the tombs and their relationship with the socio-cultural aspects of the Kutai Kartanegara Sultanate. This information can help the local government manage information about the tombs based on existing scientific data, so that the information circulating in the community can be trusted. On the other hand, this study can be used to develop further research on sultanate tombs in Indonesia using quantitative methods. Therefore, this study aimed to explore design preferences, symbolism, and social hierarchy through a clustering analysis of the Kutai Kartanegara Sultanate Tomb Complex. Some of the research questions to be answered are as follows: How is the design preference of the Kutai Sultanate tombs determined using cluster analysis? What is the symbolism tendency of Kutai Sultanate tombs using cluster analysis? How are design and symbolism preferences related to the social hierarchy of the Kutai Sultanate? Zheliznyak *et al* (2017) explained that clustering analysis aims to group a set of objects in such a way that objects in the same group are more similar to each other than objects in other groups (clusters). Exploration was performed using data on the physical characteristics of the tombs, including their structure, decoration, dimensions (length, width, height, and diameter), and time period. Quantitative analysis of the physical characteristics of tombs can also serve as a bridge to reveal their attachment to historical aspects.

In contrast to previous studies that relied on visual observation or manual typological classification, this study presents a quantitative analytical framework based on mixed-type clustering algorithms to systematically explore the interrelationships between tomb architecture, decorative symbolism, and social hierarchical structures in the context of Islamic sultanates in Southeast Asia. By integrating design, aesthetic, and historical dimensions into a single classification model, this study offers a methodological innovation that strengthens the practice of digital archaeology and provides a replicable analytical approach to understanding sociocultural stratification through burial landscapes in underexposed Islamic regions.

2. Literature Review

Islamization on Kalimantan Island has a long historical journey, starting in the 7th to 10th centuries, then accepted in the 11th to 15th centuries, and developed massively in the 16th century. Islamic civilization has become great until today, inseparable from the role of the sultanates in East Kalimantan, including the Berau, Kutai Kartanegara, and Bulungan Sultanates. However, this study focuses on the Kutai Kartanegara Sultanate. Ancient

gravestone markers have important historical value in representing the socio-culture of the past. Samad *et al.* (2020) found that tombstones have important meanings in beliefs because of their close relationship with human beliefs. The motifs that appear on tombstones are associated with religious traditions. The Eid al-Adha prayer and the image of the three palm leaves are symbols of Imam Hussein's tomb, which was common during the Safavid era (16th century to mid-18th century). Satarnezhad *et al* (2021) reveal that tombs and tombstones are an integral part of this thinking in all societies from ancient times to the present, which have been used as a basic tool for their objective and spiritual manifestations. The ornamental motifs of tombstones reflect the cultural, social, and religious conditions of society, realized in the form of geometric, symbolic, plant, epigraphic (inscription), and Muqarnas motifs. The study of tombstones in Maragheh City shows that the tombstones of this museum generally date from the period 1495-1883 AD. The motifs used on gravestones also reflect the social status and religious beliefs of the deceased.

Ancient Islamic tombs are one of the sub-studies of archaeological aspects used as a medium to reveal several things related to the identity of figures, placement patterns, identification of decorative motifs, chronology, and the cultural background of the supporting community in the past (Ibrahim & Ibrahim, 2025). The tomb is one of the products of cultural ideo-techniques; thus, the diversity and changes in the tomb institution will reflect the diversity and changes in the religious subsystem in society. Archaeological aspects of Islamic heritage, such as the gravestones of Islamic tombs, produce typology and distribution in classes and variants, and it can be concluded that there are gravestones of Aceh type, Demak-Troloyo, Bugis-Makasar, and local forms (Ambary, 1998). However, previous studies have generally only discussed, in a descriptive manner, the classes and variants of Islamic tomb designs, without quantitatively examining the preferences for Islamic tomb designs, especially those of the Kutai Kartanegara Sultanate.

Research on Islamic archaeological remains in Kutai Kartanegara has been conducted, including at the Banjarmasin Archaeological Center. Research since 1993 has revealed Islamic archaeological remains in the form of buildings, structures, sites, and areas. The periodization of archaeological remains dates from the 15th to the 19th centuries AD, which are scattered in coastal areas, watersheds, and hills (Atmojo, 2012). On the other hand, the Banjarmasin Archaeological Center revealed that the remains of Islamic tombs in Kutai Kartanegara are spread across several areas, namely the Old Kutai Site (Anggana Regency), the Jembayan Site, the Tombs of the Kings of Kutai Kartanegara, and the Kelambu Kuning Site (Tenggarong Regency) (Atmojo, 2003). The potential of Islamic archaeological heritage has also been widely studied in terms of preservation; for example, Elviana and Lesmana (2017) discussed the preservation of buildings and objects of heritage in Kutai Kartanegara as a form of city identity. Astiti (2018) discusses the potential of Kutai Kartanegara's archaeological resources as a cultural identity and tourist attraction. Islamic archaeological research on Kutai Kartanegara is generally qualitative and descriptive, focusing on tomb architecture and cultural resource management. Astiti (2018) revealed that studies related to Islamic archaeology in the Kutai Kartanegara region tend to be qualitative and descriptive, focusing on tomb architecture. However, much can be explored from other perspectives, such as through quantitative studies. Thus, the study of the Kutai Kartanegara Sultanate tomb cluster, particularly regarding the analysis of design preferences, symbolism, and social hierarchy, can fill this existing gap.

However, preferences for tombstones are influenced by socioeconomic conditions. A study by Mallios and Caterino (2011) in Southern California in the 19th and 20th centuries and confirmed a direct correlation between financial conditions and the decision to choose tombstone materials. This is evidenced by the shift in tombstone materials from granite to marbles. This occurred in the 19th and early 20th centuries due to the banking panic of 1907 and the Great Depression, which led to a surge in demand for marble and metal, which were cheaper than granite. This confirms that design and material preferences in tombstone selection can be variables for tracing or understanding the socioeconomic hierarchy in the tombs of the Kutai Kartanegara Sultanate family members.

Another study explains that the shape, imagery, letters, and inscriptions of gravestones can be used to understand cultural diversity through a quantitative approach using geometric morphometric analysis (Thomson, 2019). O'Donovan *et al.* (2024) report that the people of Medellin tend to spend a lot of money on gravestones that mark the tragic deaths of young children. A study conducted by Karaçağ (2011) analyzed the Bektashi tombs and gravestones of the Elmali-Abdal Musa Lodge dating back to the Ottoman period. A total of 150 tombs were excavated. Forty of these, which have inscriptions, date back to the Ottoman period. The inscriptions on tombstones provide important information about the identity, profession, and status of these individuals. Tombstones are considered a

set of semantically charged elements (gravestones, visuals, design features, etc.) that help consolidate the image of a deceased person. This study also explores the features of Grigory Shelikhov's tombstone and the historical context surrounding the activities of the Shelikhov family after his death. This practice represents a family effort to address the deceased's role in the Russian American Company. In contrast, Boltunova and Mitina (2024) exemplified the use of monuments to signify the family's social capital at the local level and as a form of safeguarding the Company's control rights. In the context of the cluster analysis of the graves of the Kutai Kartanegara Sultanate, indicators such as shapes, images, letters, and motifs can serve as important markers for understanding the symbolic relationships and social hierarchy within the Kutai Kartanegara Sultanate. This study also illustrates that a quantitative approach in the cluster analysis of the graves of the Kutai Kartanegara Sultanate makes it possible to identify more accurate and systematic patterns related to design preferences, symbolism, and social hierarchy than a qualitative approach does. Thus, the variables play an important role in revealing design preferences, symbolism, and social hierarchy through cluster analysis of the tombs of the Kutai Kartanegara Sultanate.

3. Methods

3.1. Study Design

An exploratory descriptive quantitative approach was used to analyze design preferences, symbolism, and social hierarchy in the Kutai Kartanegara Sultanate tomb complex. This approach can reveal phenomena in the complexity of the collected tomb data (Creswell, 2018). This approach is suitable for measuring and grouping according to predefined variables (Barceló *et al.*, 2015; Menghini *et al.*, 2020). Several related studies were used to strengthen the analysis and interpretation of the findings, particularly regarding the design, symbolism, and social hierarchy in the Kutai Kartanegara Sultanate tomb complex (Siegrist, 2006). Thus, this study design can clearly reveal design preferences, symbolism, and social hierarchies in the Kutai Kartanegara Sultanate tomb complex.

3.2. Study Area

Data were collected at the Kutai Sultanate Tomb Complex, located in Panji Village, Tenggarong District, Kutai Kartanegara Regency, East Kalimantan Province, Indonesia. The tomb complex is the oldest royal burial complex in Indonesia. The Kutai Sultanate played an important role in Islamization and trade along the coast of Borneo. The research included field surveys in five sub-districts namely Anggana, Loa Kulu, Tenggarong, Muara Kaman, and Kota Bangun. Eight sites and 200 tombs are scattered across the five sub-districts (Figure 1). The widespread distribution of tomb complexes in several areas with varying numbers of tombs makes it an ideal research area for uncovering design preferences, symbolism, and social hierarchies.

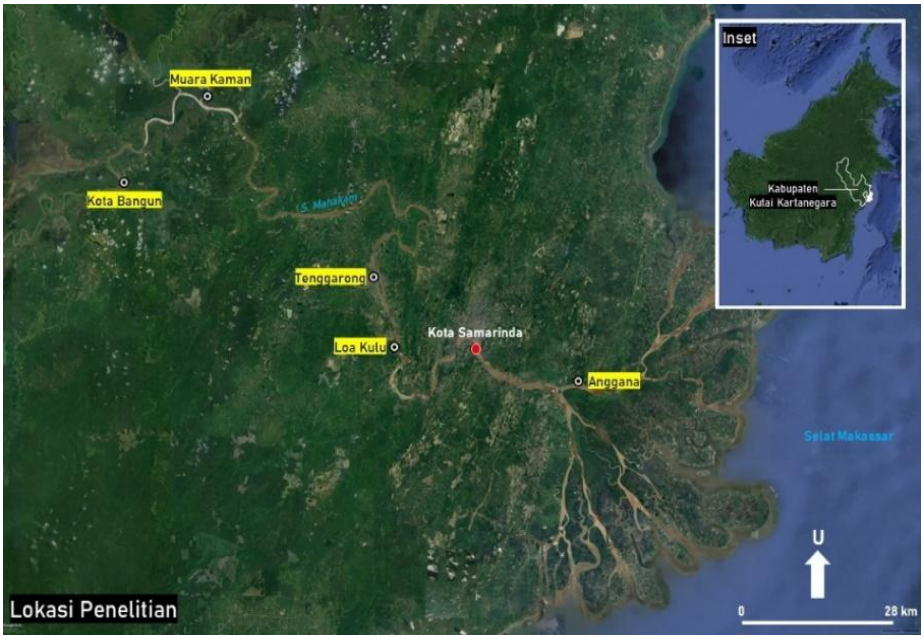

Figure 1. Research Location in Kutai Kartanegara Regency

3.3. Procedure

Several procedures were carried out in this study to meet scientific standards, including field surveys, identification, initial documentation, and recording the general characteristics of the Sultanate tomb complex. Second, coding and measuring the *jirat* and headstones, as well as identifying the decoration and type of headstones in each tomb, were selected as a sample. Third, we documented all sampled tombs from several angles to produce quality data. Each photo was coded and adjusted using the tomb code. To reduce inaccuracies, the dimensions of each grave were measured using a measuring tool and rechecked by measuring and confirming on site. Fourth, we digitized the data to be entered into the application for further analysis.

3.4 Sampling Methodology

This study used a purposive sampling method by selecting 74 tombs from a total of 200 tombs at the Kutai Sultanate site that had names on their headstones. The selection of this sample is based on historical significance, where tombs with an identity are considered capable of providing richer information related to the identity, social status, and cultural dynamics of the people of Kutai. Purposive sampling was used to ensure that the collected data were relevant and in-depth, focusing on tombs with high information values. This approach supports clustering analysis in identifying design preferences, symbolism, and social hierarchies in the Kutai Sultanate.

Spatial representation was given less consideration in this study because the number of graves at each site in the Sultanate of Kutai Kartanegara is highly disproportionate, such as between the Kutai Kartanegara Sultanate Cemetery Complex in Tenggarong and the cemetery complex in Kutai Lama. Therefore, the selection of samples was based on the completeness of the inscriptions. The importance of inscriptions is possible because they generally contain information about full names (along with titles), positions, genealogy, the role of the figures in their environment (for example, the royal environment), date of birth, date of death, age, and prayers. By looking at all of that, we can understand the character of the person buried during their lifetime. An equally important aspect is the chronology of these figures. To ensure that the clustering results remained representative despite purposive sampling, this study conducted sensitivity and robustness tests. The procedure employed stability testing through subsampling (400 repetitions with 80% of the data points). This approach demonstrated that the cluster arrangement remained consistent across various resampling conditions and when there was data variation, thus alleviating doubts about the representativeness of the results (Banerjee & Dave, 2012).

3.5. Variable

The variables in this study are used to understand in depth related to the manifestations of a tomb, which refers to the preferences of design, symbolism, and social hierarchy. Variables include the dimensions of desai, decoration, shape, material, and language of gravestones and jirat in a tomb. Complete variables can be seen in Table 1. Dimensional variables and tomb shapes can be used to explore the social status of the deceased. This is in accordance with the study which states that the tomb has a larger dimension and has a special design shows the deceased as long as his life has a higher social status. For example the tombs of the nobles or religious leaders (Boltunova & Mitina, 2024; Karaçağ, 2011). In addition, the material of a tomb can reflect the economic conditions of the deceased during his life. Tombstones made of rare or high -quality stone can reflect a family member have easy access to available resources (Mallios and Caterino, 2011; Somda, 2014).

On the other hand, language variables can provide instructions related to the influence of foreign culture (Gori, 2017; Ismail *et al.*, 2023). Decoration on gravestones, such as carvings or specific motives, can also show exclusivity in certain social classes. This also indicates a cultural and aesthetic hierarchy (Samad *et al.*, 2020; Satarnezhad *et al.*, 2021). By connecting the variables of this tomb, researchers can reconstruct social symbolism and hierarchy in the Sultanate of Kutai Kartanegara. In this study we use a flower or geometric code that supports the analysis of this category in our data collection. Aghabayli (2016) notes that Islamic Craftsmen Excelled Virtuosic Displays. They were able to further enrich ornamentation by deviating from monothematic principles and decorating geometric interweaving with floral designs or overlapping ornaments with links emerging from benefits and How Islamic Decorative Language Uses Geometric or Floral Categories.

Table 1. Variable and Description of Tombs

Aims	Unit of Analysis	Variables	Indicators	Description	Data Source
Tomb Design Dimension Preferences	*Jirat*	Dimensions	-Length -Width -Height	The physical size of the *jirat* (the main body of the tomb) is measured in units of length (cm or meters). This variable shows how large the dimensions of the *jirat* are chosen by the community as a visual and cultural preference.	Survey & Observation
	Tombstone	Dimensions	-Length -Width -Height	The physical size of grave marker is measured in terms of length, width or diameter. These dimensions indicate the symbolic preference of the grave marker.	
Grave Decoration Preferences	*Jirat*	Decoration	- Floral - Geometric -Arabic Calligraphy	Visual elements or ornaments applied to the surface of the jirat as a form of cultural expression, aesthetics, and religious symbolism	
	Tombstone	Form	-Flat -Mace	Variations of headstone shapes. Flat is a flat, plate-like shape, while mace is a thicker or mace-like shape (round or oval).	
		Material	-Wood -Stone	Types of gravestone materials.	
		Language	-Arabic -Local	The language used in the inscription on the gravestone.	
		Decoration	- Floraistis -Geometris	Visual elements or ornaments applied to the surface of gravestones as a form of cultural expression, aesthetics, and religious symbolism.	

3.6. Data Analysis

The data were analyzed using a clustering approach. Similar data points are grouped in the same cluster, and different data points are grouped into different clusters based on the concept of "similarity" (Jain, 2010). K-Means and Hierarchical Clustering algorithms are effective for grouping objects based on the Euclidean distance or similarity of numerical values between objects, especially in numerical data (Jain, 2010). In contrast, for categorical data, approaches such as K-modes or ROCK are used, considering category frequencies as the basis for clustering (Rostamirad & Naghshineh, 2025; Tao *et al.,* 2015). In the case of mixed data containing both numerical and categorical variables, algorithms such as K-Prototypes or the application of Gower distance are often used to integrate both in the clustering process (Bishop and Nasrabadi, 2006). In archaeological research, clustering analysis has been widely applied to group artifacts and tomb features, based on physical and contextual characteristics, to reconstruct the social, cultural, and temporal patterns of past societies (Baxter, 2003; Crema, 2025; Drennan, 2008).

Data analysis in this study uses two grouping approaches to answer the main objectives related to the dimensions and decoration of the grave of the Sultanate of Kutai Kartanegara. The first analysis was performed on numerical data from the physical size of the tomb to trace the tendency of design based on dimensions. The variables used in this study are height, width, diameter, and thickness of the headstone, as well as the length and width of the jirat. All data is normalized by the Z-Score method. The grouping process in the first stage uses hierarchical agglomerative grouping techniques with euclidean distances, so that the tombs that have the same structural size are grouped in the same cluster (Tan *et al.,* 2014). The optimal number of clusters is determined through dendrogram interpretation and the next step is to test using a number of validity indexes. Some of the sizes used are the Elbow method, the Silhouette coefficient, the Calinski -Maarabasz (CHI) index, and the Davies -Bouldin (DBI) index (Rousseeuw, 1987; Khan *et al.,* 2024). The use of this index combination gives a more convincing statistical basis in determining segmentation and uncovering the pattern of the proportion of the tomb. The data was analyzed using R software version 4.3.3 to generate groupings based on predetermined variables.

The second analysis is used in categorical data related to the decorative aspects of the tomb, to see aesthetic preferences in the use of ornaments. Variables are used from the type of decoration, the material used, and the shape of the tombstone. This categorical data was analyzed with the K-Modes algorithm (Chaturvedi *et al.,* 2001; Rostamirad & Naghshineh, 2025). The results of this clustering are expected to be able to separate preference groups that are not only based on structural sizes, but also on the expression of ornaments, so as to enrich the understanding of the socio-cultural dynamics of the Kutai Kartanegara community in the tradition of the development of the tomb. Advanced analysis after clustering is a non-parametric statistical test: Kruskal-Wallis test used to test differences between clusters, accompanied by Dunn advanced tests with Bonferroni correction. The results of this test will show differences in the dimensions of the tomb that are identified as statistically significantly. Thus, the grouping obtained is not only proven valid algorithmic, but also confirmed quantitatively, thus supporting findings about social stratification patterns.

4. Results and Discussion

4.1. Design Dimension Preferences of Kutai Kartanegara Sultanate Cemetery

Cemeteries can be a useful source of information about social inequalities in mortality, especially when data on the social determinants of health, such as income, education, employment, or social support, are unavailable (Kang *et al.,* 2021). In general, the data from the analysis of tomb design dimensions showed that the headstone height varied from 35 to 300 cm, while the jirat length varied from 0 to 410 cm. These significant differences may indicate differences in social status, roles, or kinship lines.

The number of clusters in this study was determined using a combination of statistical approaches and substantive interpretations of tomb dimension data. Elbow Method analysis showed a bending point at three to four clusters, indicating the change in the rate of decrease in intra-cluster variance began to slow down after three clusters were formed (Figure 2). Furthermore, evaluation using the Silhouette Coefficient showed an increase in the score from two clusters (0.235) to three (0.285). Although the maximum value was achieved in four clusters (0.351), the value in three clusters remained within the range of moderate stability acceptable in sociocultural research (Rousseeuw, 1987).

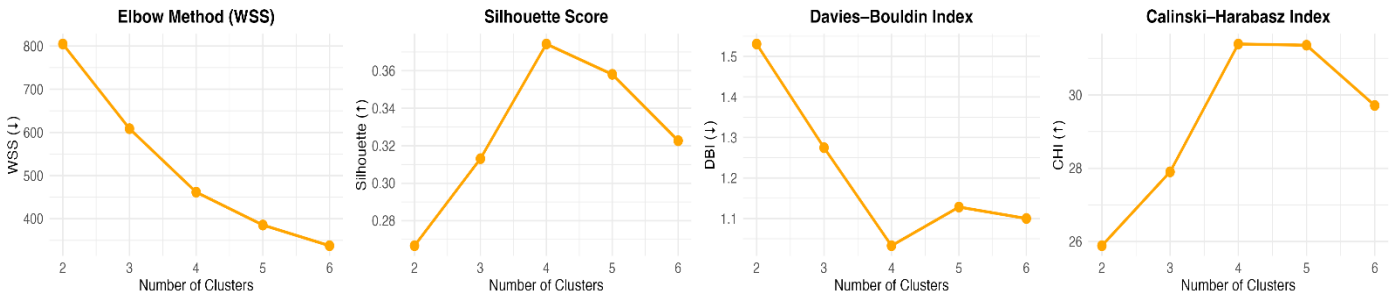

Figure 2. Determining Optimal Number of Clusters

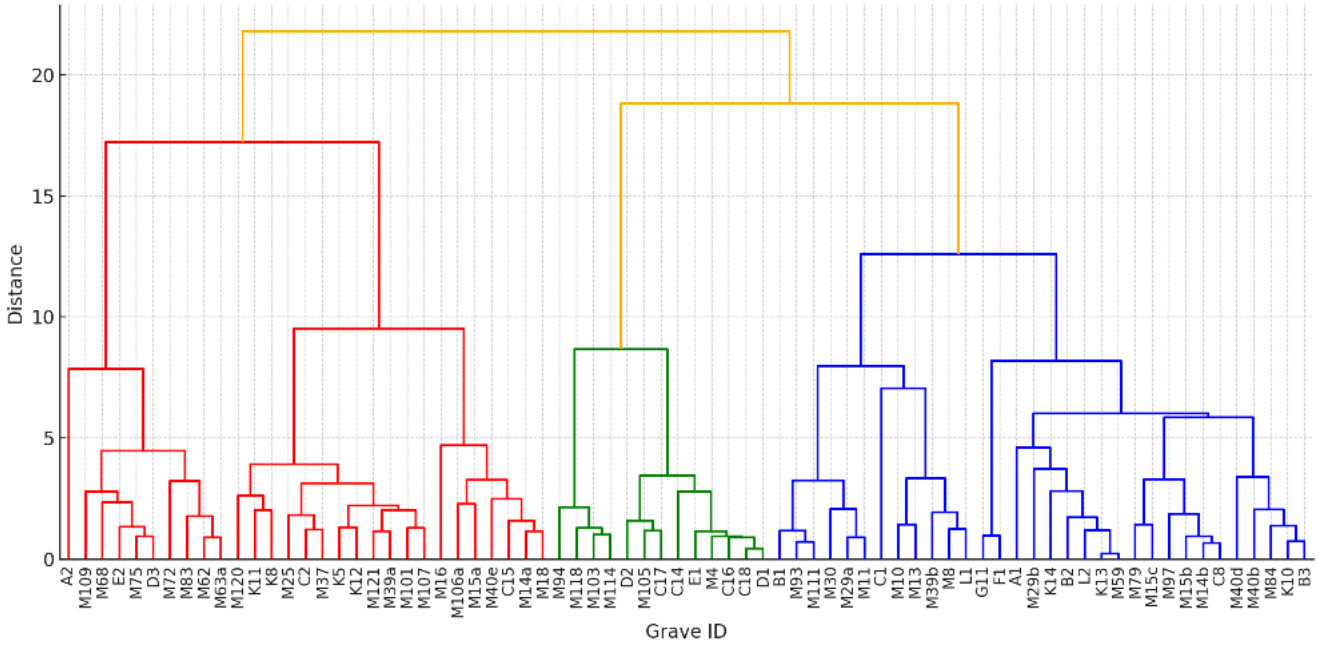

Figure 3. Sultan's Tomb Cluster based on Design Dimension Aspect

(a) **(b)**

Figure 4(a). The tomb of Aji Imbut with the title Sultan Aji Muhammad Muslihuddin (15th King of Kutai Kartanegara Ing Martadipura Kingdom), **(b)** Tomb of Sultan Aji Muhammad Salehuddin 1 (16th Sultan of Kutai)

Further testing was carried out using the Davies–Bouldin Index (DBI = 1.033) and the Calinski–Harabasz Index (CHI = 31.39), which also confirmed that four clusters were the most statistically appropriate solution. Furthermore, the researcher had already conducted a substance analysis for four clusters and found that two of the macro-clusters showed significant similarities in their preference for simple and compact dimensions, making it interpretatively feasible to combine them. Therefore, the three-cluster configuration is not only statistically justified, but also strengthens the coherence of interpretation in revealing the dimensional preference of tomb design in the Kutai Kartanegara Sultanate.

The analysis showed that the sizes of the headstones, footstones, and *jirats* were divided into three clusters. Cluster 1 shows smaller and uniform sizes, Cluster 2 shows greater differences in size and design, and Cluster 3 shows larger and grander sizes. See Figure 3.

The tombs in Cluster 1 can be categorized as "distant families, " with smaller and more uniform size characteristics (green in Figure 3). The average height of the headstones is 81.63 cm, and the width of the headstones is 163.3 cm, and the width of the headstones is 60.92 cm. These simple and functional sizes may reflect

lower social status and economic capabilities. The second cluster of tombs in blue on the dendogram can be categorized as "close family" which shows a greater difference in size. The average headstone height was 93.6 Â cm, the jirat length was 205.77 cm, and the jirat width was 95.85 cm. From this size, it is possible that social and familial status tends to be higher compared to the "distant family" category. Nevertheless, the "close family" cluster still shows relatively simple design dimensions, reflecting that simplicity is still prioritized in tomb design dimensions. Furthermore, the third tomb cluster can be referred to as the "core family" (Figure 4a and b). This cluster reflects the important figures or kings of the Kutai Kartanegara Sultanate (red in Figure 3). The average size of the headstone is 99.21 cm in height, 224.76 cm in length, and 106.79 cm in width. The larger sizes of clusters 1 and 2 illustrate that the noble tombs were designed with a more striking and elaborate design, indicating the use of more expensive materials and higher-quality workmanship (Table 2).

This design aimed to portray a high social status and role of the wearer. This can be seen in the descriptive statistical data, which show that the length of tombstones can vary greatly, reaching 410 cm. Kang *et al.* (2021) stated that the size of tombstones (volume and height) is often associated with longer life expectancy because wealthier individuals or families are likely to have better access to food and healthcare. This phenomenon is reflected in the results of a cemetery analysis in Glasgow, which shows that the age at death correlates with the height of 843 memorial obelisks for 1,349 individuals who died between 1801 and 1920. However, a direct relationship with this study, particularly regarding grave size and life expectancy, cannot be confirmed; further research is needed to establish this.

Table 2. Cluster of Sultan Kutai Kertanegara Tomb based on Design Dimension

Cluster	**Headstone Height (cm)**	**Length of *Jirat* (cm)**	**Wide of *Jirat* (cm)**
1Distanct Family	Average: 81,63	Average: 163,30	Average: 60,92
2 Close Family	Average: 93,62	Average: 205,77	Average 95,85
3 Core Family	Average: 99,21	Average: 224,76	Average: 106,79

In the context of intra-family relations, this cluster illustrates that dimensional differences are deliberate in identifying family groups of lower status within larger kinship groups. This is consistent with Baker's (2010) suggestion that there is a deliberate clustering of tombs to identify smaller family groups within the larger kinship groups that share the tombs. If this is true, such clustering would underscore the importance of burial with one's own kin, demonstrate intrafamilial relationships, and maintain the integrity of smaller family groups.

The integration of the analysis of the physical dimensions of the tombs and the administrative spatial distribution suggests a clear relationship between the size of the tombs and their proximity to the center of power in the Kutai Kartanegara Sultanate. Tombs with tall headstones and wide jirats are found almost entirely in the Tenggarong Sub-district and belong to the Red Cluster, which includes 29 tombs belonging to the core royal family of Kutai. In contrast, the graves in Loa Ulu and Anggana, containing 32 royal family tombs, fall into the blue cluster, which is medium-sized and includes immediate relatives. Meanwhile, the green cluster represents modest dimensions and is generally distributed in the outlying areas (Muara Kaman and Kota Bangun), with 13 graves belonging to extended relatives of the deceased. These areas are far from the center of the Sultanate. These results may reflect the social status of the clusters. Baxter's (2003) study revealed that tomb dimensions reflect the social structure of a community. This also aligns with Mytum's (2004) statement that the size and complexity of tombs serve to indicate social status, family identity, respect, and part of the community's collective memory. Thus, the design dimension preferences of the Kutai Kartanegara Sultanate tombs are manifested in the social stratification and cultural values of the local community.

4.1 Preference of Decorative Variety of Kutai Kartanegara Sultanate Tombs

The results of the analysis of the clustering of decorations on the sultanate tombs are divided into three categories: simple, medium, and luxury decoration clusters (Figure 5). This clustering shows significant differences

based on the level of complexity of the decoration and the type of decoration, such as floral motifs, Arabic calligraphy, and geometric motifs. These significant differences may reflect the social, cultural, and familial status of tomb owners.

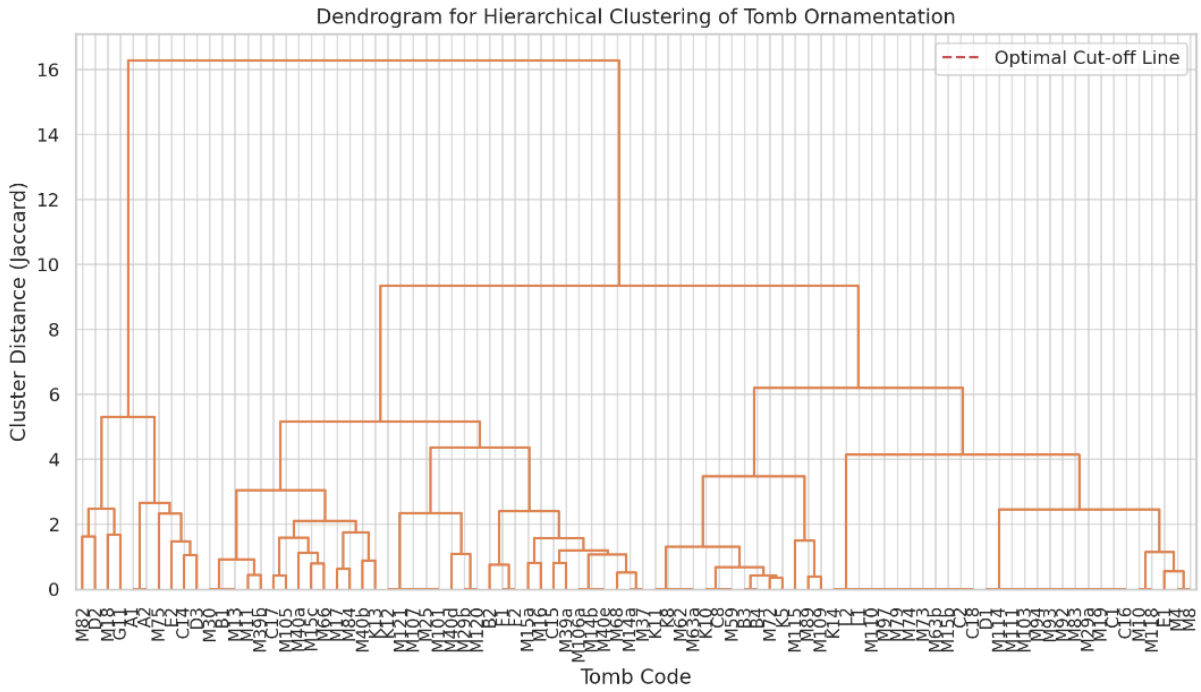

Figure 5. Dendrogram of Hierarchical Clustering for Tomb Ornamentation

The first cluster, "simple decoration," is characterized by minimal tomb ornamentation and little decoration. This cluster tends to prioritize function over aesthetic value. This reflects that the simplicity of the decoration on the tomb is related to families or individuals with distant family status or relatively low social status compared to other sultan families. The second cluster, in the category of moderate decoration, displays a moderate level of decoration accompanied by ornaments that are more visible on the middle and lower feet of the tombstone. On the other hand, there is also a moderate level of decoration in the tomb's jirat, which does not present complicated ornaments or decorations. The decoration in this cluster may reflect a close family with a higher social status than that in the first cluster.

Meanwhile, the third cluster, or "fancy decoration" features complex and luxurious decorations. The ornaments in this cluster are scattered throughout the tomb, with the most dominant ones located at the center of the headstone and jirat. The complexity of the decoration in this cluster may reflect the higher social status of this family as well as a symbol of special respect from the family for the individual buried. A summary of the clusters based on the decorations is presented in Table 3. This can also be represented as the social identity of the buried individuals and their families (Figure 6(a) and b). Zhou and Sirisuk (2021) revealed that this representation of tomb decorative arts is also reflected in the Eastern Qing Tombs, which reflect the political, economic, and socio-cultural characteristics of a particular period and symbolize special power and status. The tombs have important symbolic meanings and are also a testimony that the Qing Dynasty went from glory to decline. From the perspective of the anthropology of religion, the expression of symbols on graves can reflect the identity, beliefs, and status of the deceased (Maddrell & Mathijssen, 2022; Satarnezhad *et al.*, 2021). These symbols serve as a bridge between the afterlife and the real world, becoming part of the community's collective awareness.

Table 3. Summary of Clusters Based on Tomb Decoration and Inscription Variety (%)

Cluster	Floral Motif (%)	Geometric Motif (%)	Arabic Inscription (%)	Local Inscription (%)
1Distanct Family	65.2	34.8	70.0	30.0
2 Close Family	58.4	41.6	62.5	37.5
3 Core Family	72.0	28.0	80.0	20.0

(a)

(b)

Figure 6(a). Variations in Tombstone Motifs dominated by calligraphy at the Kutai Kartanegara Sultan's Tomb Complex (Cluster 1), **(b)** Variations of Tombstone Motifs at the Sultan Kutai Kartanegara Tomb Complex (Cluster 3).

Blair (2015) found that the use of Arabic calligraphy symbols can reflect social, cultural, and religious identity. Similarly, the use of floral motifs symbolizes eternity and spiritual protection (Acar, 2021). Thus, tomb symbols have complex manifestations in the life and social relationship practices of the community, connecting generations to one another.

In contrast, a semiotic analysis of Islamic visual culture reveals that calligraphy and ornamentation function not merely as decorative art, but as a "visual semiotic system that conveys spiritual identity and communal values" within sacred spaces (Fauziah, 2025). This perspective supports our interpretation of floral, geometric, and epigraphic motifs as not only aesthetic preferences but also as symbolic signifiers embedded in broader theological and cultural frameworks. Uzrina *et al.* (2024) revealed that calligraphy ornaments and geometric motifs represent spiritual and religious messages. This shows that the art of Islam has an influence on the design of gravestone ornaments. Not only that, the art of Islam also pinned the layer of symbolism and theological Islamic.

4.3. Symbolism Representation and Social Hierarchy of Kutai Kartanegara Sultanate Tombs

The Sultanate of Kutai Kartanegara continues to maintain the design dimensions and symbols in their family tombs. Various sizes, designs and symbols show the role, position or social hierarchy in society. Traditions in the funeral of the Kutai Kartanegara Sultanate can also be viewed from the theory of social stratification which states that there are some strata distribution in society based on socioeconomic conditions. For example social stratification in the context of burial can be seen from grave items or other material culture (Garrido, 2022; McGuire, 2019; Rayaprol, 2024). This phenomenon shows that the tomb is a form of statement of social status and the influence of the deceased on society. Not only as a place for the last research, have these tombs also reflected direct respect for the families of the Sultanate of Kutai Kartanegara who are influential.

There is a message that the design and decorative dimensions of the tomb serve as a reminder to current and future generations of the power of the Kutai Kartanegara Sultanate. This representation can also be a medium for commemorating the services and struggles of the Kutai Kartanegara Sultanate family. Gibbs (2016) revealed that burials have become a new form of status symbol, such as increasing prestige to demonstrate the obligation and loyalty of followers to the deceased. This also serves as a more lasting reminder for followers of the deceased's fame. Zissu and Kloner (2025) add that tombs can also reflect the social stratification of the deceased. For example, the tomb of Maresha has a Hellenistic style or a blend of local and Alexandrian architecture.

On the other hand, various decorations appear on jirat and gravestones such as Arabic writing, calligraphy, geometric carvings, flowers, etc., can reflect good expectations for spirits in order to obtain peace and forgiveness. This decoration can also be a symbol of sacredness and part of the beliefs of the local community. This is in line with the study of Satarnezhad *et al.* (2021) that the use of motifs in ancient gravestones also reflects the tribute of religion and social status of the deceased. In the context of the tomb of the Sultanate of Kutai Kartanegara, which is generally motivated by Arabic writing and contains information about identity and time, as well as prayer to the Creator, can reflect the religion adopted by the deceased. Thus, the decorations that exist in jirat and gravestone have a strong relationship between the social and religious elements of the Kutai Kartanegara Sultanate's family.

Wright (2012) in his study of stone monuments of varying scale and complexity that dominate the archaeological landscape of Bronze Age Mongolia. These monuments are described as monumental places created for living communities to communicate their organization and timeless nature to others and themselves. This communication was essential for the establishment and survival of early herding communities. However, the tombs of sultans and their families are generally placed in a single cemetery complex. This also reflects that the social stratification in the tomb complex of the Kutai Kartanegara Sultanate expresses the position of individuals and the social structure of families (Martinón-Torres, 2016; Rayaprol, 2024). Von Hesberg *et al.* (2015) reveal that funerary rituals reflect collective conceptions of the interaction between life and death, and allow insights into the distribution of social roles, the order of society, and its moral values. Tombs and burial grounds in Etruria and elsewhere functioned as spaces, and burials were events that brought families together. This phenomenon can be seen in some of the burial complexes of the kings of Kutai Kartanegara, which are located in several cemeteries.

5. Conclusion

This research proves that the design and ornamental dimensions of the Kutai Kartanegara Sultanate cemetery complex reflect the social symbols and hierarchical structure of traditional Islamic society. The clustering results identified three main groups: the first cluster depicted the lower social hierarchy, characterized by simple design attributes and small size; the second cluster reflected the immediate family with medium design proportions; and the third cluster depicted the nuclear family or central figures of the kingdom with monumental designs and complex ornaments. This pattern shows that tombs not only function as a final resting place but also as a manifestation of social status, a means of articulating power, and a medium of collective memory passed on across generations. The symbolism reflected in the tomb's decoration and structure functions as a form of respect for influential individuals and a strategy for representing the value of power in the public sphere. This funeral practice became a means of maintaining legitimacy, increasing family prestige, and communicating the Kingdom's social structure to the community and the next generation.

Nonetheless, this study has limitations, especially the lack of written historical data related to the individual identities of each grave site. Consequently, the interpretation of family relationships relies on design and symbol approaches. Therefore, the potential for bias or oversimplification in interpretation may occur due to the limited individual data available for each tomb. However, some tomb structures are incomplete or even missing, making it difficult to interpret the design and symbols. Therefore, this aspect should be considered in future research to strengthen the accuracy and depth of analyses. In addition, the direct involvement of local communities and the Kutai Kartanegara Sultanate families in the interpretation process has not yet been explored. The insights of the Kutai Kartanegara royal family can significantly contribute to design preferences, symbolism, and social hierarchy in these tombs. Future research should adopt a participatory approach and utilize oral sources to deepen our understanding of symbolism and internalized collective memory in tomb complexes. This study makes two main contributions to the literature. Theoretically, tomb architecture and decoration are reconstructed as spatial and hierarchical sociopolitical expressions, enriching the study of death archaeology with a sociological-material approach. Methodologically, the application of mixed-type clustering algorithms is a new approach in Indonesian archaeology that enables a more precise multivariate classification and can be replicated at other Islamic tomb sites in Southeast Asia.

Therefore, although this study focuses on the Kutai Kartanegara tomb complex, the approach used here allows for a deeper exploration of how the material culture of tombs reflects identity, culture, and social structure. This finding also promotes the integration of social archaeological approaches and quantitative computational

analysis. The classification model developed in this study has the potential to serve as an initial framework for the management of cultural landscapes based on scientific data and as a basis for public education on Islamic heritage. Thus, this research provides not only academic contributions but also practical implications for preserving historical sites and strengthening Islamic cultural narratives in Indonesia and in Southeast Asia.

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Author's contribution

Titin Agustin Nengsih: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing – Original Draft, Writing – Review & Editing, Visualization. Muhammad Chawari: Conceptualization, Writing – Review & Editing, Investigation, Supervision, Funding acquisition. Irfanuddin Wahid Marzuki: Writing – Review & Editing, Investigation, Supervision, Funding acquisition. Henki Riko Pratama: Investigation, Resources, Data Curation, Writing – Review & Editing, Project administration, Funding acquisition. Imam Arifa'illah Syaiful Huda: Conceptualization, Writing – Original Draft, Formal analysis, Writing – Review & Editing. Benny Agusti Putra: Investigation, Resources, Data Curation, Project administration. Wahyu Rizky Andhifani: Formal analysis, Investigation, Writing – Review & Editing. All authors have read and agreed to the published version of the manuscript.

Ethics Approval

This study did not require ethical approval as it involved analysis of archaeological artifacts and did not involve human or animal subjects.

Does this article screen for similarity?

Yes

Conflict of Interest

The authors have no conflicts of interest to declare. There is also no financial interest to report. The author certifies that the submission is original work and is not under review at any other publication.

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