Journal of Engineering Science and Technology
Vol. 16, No. 2 (2021) 1614 - 1629

GIS APPROACH TO SPATIAL ANALYSIS OF HERITAGE SETTLEMENT: CASE STUDY OF MAGERSARI KASEPUHAN PALACE, INDONESIA

INA HELENA AGUSTINA

Department of Regional and Urban Planning,
Faculty of Engineering, Universitas Islam Bandung
Jl Tamansari No 1 Bandung,40116, Indonesia
E-mail: ina.helena@unisba.ac.id

Abstract

As a country that used to be various kingdoms or sultanates, Indonesia has a rich cultural heritage including historical buildings. One of the historical buildings is the Kasepuhan Sultanate in Cirebon including its settlement called as the Magersari settlement. This settlement is part of the palace sultanate and is located inside the palace fortress. It is intended for servants in the palace. Because these settlements have historical values that need to be conserved, this study aims to analyse the changes in settlement space and their implications for settlement conservation. This study used Arch GIS 10.8 from maps obtained from Google Earth in 2006, 2012 and 2018.The results showed there was an increasing number of buildings during the period which caused damage to the remains, such as Kuta Kosod fortresses. The implication of the addition of buildings in the settlement was increasing the damage to artifacts in Magersari heritage settlement area and thus it requires conservation efforts.

Keywords: Geographic information system (GIS), Heritage settlement, Spatial changes.

1. Introduction

Heritage is something that is passed down from generation to generation and becomes the identity of society and the state [1]. As one of the cultural heritages, historical buildings are one of the identities and patterns of life of the previous community that need to be preserved for future generations. Good management of heritage building maintenance needs to be applied in order to maintain the values and traditions of the previous eras which are reflected in the heritage building [2]. One of the efforts is through effective and comprehensive conservation [3]. However, architectural heritage in many places faces the risk of being neglected and some has even become extinct or damaged [4]. Thus, a spatial analysis of cultural heritage such as traditional architecture is necessary to provide data on conservation needs.

Traditional architecture is architectural work that is oriented to the aspects of locality and the history of the time span of its existence. In fact, traditional architecture is a vernacular masterpiece recognized by acclamation and from generation to generation over a long and even very long period of time [5]. As symbols of traditional architecture, artifacts are physical manifestations and representations of a society's culture, including settlements and all other buildings [6, 7]. As the representation of the cultural aspects, the unique values are different from one another. Traditional architecture provides certain identity features that must be preserved.

Magersari settlement is a settlement that is attached to the palace of Kasepuhan and is fenced off by a fort. Magersari means the word "mager" or "fence" and the word "sari" means the core, i.e., the palace building. The initial formation of this settlement was as a residence for *abdi dalem* (people who work in the palace), and thus, the age of its formation is the same as the age of the palace which was founded in the 13th century [8]. Therefore, this area reflects the manifestation of the formation of heritage settlement spaces. The pattern of living in the palace servants only remains in the Kasepuhan Palace in Cirebon. Although Indonesia has many kingdoms/palaces with the same pattern, most of them have long been extinct. Heritage and traditional settlements have not received global attention and international publications [9], and thus, this research will make an important contribution to the conservation of the area.

Some research studies on settlements around the palace have been mostly conducted using a qualitative approach without using geospatial accurate map documentation. Geospatial accurate maps are important information for cultural heritage efforts. Some studies on heritage area using Arch GIS have been reported, such as archiving the sandstone sites of the South Paris basin [10], geospatial databases in the Kingdom of Seville [11], an analysis of cultural heritage around cities in Afghanistan [12]. In Indonesia, many relics of past kingdoms are used as heritage areas. However, little research has been carried out as conservation efforts through area mapping, especially with the Arch GIS approach. Some researchers have also conducted studies of cultural heritage in some sites, but they mostly used a phenomenological approach which investigated the meaning of space. For example, research on the cultural heritage of the Taman Sari Yogyakarta Palace settlement was carried out to assess the damage to cultural heritage elements [13]. Another study examines the settlement patterns of the Mandalangen Kasepuhan Palace with a qualitative method showing certain patterns [14]. Because few studies

focus on spatial change, this present study attempts to fill this gap by focusing on researching spatial change and its implications for elements of cultural heritage in the Magersari settlement. This study specifically aims to map the changes in the Magersari residential space of the Kasepuhan Palace in Cirebon, Indonesia, and their implications for area conservation efforts. Conservation is defined as actions that must be taken to prevent damage by adopting an approach that extends the life and basic functions of cultural heritage buildings [15].

Although the Indonesian government has a cultural heritage law, conservation practices are not optimal, including the conservation of the cultural heritage of the Kasepuhan Palace Area. As a result, the Magersari settlement cannot be maintained optimally. People living in Magersari practice traditional lifestyles, including the administration of the residents which still uses conventional paper-based data made by the chief of the palace. The palace workers, such as village chiefs and the palace servants, are too old to carry out modern management. Data management using GIS is then necessary to identify the Magersari settlement area and the residents.

GIS is part of advances in spatial data information technology and has the potential for the management, organization, and sustainability of cultural heritage. The palace area as a cultural heritage is an object that has the potential to use GIS for area documentation, replacing the paper-based format owned by the palace, especially building data in the Magersari area. Data is processed manually but will make it easy to store. As a means of documentation for cultural heritage inventory, GIS is used for some reasons [11]. GIS allows easy editing, extending, updating, and storing of heterogeneous data so that thematic maps and visualizations can be created for a wider audience. It is also used as an important tool in understanding heritage landscapes. Some studies usually address the topic from a spatiotemporal perspective using GIS. In addition, GIS is used in the development of controls and predictions for the conservation of known heritage and also to identify potential archaeological sites. It is also used to create strategic plans for natural and/or cultural heritage management. It can be used as a tool to analyse data, identify, calculate, and assess the boundaries and levels of protection of heritage areas. In addition, when combined with local and regional land use plans, GIS is useful for managing building permits and changes in land and building use.

For research, GIS is used as a method to explore, discover, identify, visualize, and question interaction patterns and processes in past societies. GIS is based on graph theory in mathematics. A graph is a set of nodes joined by a set of edges that represent the interactions between them. A network is a graph with attributes associated with its vertices and edges. This attribute is used to classify nodes and edges into categories so that patterns can be explored. Graph models have been used to understand complex relationships in past cultures, including articulating and analysing different scales of cultural heritage. The limitation of the graph model is the complexity of its application because the definition and construction of nodes and edges in historical networks is not easy to solve [11].

2. Methods

2.1. Context of study

Cirebon City is one of the cities located on the North coast of Java Island, West Java Province, Indonesia. With a geographical location of 108^0 33 E and $6\ ^0$ 41 S,

this city is known as a cultural city that has various regional arts, culinary delights, including cultural heritage in the form of a palace. There are three palaces in Cirebon: the Kasepuhan Palace, the Kanoman Palace, and the Kacirebonan Palace. In general, this palace is surrounded by settlements inhabited by followers of the palace leadership, or so-called Magersari settlements. In the context of settlement formation, Magersari is translated as the formation of settlements surrounding the houses of their local leaders [16]. The location of this research is located in the Magersari residential area of the Kasepuhan Palace. These settlements are intended for *abdi dalem* (a term for people who work in the palace). The Magersari area was established since the Kasepuhan Palace was founded in the 13th century AD [17].

The overall principle governing site selection is to understand the spatial changes that occur in the Magersari area. This area is the initial form of people living in the city of Cirebon. Settlements within the palace fort and related to palace artifacts. Changes in spatial patterns that occur indicate that there are social relations that still exist between the palace and the Magersari community. Physically, changes in space with the characteristics of high building density will have implications for the possibility of damage to palace artefacts. Position of Cirebon City Magersari area can be seen in Fig. 1.

Fig. 1. Position of Cirebon City Magersari area.

2.2. Data collection procedure

Magersari settlement location data were obtained from Google Earth in 2006, 2012 and 2018. However, for the needs of field observations, a 2018 google earth map was taken which was printed at a scale of 1: 5000. In addition, interviews were also used to obtain demographic data from local residents. 253 participants were selected based on convenient sampling. The reason is that the majority are informal traders with uncertain and irregular working hours, this technique is applied for this. Interviews were conducted one by one with each occupant using recording tools in mixed languages: local language and Indonesian. Interview questions were related to the history of the Magersari location, reasons for choosing Magersari, name of family head, age of each occupant, livelihood, population status, and number of people who live in one house. The time for conducting interviews was from 8.00 to 17.00 for one week. Data collection was assisted by a team of 3 surveyors. The surveyors were briefed first to equalize their perceptions, they were students who were preparing the final project of the urban and regional planning study program at a private university in Bandung, Indonesia. Data collection was carried out on residents because they have lived for generations in this area.

In addition, data were collected through field observation techniques in the Magersari area. Observations were carried out for one week in September 2019. Field observations were assisted by two surveyors. The object of field observation is the collection of data such as: building type, building condition, type of building function, building area, number of building floors, residential facilities. Next, observe the situation of the area from the results of the interview with the courtiers, such as plotting zones (Lawangsanga zone, water park zone, Mandalangen zone) guided by the information on the map. The camera is a tool for documenting the infrastructure of buildings and area. Approval of area documentation is carried out after sending a survey permit application letter to the head of the palace.

2.3. Data analysis

A Geographic Information System (GIS) software, ArcGIS 10.8, is used to map and analyse spatial patterns in the Magersari settlement. Initial data for analysis were taken from Google Earth maps in 2006, 2012, and 2018. The reason for taking the map in that year was because the data for that year received complete and clear information. Other data is a map of the area's height obtained from the Geospatial Information Agency (Indonesia: BIG). The stages of the analysis carried out are: (1) investigating the results of the interview plotting the courtiers producing the Mandalangen zone, the water park zone and the Lawangsanga zone (2) digitizing the Google map Earth in 2006, 2012 and 2018, (2) Comparing the map digitized from 2006, 2012 and 2018, (3) Marking the spatial changes that occurred in 2006, 2012 and 2018, (4) Overlaying the map digitized from 2002, 2006, 2018 with a map plotting zone results, (5) Marking spatial changes in each zone (6) Analysing the elevation of the area by taking the raster map data from the BIG then converting it into a shp map (shapefile), (7) Analysing the elevation of the area with the National Digital Elevation Model method (8) Comparing spatial changes in 2006, 2012 and 2018 (9) Interpreting changes in regional space.

3. Results and Discussion

3.1. Modeling of Magersari ancient settlements

This study aims to develop a spatial analysis through modeling changes and damage to space and formulating its implications for area conservation. The study used GIS in a database system and its analysis to evaluate its limitations and to properly design a spatial database. This process goes through the stages of data collection, database design, data processing, digital modeling in GIS, analysis, and visualization (see Fig. 2).

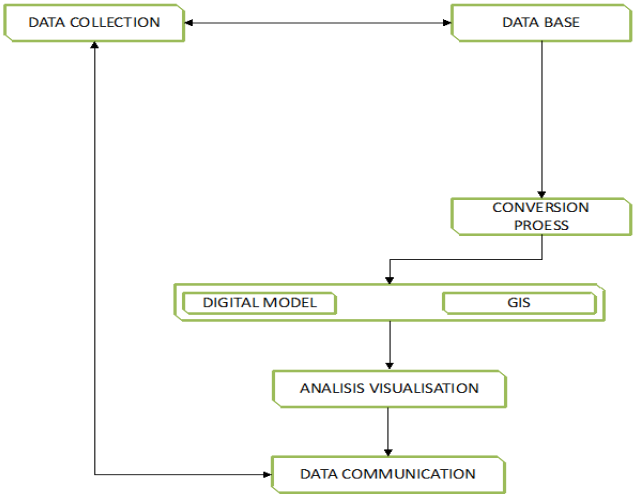

Fig. 2. GIS process framework.

Several programs were used during different phases, including Microsoft Excel® and ArcGIS®. ArcGIS® is the main software package used to create historical databases of Magersari settlements as it can digitize and vectorize data from traditional historical sources, such as maps, and correlate alphanumeric values to geometric entities. This device consists of a series of tools used in the spatiotemporal analysis phase (see Table 1). Google Earth maps for 2018 are digitized and data are processed and converted from analog to digital format.

Table 1. Summary of infrastructure data spatial.

Group	Layer	Entity Type
01_BATAS_LN	BATAS_ZONA_LN	Polyline
06_TRANSPORTASI_LN	JALAN_LN	Polyline
08_PERAIRAN_LN	SUNGAI_LN	Polyline
11_BANGUNAN FASUM_AR	BANGUNAN_AR	Polygon
14_TOPONIM_PT	BANGUNAN_PT	Point

Some data regarding architectural production information were obtained from the palace courtiers. The data are very heterogeneous and interrelated in large numbers and then proceed to design the GIS model database. One of the main features of a GIS system is that it can link data and information to geographic locations such as latitude or [18]. Its purpose is to organize and structure the data

to reflect certain features of the system being modelled. Hence, the preliminary stage consisting of conceptualization, abstract, and simplification of case studies was carried out to work with complex systems like the one used in this study.

The results of field observations reveal historical information of Magersari settlements on the ease of interaction with the palace and the artefacts. Some of the artefacts include the remains of the palace fortress (Kuta Kosod) which is composed of 2 meters high red bricks, three imaginary zones namely the Mandalangen zone, the water park zone, the Lawangsanga zone, the presence of palace symbols such as animal and flower statues for courtiers. The results of observations also found that there were artifact buildings of Lawangsanga and Gedong Patih houses and understood the concept of settlements that had the value of mutual protection between the king and his workers. These artifacts become information that will change the history of the economy and society and the history of the formation of cities in Cirebon.

The results of observations related to the history of living in Magersari provide information visualized on the map modeling. Geographically integrated historical approaches and data visualizations provide new possibilities for analysing and complementing traditional historical narratives. Historical narratives offer no concepts and almost no standard terminology or methods to facilitate the analysis of complex historical systems [11]. The results of GIS modeling of the Magersari living space can be seen in Figs. 3 and 4.

Fig. 3. Spatial data model of distribution of servants' houses and other buildings.

The results of the spatial data model above have shown that only eight houses are occupied by the royal servants or 3% of the total houses in Magersari. Some changes occur in the building of the Magersari settlement. The house buildings have been built beyond the height of the palace buildings, and this has violated the rules in the palace. The height of the two-story house building is 7% of the total existing buildings.

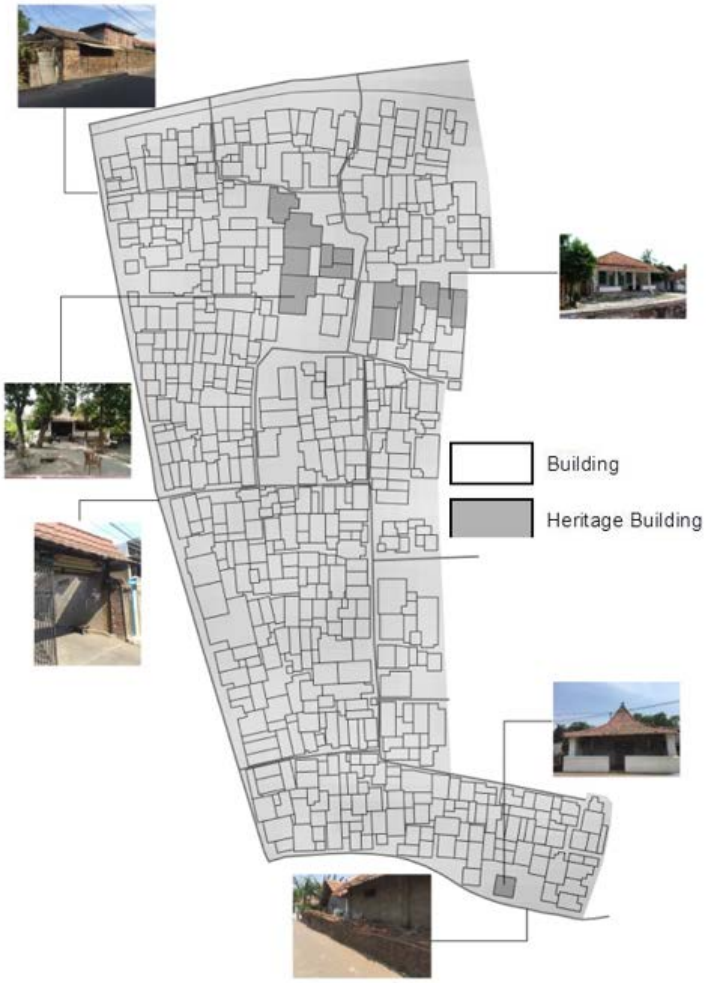

Fig. 4. Spatial data model of the position of Magersari heritage buildings.

The results of field observations reveal the damage to artifacts in Magersari settlement area (see Fig. 5). The results of field observations show that the density of houses worsens the condition of the artifacts in the area, especially the forts (Kuta Kosod) that are damaged and covered by other house buildings.

Understanding the spatial transformations of architectural heritage over time is essential for documentation and conservation purposes. In addition, documentary information communicates salient architectural features of the evolution of buildings to the wider public. With the rapid evolution of technology, mapping offers great potential

in communicating heritage in a way because its graphic depiction of the heritage itself can more directly relate to the real context in a more experiential way [19].

Fig. 5. Damage to palace artifacts in Magersari area.

3.2. Modeling of the altitude of Magersari settlement land

Land height modeling is carried out to analyse the lowest zone in the residential area. The lowest zone has the potential to collect rainwater. Land height modeling is done by overlaying the results of digitizing the 2018 map from Google Earth with altitude data. The overlay technique is carried out by combining the elevation data sourced from the National Digital Elevation Model issued by the Geospatial Information Agency. In order to overlay, the model data in raster format must be converted into vector data. The results can be seen from the land height model in Fig. 6.

The map of the land height model in the research area ranges from 0 - 7 meters above sea level. The lowest altitude zone is located in the water park zone. The water park zone is an imaginary zone naming and is a historical zone in the past. The characteristics of this zone are obtained from the information of the courtiers. Historically this zone is a place of infiltration of water and therefore this zone should not have any buildings. However, many residents' houses were found in this zone which caused flooding in the rainy season which resulted in damage to regional artifacts. Most of the heritage buildings are in a damaged condition and the main cause of their deterioration is environmental conditions [20]. Heritage buildings are affected by climatic conditions and every building material is influenced by the environment [20]. The artifacts in the Magersari area are in a

damaged condition which is influenced by the environmental conditions. Environmental conditions (such as variations in temperature, levels of air pollution, soil salinity, wind, rainfall, etc.) can provide additional clues for the identification of the process deteriorating these artifacts [20].

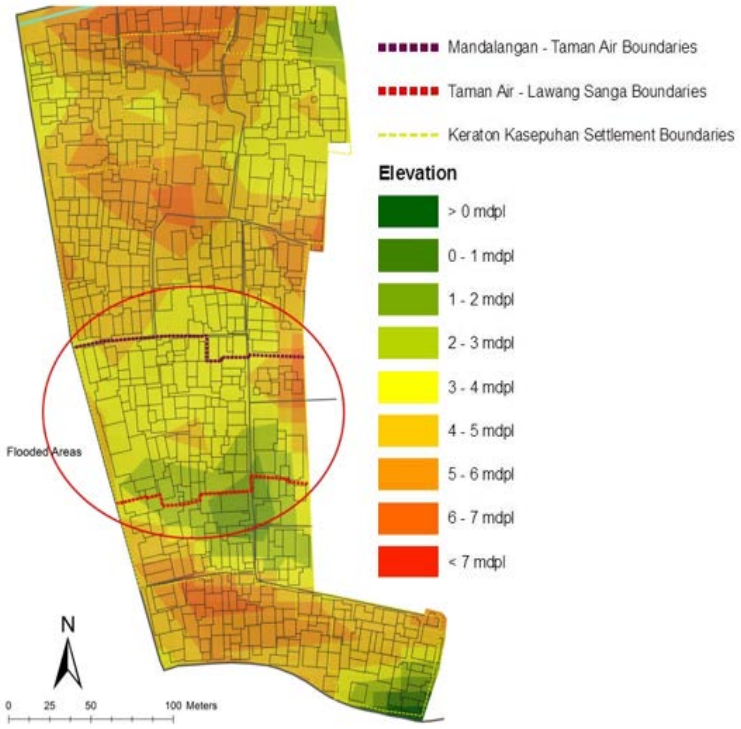

Fig. 6. Map of area land elevation overlay model.

Another cause of damage to cultural heritage is the low awareness of the community about the value of cultural heritage. Cultural heritage refers to all "movable and immovable property which is very important to the cultural heritage of everyone ...." [21]. Cultural heritage is an invaluable resource for the advancement of knowledge and economic development. However, the lack of appropriate monitoring and conservative solutions and poorly implemented interventions increases the risk of damage. An understanding of historical sites is both a starting point and an indispensable condition for maintaining these sites. However, how to maintain the site is also closely related to the knowledge and awareness of the community about the historical value of the site [21].

3.3. Modeling of spatial change

Space change modeling was performed by creating a raster and a vector database. Raster databases display, place, and store spatial data content by using a matrix structure or pixel arrangement that forms a grid (rectangle). The spatial data model relies heavily on the spatial resolution or the size of the pixels (grid cells) on the earth's surface.

The identification of changes in settlement areas was obtained by delineating settlements/buildings based on satellite images from Google Earth in 2006, 2012

and 2018. The results of settlement identification were complemented by field observations. The data were presented in three forms, including the point data to present place/location names, the line data used for boundaries, and the polygon data to represent houses/facilities. The results can be seen in Fig. 7.

Modeling of space changes in the Magersari area from 2006, 2012, and 2018 is marked by the increase in buildings in a period of 6 years. The red buildings are new buildings. The increase in buildings resulted in an increase in the density of built -up space creating reduced land for rainwater infiltration, less sunlight to enter the house, and flooding that damages area artifacts.

The road network that forms the spatial structure of the area did not experience any increase from 2006, 2012 and 2018. However, the dense buildings disrupted the regional circulation system which caused damage to the Kuta Kosod fort. The width of the road network is around 1 meter so that circulation can only be done by pedestrians and 2-wheeled vehicles.

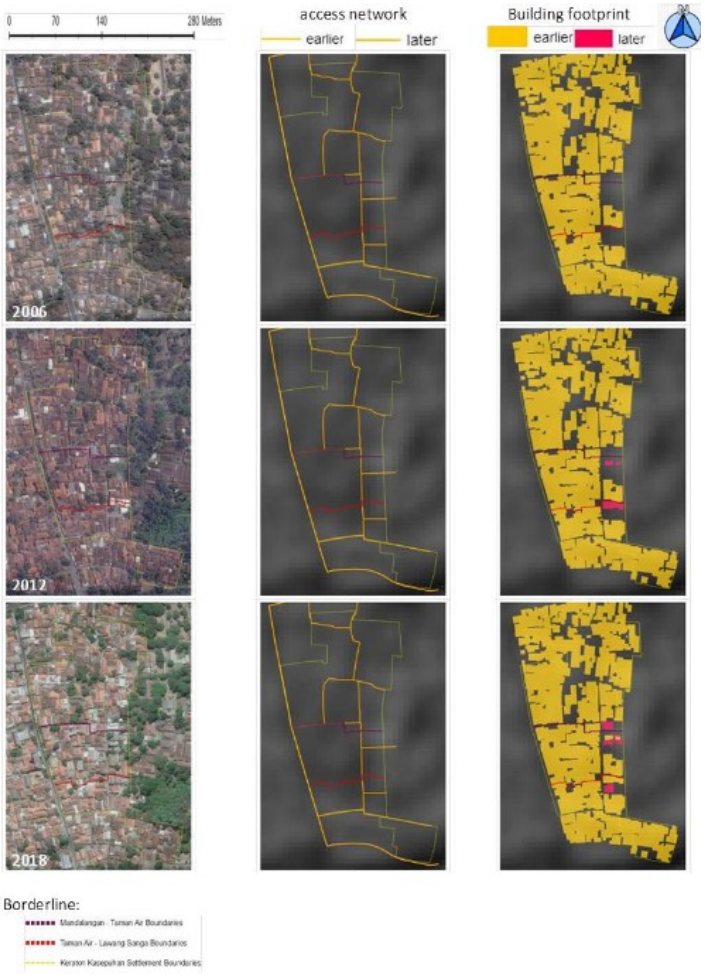

Fig. 7. Model of Magersari area spatial change.

The Magersari residential area has experienced spatial changes which have implications for the threat of damage to artefacts. Magersari houses form dense settlements, with narrow land. Its growth is similar to informal settlements, where settlement formation is not a single process but is influenced by culture, politics, economy, climate and topography and materials [22]. Seen from the elevation level ranging from 0- 7 meters below sea level, the topography of the area is relatively flat which enables a rapid growth of settlements. The artifact of the fort (Kuta Kosod) as a characteristic of dividing residential areas has been lost. The maps for 2006, 2012 and 2018 do not provide information on the fort as a whole. The fortresses were covered with houses and even destroyed. This shows that the change in space due to additional buildings causes the loss of the fort (Kuta Kusod) as the vital artifacts that characterize the Magersari area.

Each cultural heritage building has unique salient features to form architectural and aesthetic values. The shape of the Kuta Kosod fort and the artifacts in Magersari are prominent features of the architectural heritage. These artifacts are architectural elements that determine human functions, activities, perceptions, and experiences of space. The synthesis of space, volume, material, and constructive systems of architectural heritage results from various spatial and aesthetic transformations and modification processes over time [23].

Studying and communicating the spatial transformations of architectural heritage is essential for documentation and conservation purposes [24, 25]. The ICOMOS Charter emphasizes the importance of heritage communication to increase public awareness and to enhance their understanding of cultural heritage [26]. As such, heritage must be presented in a way that is physically accessible to the public, and interpretation of content should assist them in building meaningful relationships with cultural heritage as a heritage asset.

3.4. Spatial database model as initial stage of conservation

The rapid addition of houses in the Magersari area is due to ineffective management that uses a manual data collection system using a record book. Consequently, the palace is unable to control house growth because it is not properly recorded. For that, a spatial database in this area is required. The development of the database was designed according to the framework shown in Fig. 8.

The results of house building identification were obtained from satellite image data in 2018, where polygon data in the form of buildings/houses are given information on the attributes. Attributes are data usually used for population census purposes, survey records, and other statistical data. The attributes of the study area are the name of the owner, age, number of residents, number of floors of the building, area of the house, population status, and condition of the house. The results can be seen in Fig. 9.

Creating a spatial database is needed to make it easier to check Magersari houses. This database is the first step in limiting new residents from obtaining residence permits and limiting the addition of new buildings and may even limit the residence permits for existing residents in this area. In the end, it serves as a means of control so that the palace artifacts are not damaged and lost.

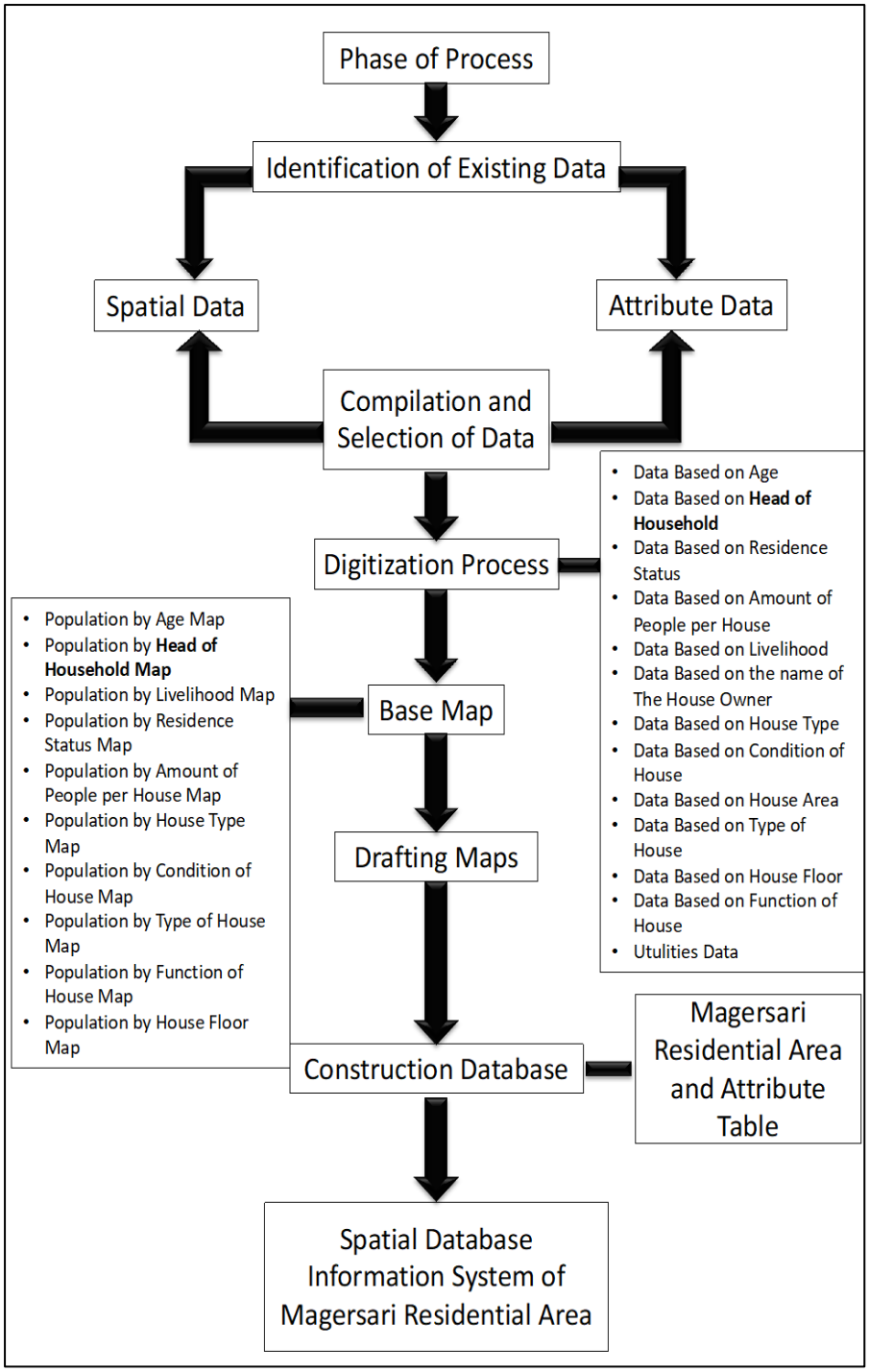

Fig. 8. Magersari spatial database framework.

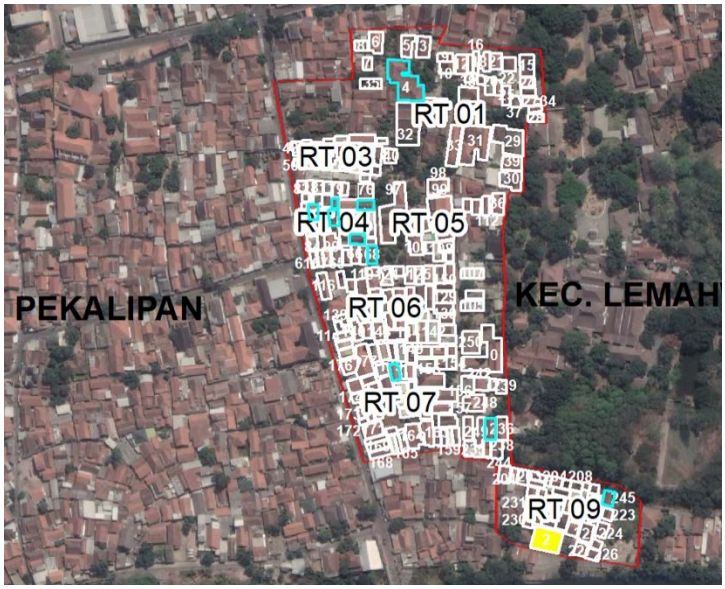

Fig. 9. Spatial database modeling of Magersari settlement area.

Cultural heritage management remains a complex challenge, especially due to the heterogeneity of the data processed and related to various factors such as history, geology, architecture, and/or archeology [21]. GIS is used as a spatial database and is one way of documenting this complex data. The use of GIS for cultural heritage management purposes has grown rapidly in recent decades, becoming a very widespread tool among conservation specialists [27]. Utilization of GIS as a social database for the Magersari Area is an early stage of the conservation process.

4. Conclusion

Cultural heritage areas in Indonesia have not received optimal attention. Many cultural heritages are neglected even though they play a role in building the nation's civilization.

The results of the study indicate that the residential area of Magersari in Kasepuhan Palace Cirebon has undergone spatial changes and has suffered damage to artifacts. This condition was exacerbated by the addition of house buildings and occurred during the period 2006, 2012 and 2018.

The water infiltration zone turned into housing/ buildings so that rainwater caused flooding. To anticipate this, efforts to conserve the area must be carried out immediately. As a first step, a spatial database containing the inhabitants of the area must be created. The use of GIS to create an occupant database makes it easier to control residents and buildings in Magersari. All cultural assets must be interpreted in the context of the relationship between objects and their environment, between objects and other objects, between humans and objects, and between humans and other people.

To date, very few studies have addressed this theme, and none have used a GIS methodology. In fact, they all adopted an approach based on existing documents. GIS has made it possible to view and verify and has succeeded in filling in the gaps in the documentation of Magersari settlement areas.

References

1. Prentice, R. (1994). Perceptual deterrents to visiting museums and other heritage attractions. *Museum Management and Curatorship*, 13(3), 264-279.
2. Idrus, A.; Khamidi, F.; and Sodangi, M. (2010). Maintenance management framework for conservation of heritage buildings in Malaysia. *Modern Applied Science*, 4(11), 66-77.
3. Zeayter, H.; and Mansour, A.M.H. (2018). Heritage conservation ideologies analysis–Historic urban Landscape approach for a Mediterranean historic city case study. *Housing & Building National Research Center Journal*, 14(3), 345-356.
4. Embaby, M.E. (2014). Heritage conservation and architectural education:"An educational methodology for design studios". *Housing & Building National Research Center Journal*, 10(3), 339-350.
5. Suharjanto, G. (2011). Membandingkan istilah arsitektur tradisional versus arsitektur vernakular: studi kasus bangunan Minangkabau dan bangunan Bali. *ComTech: Computer, Mathematics and Engineering Applications*, 2(2), 592-602.
6. Abu-Ghazzeh, T.M. (1997). Vernacular architecture education in the Islamic society of Saudi Arabia: towards the development of an authentic contemporary built environment. *Habitat International*, *21*(2), 229-253.
7. Yıldırım, M.; and Turan, G. (2012). Sustainable development in historic areas: Adaptive re-use challenges in traditional houses in Sanliurfa, Turkey. *Habitat International*, 36(4), 493-503.
8. Agustina, I.H.; and Hindersah, H. (2019). Explorations of social values in Magersari Settlement in Indonesia. *International Society for the Study of Vernacular Settlements e-journal*, 6(1), 1-9.
9. Dalkılıç, N.; and Nabikoğlu, A. (2020). Documentation and analysis of structural elements of traditional houses for conservation of cultural heritage in Siverek (Şanlıurfa, Turkey). *Frontiers of Architectural Research*, 9(2), 385-402.
10. Lesvignes, E.; Robert, E.; Valentin, B.; Ballinger, M.; Bénard, A.; Bellanger, F.; and Zotkina, L. (2019). Using digital techniques to document prehistoric rock art: first approaches on the engraved panels of the Paris Basin shelters. *Digital Applications in Archaeology and Cultural Heritage*, 15, e00122.
11. Ferreira-Lopes, P.; and Pinto-Puerto, F. (2018). GIS and graph models for social, temporal and spatial digital analysis in heritage: The case-study of ancient Kingdom of Seville Late Gothic production. *Digital Applications in Archaeology and Cultural Heritage*, 9, e00074.
12. Kristy, G. (2018). The impact of urban sprawl on cultural heritage in Herat, Afghanistan: A GIS analysis. *Digital Applications in Archaeology and Cultural Heritage*, 11, e00086.
13. Sulistyanto, I.; Krisnawati, E.; and Karsono, D. (2015). Pengaruh Perkembangan Permukiman Swadaya Terhadap Upaya Pelestarian Cagar Budaya Tamansari. *Jurnal Permukiman*, 10(1), 49-60.
14. Purwantiasning, A.W. (2011). Pola permukiman mandalangen di sekitar keraton kasepuhan Cirebon. *INformasi dan Ekspose hasil Riset Teknik SIpil dan Arsitektur (INERSIA)*, 7(1), 53-69.
15. Arazi, N. (2009). Cultural research management in Africa: challenges, dangers and opportunities. *Azania: Archaeological Research in Africa*, 44(1), 95-106.

16. Budiarto, L. (2005). Magersari: the spatial-culture of kampung settlements as an urban strategy in Indonesian cities and urban housing. *Proceedings of the XXXIII IAHS World Congress on Housing.* Pretoria, South Africa, 1-15.
17. Agustina, I.H. (2016). Spatial Constructs of Spiritual Consciousness: The case of Keraton Kasepuhan in Cirebon, Indonesia. *International Society for the Study of Vernacular Settlements e-journal* , 4(2), 16-28.
18. Al-Mansoori, T.; Abdalkadhum, A.; and Al-Husainy, A.S. (2020). A GIS-enhanced pavement management system: A case study in Iraq. *Journal of Engineering Science and Technology*, 15(4), 2639-2648.
19. Nofal, E.; Stevens, R.; Coomans, T.; and Moere, A.V. (2018). Communicating the spatiotemporal transformation of architectural heritage via an in-situ projection mapping installation. *Digital Applications in Archaeology and Cultural Heritage*, 11, e00083.
20. Lakhani, R.; and Sharma, R.K. (2018). Strategies for the restoration of heritage buildings: material issues. Retrieved January 8, 2021, from https://www.researchgate.net/profile/Rajesh-Sharma-54/publication/329446459_Strategies_for_the_Restoration_of_Heritage_Buildings_Material_Issues/links/5c09136592851c39ebd7712b/Strategies-for-the-Restoration-of-Heritage-Buildings-Material-Issues.pdf.
21. Di Benedetto, C.; Gautiero, A.; Guarino, V.; Allocca, V.; De Vita, P.; Morra, V.; and Calcaterra, D. (2020). Knowledge-based model for geomaterials in the Ancient Centre of Naples (Italy): Towards an integrated approach to cultural heritage. *Digital Applications in Archaeology and Cultural Heritage*, 18, e00146.
22. Dovey, K.; van Oostrum, M.; Chatterjee, I.; and Shafique, T. (2020). Towards a morphogenesis of informal settlements. *Habitat International*, 104, 102240.
23. Mehdi Khosrow-Pour, D.B.A. (2014). *Encyclopedia of information science and technology* (3rd ed.). Pennsylvania: IGI Global.
24. Doulamis, A.; Grammalidis, N.; Ioannides, M.; Potsiou, C.; Doulamis, N.D.; Stathopoulou, E.K.; and Dimitropoulos, K. (2015). 5D modelling: an efficient approach for creating spatiotemporal predictive 3D maps of large-scale cultural resources. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2(5W3), 61-68.
25. Fredheim, L.H.; and Khalaf, M. (2016). The significance of values: heritage value typologies re-examined. *International Journal of Heritage Studies*, 22(6), 466-481.
26. Silberman, N.A. (2008). ICOMOS charter for the interpretation and presentation of cultural heritage sites. Retrieved January 5, 2021, from https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1008andcontext=efsp_pub_articles.
27. Campanaro, D.M.; Landeschi, G.; Dell'Unto, N.; and Touati, A.M.L. (2016). 3D GIS for cultural heritage restoration: A 'white box'workflow. *Journal of Cultural Heritage*, 18, 321-332.