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The Climate conscious concept of Majapahit settlement in Trowulan, East Java

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Abstract

Curiosity about how the ancestors in Nusantara pass on local wisdom in their harmonize with the climate and the environment to create physiological comfort, directing research on the cultural environment of Majapahit, as a largest Hindu civilization at Nusantara in the 13th until 16th century, in harmony with nature to be able to sustain until now in Bali.
This study aims to find the climate conscious concept from Majapahit settlements that can be used as an example in the present and the future. The research was a qualitative descriptive research method of the historical-intrepretive research. There were three principal planned research process: first, the theoretical study of the Majapahit settlement in Trowulan in the climate anticipated; second, empirical study on the site, artifacts and comparing the settlement patterns in the traditional villages in Bali and the last is analysis and evaluation. The results that the settlement of Majapahit in Trowulan is a concept of climate conscious settlements that are part of the Nusantara's bioclimatic wisdom, based on ethical values, norms and contextual actions with the local environment, through a process of long experience and hereditary in bond of mutual benefit to achieve an ecological balance. It can be concluded that the technology developed in a sensible and wise by the people of Majapahit in Trowulan for settlement is the solution to solve the climate problem and the nature of life in the settlement, and always in the context of the local culture that is deeply rooted in people's lives.

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Keywords: *climate conscious; local genius; bioclimatic architecture; Majapahit settlement*

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1. Introduction

Rapid development of global culture and technology, has plagued in Indonesian architecture. Need a depth study into the past, where people in Nusantara has wisely and intelligently align themselves with the environment and climate. Concepts and the patterns were applied in the past has experienced hundreds of years of evolutionary wisdom that can be developed for environmental solutions in the future. Traditional architecture could be sustained because the necessities of life, through climate adaptation and use of materials (Scardigno, 2014). It can be used to give a clearly limitation the local concept of sustainability to architecture and environmental planners, giving hope for architecture science to turn back to the local traditional architecture. Because the local architectural typology really successfully responding in a way that most appropriate the local climatic conditions (Manriquez, 2006).

Nusantara's bioclimatic wisdom could be the answer for Indonesian architecture development in the future by applying the cultural wisdoms from the past back. Traditional societies had uniquely local knowledge as a strategy of adaptation to the environment. The strategies always attached to the beliefs and customs from generation to generation (Permana, 2011). Effort to explore the local wisdom knowledge related to the tropics-humid climate in Indonesia, at this study started on local wisdom of Majapahit kingdom, that a great civilization history of cultural and architecture in Nusantara that ever victorious over more than two centuries (from 13th until 16th century). Majapahit civilization was a long time culture period in Java, and a Java's and Bali's sustainability milestone of the civilization in the next period (Munandar, 2011). Many things are yet to be revealed about this local knowledge associated with the building responsibility to the tropics-humid climate at the Majapahit settlement in 13th until 16th century, as part of the Indonesian ancestors that were wise and sensible with culture and technology to adapting the housing environment with the climate. The aims of this research is developing the concept and theory of Nusantara's architecture bioclimatic wisdom focused on Majapahit settlement in 13th until 16th century at Trowulan, East Java.

This research expected to contribute a new knowledge about the bioclimatic wisdom of Majapahit settlement enrich in architecture and environment of Majapahit realm scope from the tradition and culture. This knowledge is expected to reveal the local wisdom and noble example that have been developed by Majapahit society at anticipation the climate on the heyday of Majapahit in the former site of the royal capital Majapahit in Trowulan, East Java. The study also aimed as a stimulant for further research on architecture and the environment, archeology, anthropology and art culture in the era of the Majapahit kingdom. Ideologically the results of this architectural study are expected can develop the national identity and spiritual through local wisdom and nations noble exemplary Majapahit in the past that became the forerunner of the Indonesian nation.

2. Research theory and methods

Attempts to reconstruct the Majapahit city with a variety of approaches have been carried out by Pont (1924) by comparing the Trowulan site with Negarakertagama (shows in Fig. 1), then Stutterheim (1948) reconstructed palace of Majapahit by comparing the Negarakertagama with the existence of Puri Klungkung in Bali and Keraton at Yogyakarta. Pigeaud (1962) emphasized the dualistic pattern of Ciwa and Buddhism in the Majapahit complex structure, in contrast to Slametmuljana (1968) put forward the hypothesis that the monocentric pattern reconstruction of Majapahit. While Santoso (2008) concluded that the Majapahit's city pattern principle is microcosmic-dualistic consisting of territorial units.

Settlements pattern as the smallest territorial units of Majapahit city were depicted on many panels at reliefs from the ruin of Minakjinggo temple in Trowulan (Fig. 2). Picture of the temple reliefs reflects a real people's lives at that time (Kempers, 1976). The figure of Majapahit's residential units emerged from the reconstruction of Majapahit houses, a thesis by Oesman (1999) and forms the residence of Majapahit (Sasongko and Winarto, 2009) and the proportion of residential Majapahit (Sasongko and Winarto, 2010) gives a lot of research gaps that have not been developed about the architecture response to the climate, as illustrated in Fig. 3.

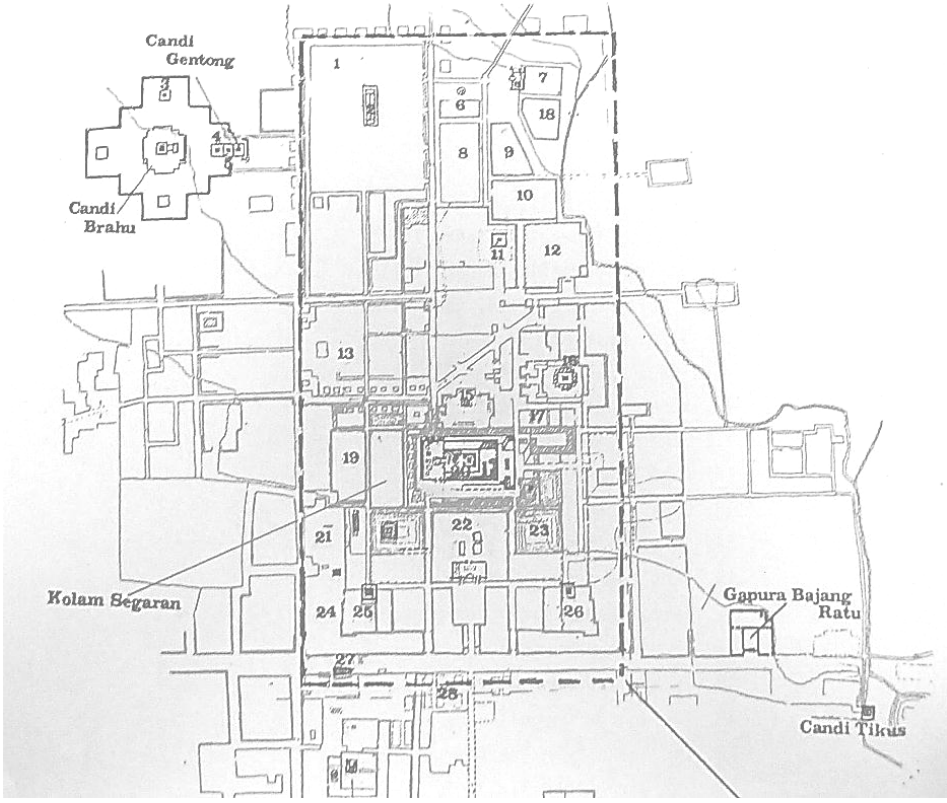

Fig. 1. Plan of Majapahit capital reconstruction in Trowulan by Pont (1924)

Fig. 2. Details reliefs that depict settlements pattern of Majapahit
Source: Majapahit Museum, Trowulan, 2013

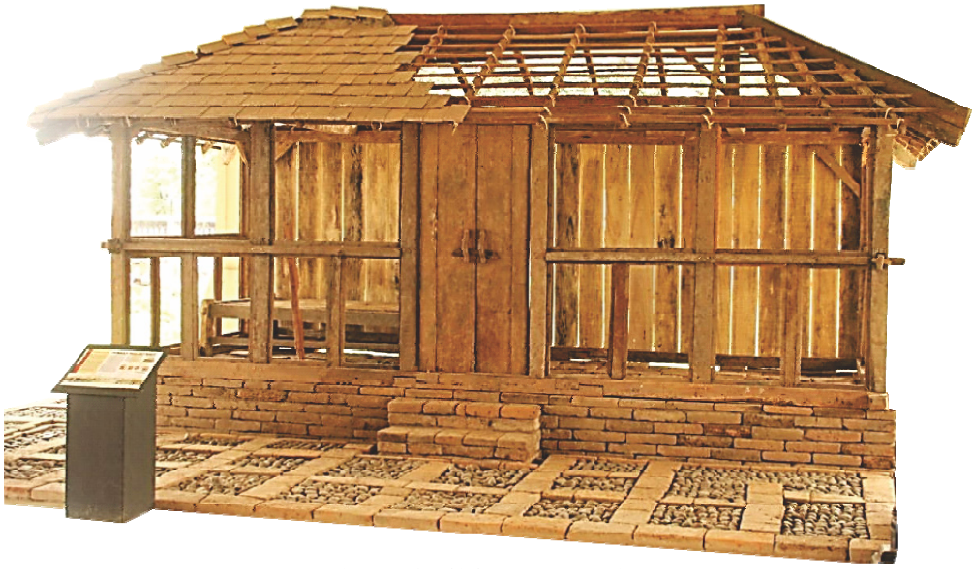

Fig. 3. Majapahit house reconstruction
Source: Majapahit Museum, Trowulan, 2013

Anticipating a tropics-humid climate is the most difficult thing in the architecture engineering to create thermal comfort inside room (Szokolay 1981). Bioclimatics Engineering strategies theory presented by Yeang (1994) and Lechner (2007) are two theories about the bioclimatic architecture design strategies in anticipation of tropics-humid climate at the context and scope in modern architecture. So in a spirit context of contemporary and future development of Nusantara architecture, need to learn how the Indonesian ancestors had been developed an architecture engineering and culture to responds the climate hereditary.

In this overall study planned, there are three main research process: first, theoretical review concerning the Majapahit settlement in Trowulan and environmental genius in traditional Nusantara public settlement. The studies mainly focused on the fundamental problems of humid-tropics climate: high solar radiation, rainfall and humidity (Lippsmeier, 1997). The second, empirical study on the site, artifacts and comparing the settlement patterns in the traditional villages in Bali as a continuation of the Ciwa-Buddhist Majapahit culture that preserved until today. The last one is the analysis which result interpretation and ongoing evaluation (Fig. 4).

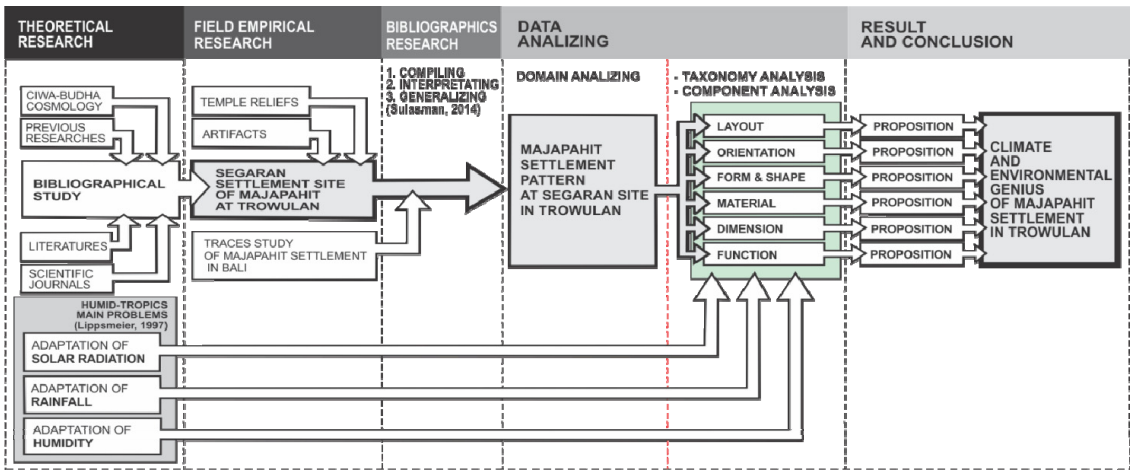

Fig. 4. Outline terms of the research process

The researchis generally used a descriptive method to create an illustration or systematic pictures, factualy and accurate among the facts, properties and relationships among phenomena, at the present time perspective, or at least the period of time which can be reached by the respondent (Nazir, 2013). Data searching through library research, field research and photograph documentation.

3. Result and discussion

3.1. Socio-cultural community

The Majapahit's main society religion in which Ciwa-Buddhist (Santoso, 2008; Munandar, 2011) are the main factors that influence the Majapahit cosmological conception in society. When translated to the Modified Factor theory by Rapoport (1969): Ciwa-Buddhism as the main religion at the main socio-cultural orientation of Majapahit became a primary factor creating architectural forms. The next factor that affects the shape of the architecture is the climate, building materials, construction, technology and land factors. Or according to Santoso (2008) cosmography concept in traditional state will regulate territorial, space and buildings.

In the Balinese civilization as advanced culture of Majapahit (Munandar, 2011), the traditional architecture always obeyed by the people way down through the generations because have eternally noble values. The wind flow and water is believed flowing from the sacred mountains to the sea and back to the mountain (Kusuma, 2003). It has a strong and significant correlation with the concept of air flow, aerodynamic architecture, heat transfer, movement of air flow and thermal comfort. So the architectural concept means harmonization between human and the environment that in the Balinese cosmologycal balancing concept called *Manik Ring Cucupu*, architecture was children of nature (Budiharjo, 1995).

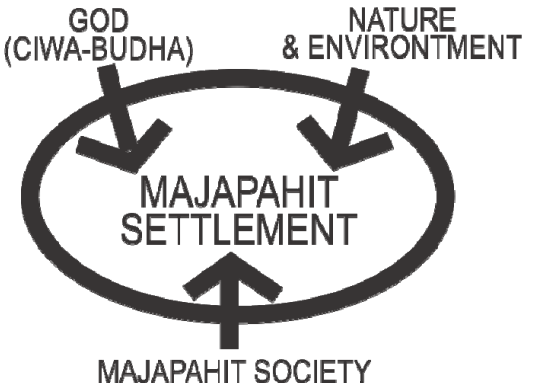

Fig. 5. Majapahit cosmologycal balancing concept at the settlement, adapted by Budiardjo (1995)

3.2. Settlement space hierarchy

From the research of Pont (1924), Pigeaud (1962), Santoso (2008) and Munandar (2011) can be deduced that the Majapahit settlement in Trowulan consists of a group of residential units (the redential unit called *Pakuwon*) which is composed of blocks of settlements, with the street as a circulation pattern, space and territory are clearly and enclosed yard. Residential units both large and small were separated by open space and the widely streets (Pigeaud, 1962).

However, in about 1980 from the aerial photograph by Bakosurtanal appeared interpetation a web of canals on the Trowulan Site (Hadisumarno, 1981). This interpretation was doubted by Hermanislamet (1999), so Yuwono in 2007 made a overlayed studies between map of Trowulan reconstruction by Pont (1924) with Topographic Map of Indonesia (RBI) by Bakosurtanal, and supported with geospatial plotting data in field (Fig. 6). However Mundardjito (2011) still believe that the canals is the only a network grid pattern water building which is found in only one city site in the Hindu-Buddhist kingdom periode in Nusantara.

Discussion in this study supports the hypothesis proposed by Gomprets et al (2008) which states that those canals are intersectional network of interconnected street. But still there were some doubt that the canals is the street

network due to found some ancient wells and brick network, so Munandar (2013) hypothesized that the canals was a residential area of lower caste in Majapahit society.

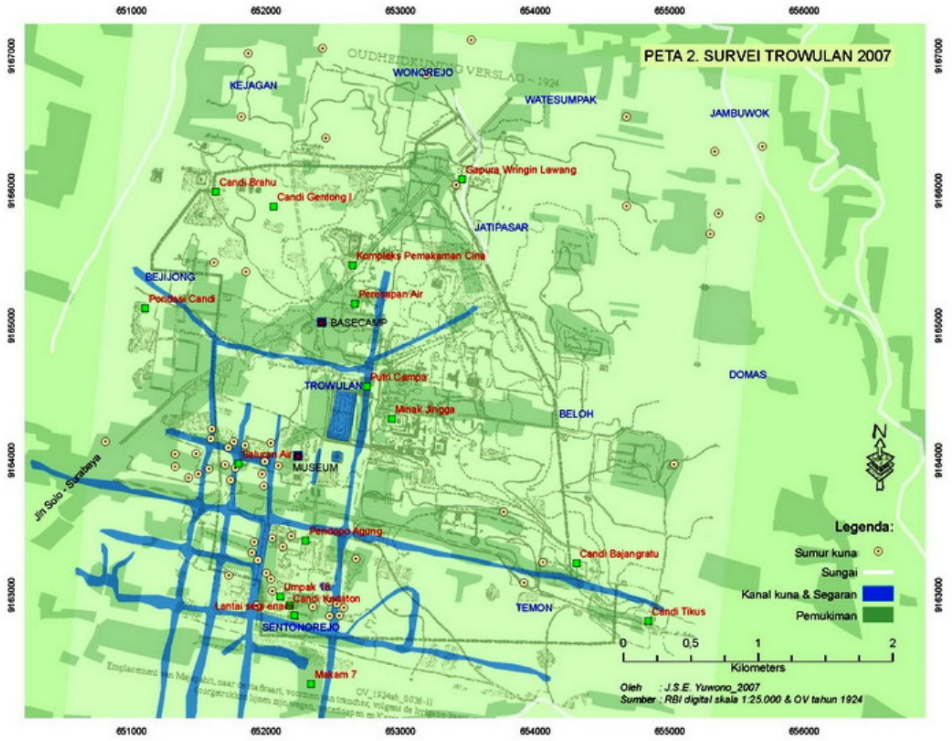

Fig. 6. Overlayed map between map of Trowulan reconstruction by Pont (1924) with Topographic map of Indonesia (RBI) by Bakosurtanal (1981), and geospatial plotting data in the field by Yuwono (2007)

This study led to finding that the open space and wide streets was the answer of Trowulan canals hypothesis that had been debated. The Majapahit settlement concept consists of a village pattern as shown in Fig. 7, where the existence of *bale ageng* allows set in middle of the street or open space. *Bale Ageng* placed on or near the sacred area in settlements close to the temple. Because it functions as a communal space where citizens gather it is equipped with various features including wells and platforms of brick or stone masonry as the base of the *bale ageng* building. The cosmological concept Ciwa-Buddhist also clearly divide spatial based on hierarchy. Street axis follow the cosmologycal axis of the sacred mountain on the southeast and the sea in the north, so that the street network in Trowulan intersect perpendicular to the direction of the north-south and east-west. Road surface about 1-2 meters lower than the original ground surface (Munandar, 2013) was a level road surface that deliberately lower than the settlement. This height difference clarify the street network pattern with the residential area also serves as a rainwater drainage network, which secured settlements from inundation and flooding during the rainy season.

Settlement align themselves with the environment with the presence of trees on all the open space that makes Trowulan was a garden city (Pigead, 1962). The Ciwa-Buddhist cosmology concept also put *Banyan* tree (*Ficus Benjamina;* or *Beringin* in Bahasa Indonesia) in public open space. Indirectly, Majapahit society has intelligently utilizing the vegetation and trees to protect the environment of the tropical solar radiation and create a comfortable microclimate in the environment.

Ciwa-Buddhist cosmological concept put shaft axis building orientation towards the mount Penanggungan (in the southeast) as the sacred space called *Utama* and the Java sea (in the north) as the space as profane area called *Nista*. In aerodynamics, blocks of settlement pattern and the grid of street network at lower elevation forming the air

flow corridor in the area that allows air movement freely flow and direction from the highland in the south to lowland in the north, through all sections. The air flow movement effectively will reduce the temperature and humidity lower in the settlements.

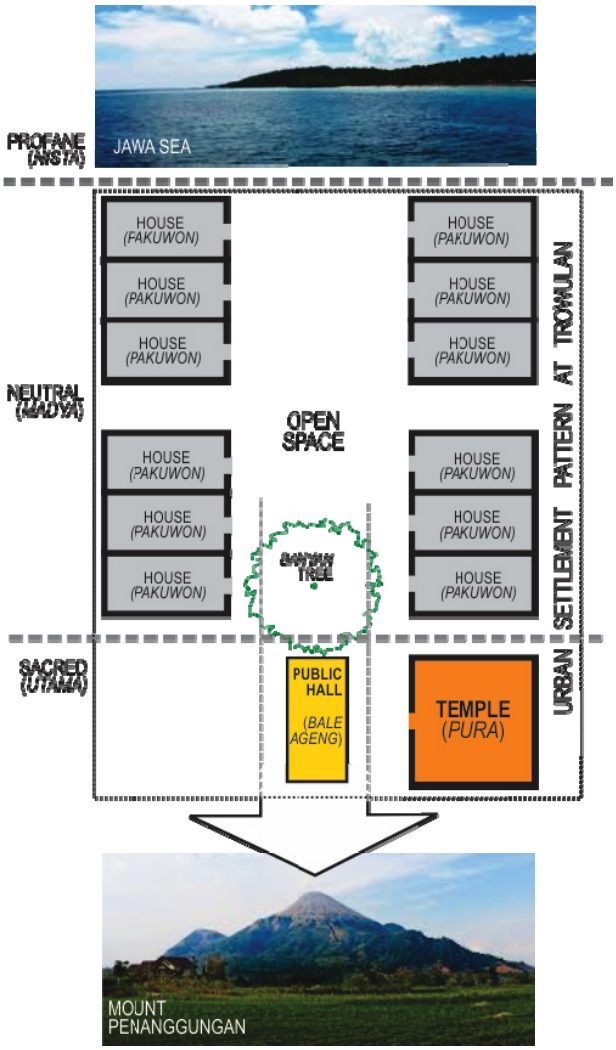

Fig. 7. The concept of space hierarchical layout on Majapahit settlement
source : author's interpretation study

3.3. Pakuwon as a residential of Majapahit

The composition of the *Pakuwon* Majapahit plan as shown in Fig. 8 as the interpretation of existing studies regarding *Pakuwon* picture in reliefs at Minakjinggo temple matched with *Segaran II* site and a lot of artifacts evidence showing the dominance concept of *Pakuwon* unit consists of fence, the open courtyard, and *kori* as in and outaccess. If it linking traced to social-culture Hindu (*Ciwa-Buddha*) a residential yard has the hierarchy of spaces, from the profane to the sacred space. In the yard consists some mass of : *bale* (open hall), *bale sakenem* (the building with walls covered) with 6 *saka* / poles, *bale meten* / *sakutus* (the building with walls covered) 8 poles, and *sanggah* as the offerings in the most sacred area. Each mass in the yard has different functions according to their hierarchy.

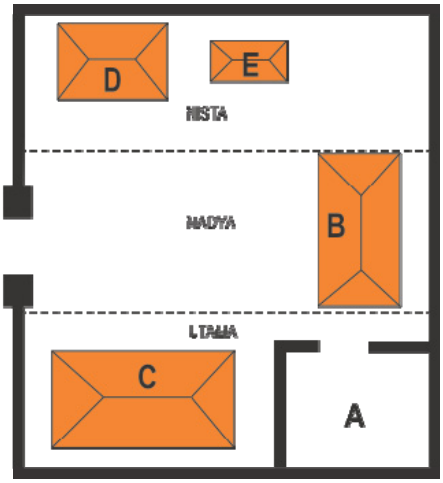

Fig. 8. Interpretation of *Pakuwon* plan at least consists of shrine - *sanggah* (A), House - *bale meten* (B), open pavilion -*bale* (C), kitchen - *pawon* (D) and barns (E) source : author's interpretation study

Sanggah, as a place of worship and the most sacred area (*Utama* area) was placed on the southeast side area, facing directly at mount Penanggungan. Majapahit house reconstruction by BPCB (Balai Pelestarian Cagar Budaya) East Java are only limited at the building mass *Bale Meten* (Fig. 3). *Bale* is open pavilion without walls as a major activity center at the *Pakuwon*. The completeness of the other masses are *Pawon* (kitchen) and rice storage barn. Interpretation in Fig. 8 is a basic and minimal unit of masses that is in Pakuwon, which can evolve according to the needs of each residence.

The concept to embodied the universe in *Pakuwon* is a community effort to harmonize themselves with nature. Humans do not subdue the forces of nature, but human synergize itself with smaller natural environtment (*bhuwana alit*) - in *Pakuwon*. Sunlight shinning in the yard, shading only on the parts that need to be protected from sunlight, rain water is left into the yard, to eventually seep into the soil and the abundance of rain flow and controlled through open drainage canals or gutters in the yard. Wind is flow free to move between the mass of the building, which the effect can reduce of air temperature and humidity in the yard. *Bale Meten* as a bedroom is a modular building-organic wood frame and covered with woven bamboo walls or wooden boards, which protects the occupants from wind and rain splash. Although the wall without windows, but air circulation and humidity of the air space is maintained relatively stable at the conditions of the outside air as woven bamboo walls or boards have gaps that allow air to pass through the wall. In fig. 9 below shows details the climate-conscious at *Bale Meten* unit on *Pakuwon*.

Fig. 9(c) shows the whole of the shape building reconstruction, with the presence of the roof and overhang eaves (b) to protect the building from solar radiation and rainfall. The existence of *Batur* as the base and foundation of the building (d), as the effort to elevate the building floor to anticipate puddles of rain or flooding. Also seen in Fig. 9(d) the existence of open drainage canals for rainwater right side of the *batur*. In detail (a) see the intermittent terracotta tile pattern installation to anticipate leaks when it rains. In the reconstruction that taking a home model with a wood boards wall have a cavity between the boards on the wall of the building that allows the walls have pores to breathe, the air flow to be able enough to protect occupants from low temperatures, strong winds and rain splash. Pores of the wall can also serve to lower the humidity in the room so it is relatively more convenient.

Open *Bale* (Fig. 10), as the family living room or day activity center, open without wall. The open form of *Bale* dominates in relief of many temples in the Javanese Hindu kingdom period in 13th until 16th century during Singasari-Majapahit era as seen in Penataran temple, Jago temple, Minakjinggo temple, Surawana temple and Sukuh temple. The open *bale* is very adaptive to the climate, where the roof is able to protect heat radiation of the sun and rain splash, also creates shadowing and shading, but cold air to move so as to create physiological comfort conditions for human underneath.

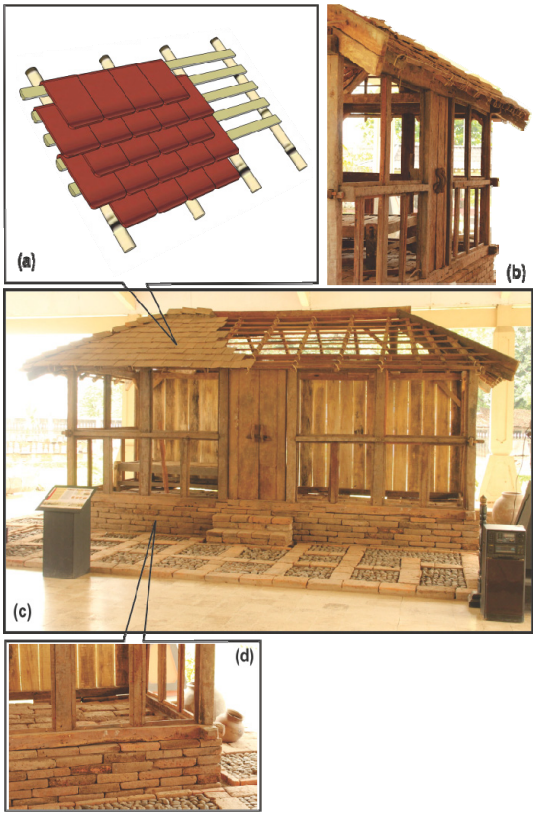

Fig. 9. *Bale Meten* (part of *Pakuwon*) reconstruction details
source : author's analysis from Majapahit's house replica
at Majapahit Museum, Trowulan, 2013

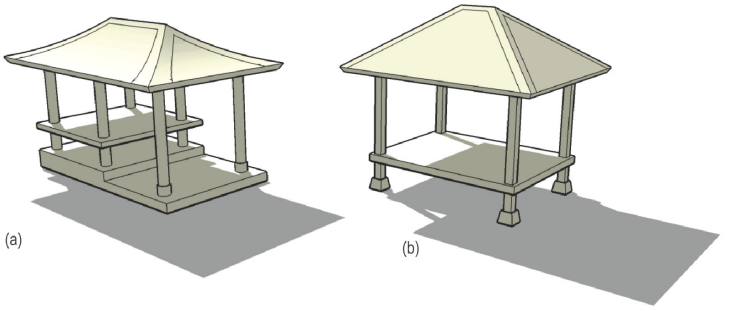

Fig. 10. Illustration of Open *Bale* as part of *Pakuwon*
source : author's interpretation study

3.4. Ornaments, materials and building technology

The dominance of using local natural materials are part of the local indigenous of Majapahit culture. Although the Majapahit as a maritime nation associated with international trade, but they do not importing the building materials. The technology that developed is a terracotta, like the bricks, tiles, ventilation rosters, ornaments pole building envelope, roof decoration, and so forth. Terracotta tile installation pattern can be seen clearly in many miniature houses artifacts such in Fig.11. Intermitten tile installation pattern shows technical solutions in leak anticipation of rainfall flow so as not to get into the building.

Majapahit society has also realized the importance of ventilation in buildings, and even developed into an attractive decorative ornaments (see Fig. 12). This evidence indicates that they have very good knowledge how to using the air flow from outside environment into the inside building for the purpose of thermal comfort. They have to understand that ventilation is a technical solution to reduce the humidity and flowing outside air into room is to create a more comfortable air.

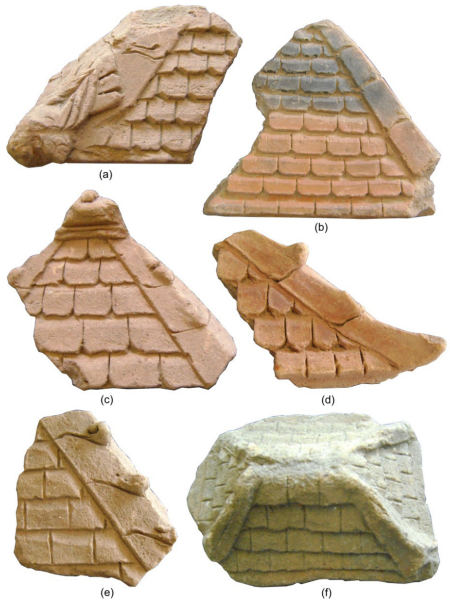

Fig.11. Roof patterns of Majapahit's miniature house artifacts.
Source: Majapahit Museum, Trowulan, 2013

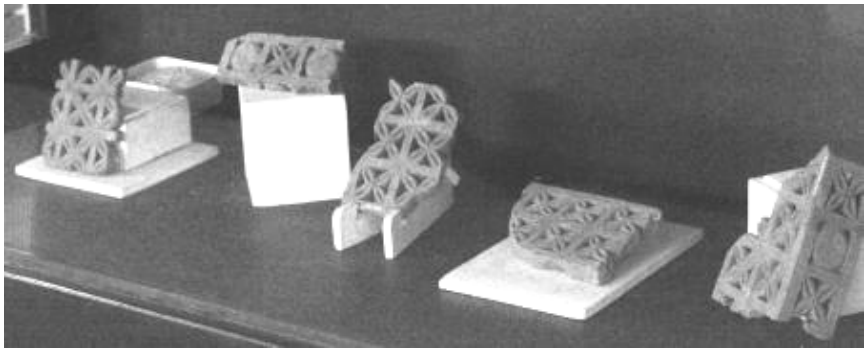

Fig. 12.Variety of terracotta artifacts that use as air vent cover.
Source: Majapahit Museum, Trowulan, 2013

4. Conclusion

Climate conscious settlement of Majapahit society in Trowulan is a bioclimatic wisdom in Majapahit culture. It is a sublimely knowledge of the local culture in response to the climate, based on ethical values, norms and contextual actions with the local environment. Sublimely knowledge of the local culture is widely implemented by Majapahit society in traditional settlements, through of a long experience process and hereditary ties of mutual benefit in order to achieve an ecological balance.

Fig. 13 below shows scheme of climate conscious concept applied from models of environmental processes by Olgyay (1963), taking case study in Majapahit settlements at Trowulan, and concluded: a Majapahit traditional settlement (Majapahit Settlement) always in the context of the local culture (Culture) deeply rooted in people's lives. Local cultural context of Majapahit strongly influenced by the Ciwa-Buddhist cosmological concept as a major religion at that time. With the local culture concept, Majapahit also developed wise and sensible technologies to solve the climate problem (Climate) to provide a better life in harmony with natural environment (Nature). This concept is sustainable, and evolutionary passed down through the generations until hundreds of years, even today still preserved in the traditional Hindu settlements in Bali.

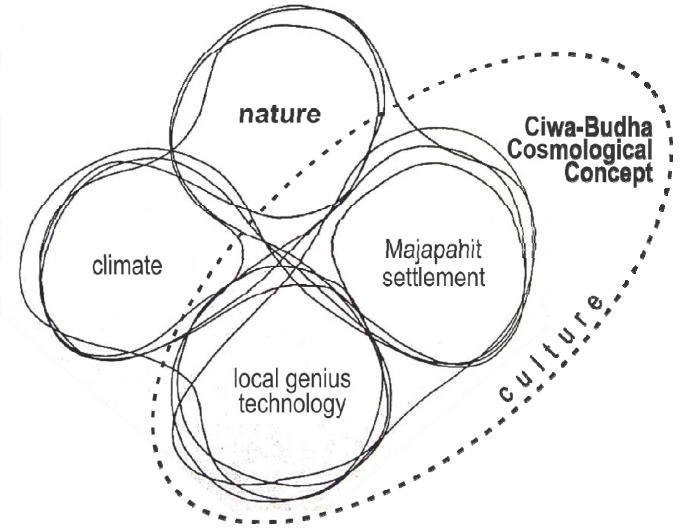

Fig. 13. Scheme of climate concious concept of Majapahit settlement in Trowulan, East Java
source : author's result and conclusion research

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