

Study of Microclimate Characteristic in Tamansari Yogyakarta as a Heritage Tourism Area

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INFORMATION ARTICLE

Abstract: Yogyakarta is known as a Tourism City because there is a lot of tourist destination that exists. One of the uniqueness of the city of Yogyakarta is the royal system that has been part of the government until this day. Tamansari Water Castle is a historic site used by the King and also the royal family for recreation. As one of the main destinations for tourists, it is important to note how the performance of the space formed in providing comfort for visitors. This study aims to determine how the microclimate characteristics in the Tamansari area, which have an impact on the thermal comfort felt by visitors. Observations are made to discover the elements forming the outdoor space such as the building mass layout and composition, the type of surface material, and also the type of vegetation that exists. This study uses simulation method with Envi-met software, using observational data as input. The simulation process will show how the microclimate conditions are formed in the Tamansari area, which includes air temperature, humidity, wind speed, and wind movement. The results represent that the landscape design in Tamansari has considered the thermal comfort through surface material and vegetation they have.

Keywords: Heritage; Tourism; Microclimate; Simulation; Envimet

Abstrak: Yogyakarta dikenal sebagai kota wisata yang memiliki berbagai macam objek wisata yang menarik para wisatawan. Salah satu keunikan kota Yogyakarta adalah sistem Kasultanan (Kerajaan) yang masih bertahan dan menjadi bagian dari sistem pemerintahan sampai dengan saat ini. Istana air Tamansari merupakan salah satu warisan budaya yang dulunya digunakan Raja dan keluarganya untuk beristirahat. Sebagai salah satu tujuan wisata utama, penting untuk dapat mengetahui performa ruang dalam memberikan kenyamanan bagi para pengunjung kawasan ini. Penelitian ini bertujuan untuk mengidentifikasi karakter iklim mikro dari kawasan Tamansari, yang memiliki pengaruh pada kenyamanan termal para pengunjung. Observasi dilakukan pada elemen-elemen pembentuk ruang seperti pola massa bangunan, material permukaan, dan juga vegetasi yang ada pada kawasan. Metode yang digunakan adalah simulasi software Envi-Met, dengan didasarkan pada data observasi sebagai input. Hasil simulasi akan menunjukkan data terkait iklim mikro seperti temperatur udara, kelembaban, serta pergerakan dan kecepatan angin, sehingga dapat diketahui bahwa desain ruang luar pada kawasan Tamansari telah mempertimbangkan kualitas iklim mikro yang bertujuan untuk meningkatkan kenyamanan pengunjung.

Kata Kunci: Warisan Budaya; Wisata; Iklim Mikro; Simulasi; Envimet

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INTRODUCTION

Yogyakarta is one of the leading tourist cities in Indonesia, which is the main destination for tourists. Various kinds of tourist destinations exist in this city, including cultural, historical, and natural attractions. Known for its culture, cultural tourism has become a special identity for Yogyakarta. One of the things that makes Yogyakarta special city is the

royal system that is still used, even integrated with the government system. Everything related to Royal life will be an attraction for tourists because it is a very valuable cultural heritage. Cultural heritage itself is a collective symbol of devices inherited from previous generations that can be physical, behavior and the way of life (Artha, 2004).

Tamansari gets the full attention of researchers because its historical value is very important to be conserved. There are various research topics conducted at Tamansari, related to the cultural values of the Tamansari, changes of function, and aspects of tourism. Tamansari has a spiritual element in its spatial layout, especially in the *Sumur Gumuling* section (Savitri et al, 2020). Furthermore, the naming of spaces / zones in Tamansari also has a unique system according to anthropological linguistic studies (Sulistyo and Salindri, 2018). A study of the cultural values of the Tamansari landscape design shows that the concepts given in landscape arrangement in Tamansari have cultural values that are useful for future generations (Tjahjani, 2005).

Several studies also show how the Tamansari area has encounter a change in function that has the potential to threaten existing historical values. Prasetyo (1999) and Subekti (2005) research the changes in the function of the Tamansari area due to tourism and commercial use. The changes in the function of the area would have an impact on the ecosystem and socio-culture (Hurdawaty et al, 2019). The emergence of the informal sector which is utilized by the people of Tamansari district (Panglipur and Amijaya, 2019) become an integral part of the development of the Tamansari area function. In addition, visual and audial aspects are also important elements in the development of Tamansari to represent the atmosphere of the past, even though in reality it is still only limited to visual elements (Noviandri and Sabono, 2018).

The Tamansari complex built by the first king, Sri Sultan Hamengkubuwana I in 1758 AD, this building has a function as the king's resting place as well as a place of relaxation. Tamansari is also known as the Water Castle because there is a pool that used to be used as a bathing place for the king and also his family. Generally, the Tamansari Complex consists of several clusters with several functions (as seen in figure 1), such as a resting place, a place of worship, and also as a place of defenses. Along with the growth of the city, some part of the Tamansari region could not survive due to the rapid growth of the settlements. The surrounding area has turned into a densely populated residential area that reduces the beauty that has ever existed in its time (Viciani & Hanan, 2017).

From a total of 58 buildings currently it's only about 22 buildings can be identified (Kurniati, 2016). However, the Umbul Binangun Complex, whose condition is still maintained as the original, remains a major attraction for tourists. This area is considered to still be able to represent the atmosphere, experience, and form of Tamansari as a whole, because there is pond, as King's bathing place, which is the main icon of Tamansari. The most important thing is the visitors can enjoy the beautiful ancient architecture of Tamansari, which integration between European architecture, Hinduism, Java, and China that collaborating with water elements.

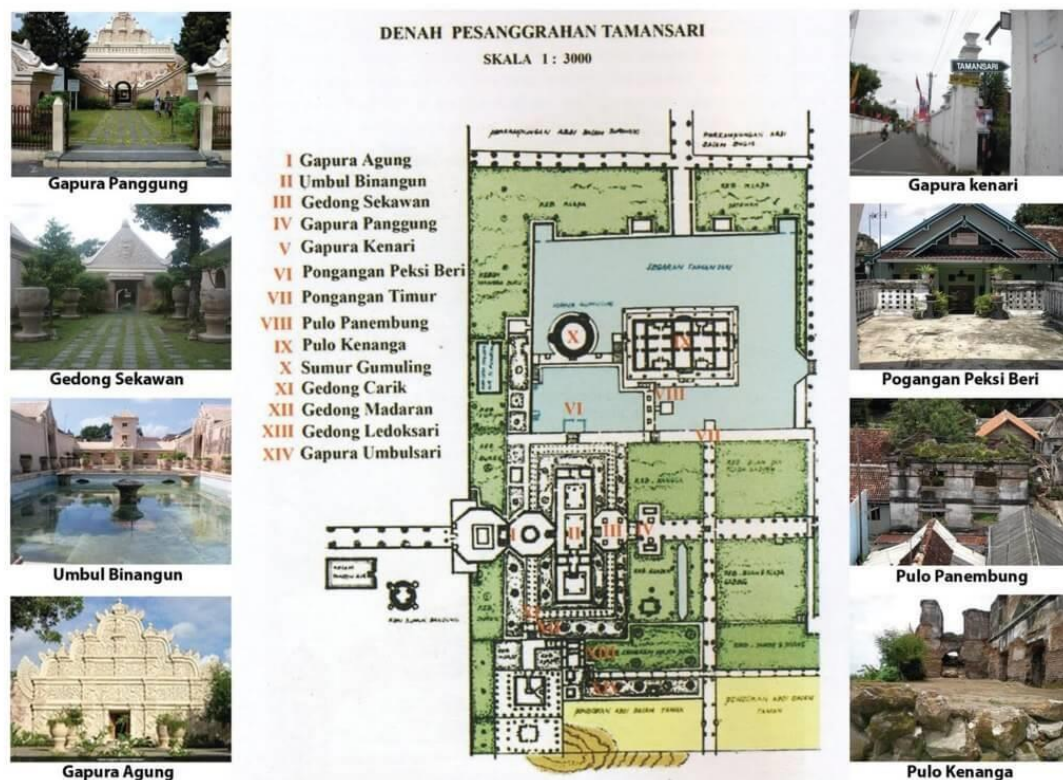


Figure 1. Tamansari Complex

Source: <http://culturaldestination.blogspot.com/2011/04/taman-sari-water-castle-yogyakarta.html> (accessed on July 12, 2019)

With its historical and cultural values, Tamansari is certainly one of the leading tourist destinations in Yogyakarta that makes this place always crowded with local and foreign tourists. Based on previous studies, it shows that functional changes can threaten the existence of Tamansari as a heritage site. These various changes at the Tamansari site also affect microclimate conditions. Microclimate has an important role because it relates to the atmosphere and comfort of the residents or visitors. Further understanding about the microclimate of the Tamansari site will make it easier to make decisions in conserving historical buildings while maintaining the comfort of visitors who come for a tour.

Therefore, it is necessary to know how the performance of outdoor area in providing comfort for the visitors. This study aims to discover how the characteristic of micro-climate in the Tamansari heritage tourism area, in relation to the thermal comfort felt by visitors. In the context of the outdoor thermal comfort, it will tend to be different from the indoor space. Human comfort in the outdoor area will have a considerable impact on the psychological aspects (Honjo, 2009). It can be interpreted that the atmosphere of the space will also determine a person's level of comfort. The factors that influence microclimate conditions can be divided into two, namely climate factors and physical factors (Kannamma & Sundaram, 2015).



Figure 2. Land use surrounding Tamansari

Source: Viciani, 2017

Physical factors are variables that can determine the character of the microclimate formed in the area. In this study, it is interesting to examine how the physical factors contained in the Tamansari complex have an impact on the regional micro-climate character. The most important aspects of concern are building mass and surface material. Buildings inside the complex of Tamansari have a special arrangement following the Kingdom’s culture. Whereas in the aspect of surface material, the presence of water elements is assessed to contribute to determining the regional microclimate. The water has an important role in controlling the microclimate of space (Hendrawati, 2016).

Considering the study was conducted in the indoor space, it is necessary to see how the role of water in influencing the microclimate of outdoor space. In fact, the design of the area or building in the past has considered architecture that is responsive to its climate environment, including conditions in the outdoor space (Sangkertadi, 2013). The results of this study will be able to give an idea of how the characteristics of microclimates are formed from a heritage area, as well as the correlation between cultural values that are manifested in the physical elements of environmental quality. This will be a consideration in the conservation and development of the new area.

Table 1. Factors that influence microclimate conditions

| Climatic Factors | Physical Factors |
|-------------------------|----------------------------|
| Air temperature | Building orientation |
| Humidity | H/W ratio |
| Wind Speed | Open space ratio |
| Precipitation | Plan form |
| Radiation | Building material property |
| | Landscape |

Source: Kannamma and Sundaram (2015)

RESEARCH METHODOLOGY

This research uses quantitative methods, using the Envi-Met software simulation. In the initial stage, field observations were carried out, which aimed to identify the elements forming the outdoor space that could have an impact on the character of the microclimate. These elements include:

1. The layout of building mass

2. Surface material
3. Trees and vegetation

In searching for data related to the elements forming the city space (physical settings of city space) will be obtained by observing 3 components and their properties: fix components, semi-fix components, and non-fix components (Gerald, 1981). Referring to urban design elements, thermal comfort will affect by the level of mass buildings, open spaces, and supporting activities. The first two elements are in line with Weisman's theory of physical settings, data will be obtained through observation. The urban design strategy can help create a more comfortable environment, such as providing shade, smooth air circulation, etc (Johansson and Emmanuel, 2006). After the physical elements the outdoor space are identified, the data obtained will be inputted into the software to do the simulation.

Analysis phase carried out with ENVI-Met software, to identify microclimate in the specific area. This software will take consideration about the interplays between building, surface, and vegetation as microclimate factors (Ambrosini et al, 2014). In terms of microclimate simulations, Envi-met software has been widely used by various scientific, academic, and government institutions research and its validity has been tested enough even though it still has several limitations (D'Souza, 2014).

This study took place in Tamansari Complex, Yogyakarta. From its history, the total area of the Tamansari complex reaches 10 hectares. This study limits the study area in the *Umbul Binangun* complex which is the King's bathing and resting area because the complex is still maintained and become the main object visited by tourists. The coverage area starts from *Gapura Agung* to the *Gapura Panggung*, including all areas inside the fort fence. The simulation is carried out in the daytime setting (12.00 - 13.00), considering that time is the hottest condition that occurs.

RESULTS AND DISCUSSION

Having a linear layout in the east-west orientation, *Umbul Binangun* area can be divided into four zones (figure 3):

1. *Zone Gapura Agung*
This area is in the form of a courtyard that is also octagonal. It used to be main gate of Tamansari area.
2. *Zone Pasiraman Umbul Binangun*
This area is a bathing place for the King, his wife, and the daughters of the Palace. There are three ponds arranged in a row from north to south. Between the middle and south pools, there is a tower to see the surrounding area.
3. *Zone Gedong Sekawan*
This area is in the form of an octagonal garden, having four identical buildings on each side.
4. *Zone Gapura Panggung*
Located on the east side, this area is the front gate to enter Tamansari area. Beside the gate, there are two buildings next to the gate, namely *Gedhong Temanten* and *Gedhong Pangunjukan*.



Figure 3. Research’s boundary area

The observation was conducted at the zones, observation variables are in accordance with the determinants of microclimate: building mass, surface material, and vegetation. The buildings in the Tamansari complex, especially in the *Umbul Binangun* area have linear layouts with relatively symmetrical mass order. It’s only in the pond area, the buildings order is not really symmetrical, but still balance on both sides. There are three building typologies in this area, first is the gate (± 12 m height), and then the tower (11 m), and the other building is just landed with 4m height. In addition, there is a fort fence that surrounds an area with a height of about 2-3 m.



Figure 4. Variation of Surface material

There are three types of surface material found in Tamansari Complex, which represent each zone (can be seen in figure 4). Zone 1 (*Gapura Agung* area) has surface material dominated by soil, with pavement at several points. Zone 2, the pond area is entirely pavement material, and also the water material in the pond. Green soft scape material can be found in zone 3, it is grass combined with paving material as a guiding path. For the building material, all of them was built from cement plastering material. Both zone 1 and 3 have quite a lot of vegetation. In zone 1, there are some big trees with wide shading area. Zone 3 does not have trees as big as the trees of zone 1, only medium-sized trees and some potted plants. However, this area feels greener because of the grass as surface material. For zone 2 there are only potted plants lined up on the side of the pond that only function as decoration.

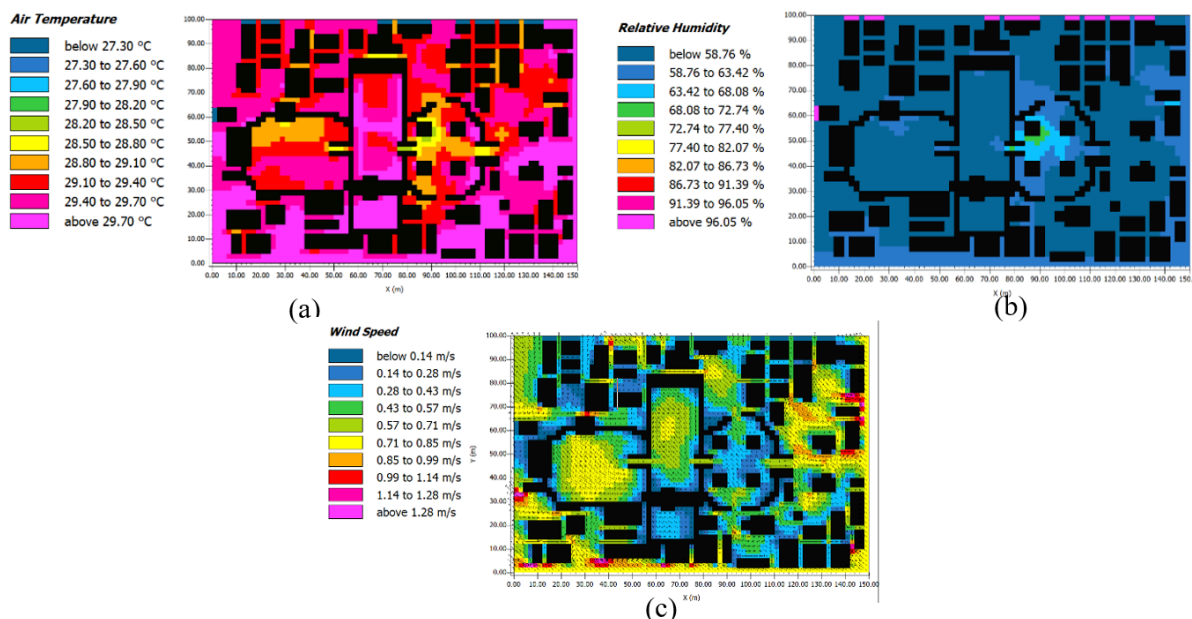


Figure 5. Simulation result: (a) Air temperature (b) Relative Humidity (c) Wind speed

The physical elements of the Tamansari area that have been obtained through observation are used as inputs to the modeling process in the Envimet software. Simulations are carried out in the daytime setting, at 12.00-13.00. The result of temperature simulation shows that this area has a range of 28-30°C (figure 5a). Although the differences in each zone are not significant, the result still shows us how it tends. Zone 3 (*Gedhong Sekawan*) has the lowest temperature compared to other areas. While the pond area is the area with the highest temperature, which reaches more than 30°C.

While the simulation results for humidity show fairly even results, only in zone 3 the humidity level is highest, which is at the number 65-75% (figure 5b). For the wind speed and air movement can be seen in figure 5c. The existence of a wall fence surrounding the Tamansari area causes the airflow to be trapped inside. It also can be seen that the wind speed increases in open areas, and at the aisle.

Based on the simulation results, it can be seen that in the Tamansari complex, the *Gedhong Sekawan* area (zone 3) has the lowest temperature, and the relative humidity is relatively comfortable. Observed by the physical elements, surface material factors are considered to be the main cause. In this area most of the land surface is grass, and there are also trees that are quite shady so that the area feels cooler. This can be proven from the behavior of visitors who spend more time in this area before moving on to the next place. Individual visual's perceptions affect thermal comfort and thermal receptions respectively (Chau, 2016). Visitor of Tamansari feel comfortable because of the wind and vegetation in this area. Shadows from vegetation can provide thermal comfort during the day (Koerniawan & Gao, 2015). This area was also used by the guides to explain more about Tamansari to visitors because it was felt to be the most convenient point (as seen in figure 5).



Figure 6. Activity in *Gedhong Sekawan* (left); wall thickness of the building (right)

Umbul Binangun (zone 2) is the area with the highest temperature. Dominated by pavement on surfaces and also lack of vegetation is the main cause of high air temperatures at this location. Seeing about visitor behavior, this area is more used to take pictures, and not to spend a long time. Responding to this condition, the existing building has a fairly deep wall thickness (around 40 cm), which can reduce heat to enter the room. One of the characteristics of heat insulation material which is thermal resistance will require material thickness (Lechner, 2014).



Figure 7. The Pond area (zone 2), lack of vegetation and dominated by hardscape material

On the other hand, the area around *Gapura Agung* actually has a fairly high temperature but it helped by the presence of large trees, especially on the north side which makes shade quite wide (figure 6). In addition, in this area there are also several shops so that visitors will spend a lot of time at this location.



Figure 7. Large trees and a lot of shops on *Gapura Agung* Area

Related to the original function of the building, the micro-climate conditions that occur are quite appropriate. Zone 3 or the *Gedhong Sekawan* area that has the best microclimate was once a place for the king and his family to rest and relax. The presence of green elements in the form of grass and also trees can certainly make resting activities better.

CONCLUSION

Based on the results of the analysis, it can be concluded that the factors of building mass arrangement, surface material, and vegetation have a significant influence on microclimate, including in heritage areas such as Tamansari. In this case, the surface material and vegetation have a significant role compared to the building mass. Areas, where surface material is dominated by non-heat absorber material, are proven to have better air temperatures, supported by the presence of vegetation that provides good shade.

These results also prove that in the past this area has been designed by considering the quality of its outdoor space. The data shows that the place for resting is designed in such a way that it has a better microclimate than the surroundings. This is supported by the typology of thick-walled buildings to increase the comfort of its users. For the next step, this research still needs to be supplemented with visitor's perception of their comfort, including thermal comfort, so that the correlation between microclimate can be found with the convenience of visitors. In the end, the results of this study are expected to be a consideration in efforts to conserve other Heritage areas, as well as the development of other tourist areas.

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