The Kudus Traditional House as a Potential Tropical Building Design for Climate Action

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ABSTRACT

One of the Sustainable Development Goals is Climate Action, meaning taking immediate actions to combat climate change and its impacts. This study evaluates the potentials of Indonesian traditional houses in helping mitigating climate change in the tropics. As a case study, the author analyses the designs of Kudus traditional house built primarily in the old city of Kudus, the province of Central Java, Indonesia. The study employs qualitative research, making use of primary data from field observations and interviews. Field observations were carried out to identify design elements of the traditional houses, while interviews were undertaken to obtain data and information on how the designs deal with climate problems. The results show that the Kudus traditional houses are designed in such a way that minimizes the need for air conditioning and energy uses given the hot tropical climate. The designs include the following: (1) building masses are built with an open yard in the middle of the masses' configuration; (2) building masses are extended from north to south direction; (3) optimization of openings, for lighting and ventilation, on the walls and the roof of the building; (4) The use of a sloping roof with a wide eaves. Although the climate has changed, the traditional Kudus house is still comfortable to use for activities. This proves that the traditional Kudus house is still relevant in responding to the local climate.

Keywords: building designs, architecture, Kudus traditional house, climate action.

INTRODUCTION

Over the past few years, climate change has been an important topic to discuss as it has a wide impact on human life and affects various aspects of nature and humans. One of the global movements launched is the Sustainable Development Goals (SDGs). On 25 September 2015, world leaders agreed on a global action plan called the Sustainable Development Goals

to end poverty, reduce inequality and protect the environment. The SDGs contains 17 Goals and 169 Targets which are expected to be achieved by 2030. In the agreement which took place at the United Nations Headquarters, approximately 193 head of states were present who officially witnessed the ratification of the SDGs Agenda. Present to represent Indonesia was Jusuf Kalla who at that time served as the vice president. With the theme "Changing Our World: The 2030 Agenda for Sustainable Development". The SDGs apply to all countries (universally), so that all countries without the exception of developed countries have a moral obligation to achieve the Goals and Targets of the SDGs. (https://www.sdg2030indonesia.org/)

Figure 1. Goals of Sustainable Development Goals

Source: https://www.sdg2030indonesia.org/

The 13th goal listed in the SDGs is to address climate change, which is to take immediate action to combat climate change and its impacts. The targets of these goals are:

1. Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
2. Integrating climate change measures into national policies, strategies and plans
3. Improving education, awareness and also the capacity of both humans and institutions on climate change mitigation, adaptation, impact reduction and early warning

Indonesia also needs to focus on SDGs goal to address climate change, more so because its location which is near the equator, that causes Indonesia to have a tropical climate. Areas that have tropical climate usually have high air temperatures and rainfall. The high air temperature is caused due to lots of sunlight in the tropical climate, the intensity of sunlight

and high rainfall causes the air temperature to be warmer. Tropical climate has 2 seasons, namely rainy season and dry season.

On the other side, nowadays construction of building has increase rapidly which potentially cause climate risk if not managed sustainably. However, buildings in Indonesia have long been built with the climate in mind. For example, the traditional house as one of the cultural wealth which is a reflection of how people consider the climate in designing their buildings. A house is a place that functions not only as a shelter but also represents local conditions. Traditional houses reflect climatic conditions, cultural conditions and local environmental conditions. For example, the shape of the roof on a traditional house in Indonesia is a sloping roof, as an answer to the local tropical climate. The shape of the sloping roof (saddle, pyramid, cone, pencu, etc.) is used to protect the house from rainwater. Because the tropics have high rainfall compared to the sub-tropics. With the shape of the sloping roof, rainwater easily flows down. To deal with the hot sun, traditional houses have several solutions. One solution is to create a sun shadow area.

Based on this background, a research was formulated with the aim to explore and obtain a meaning through identification and description of building elements in Kudus traditional house as a response to climate problems. The Kudus traditional house located in Central Java, Indonesia, was chosen as the research case because architecturally, the traditional house is able to survive for a long time. These houses were built in 1700—1900 in the area around Menara Kudus, Kudus Old City, Indonesia. Kudus traditional house is still there to date and can be occupied as a comfortable residence.

METHODS

This research is a qualitative research. The understanding of qualitative method is based on two main paradigms, namely post positivism and phenomenology. The main strength of all qualitative research is data, interpretive and constructivist as well as the research itself. Data analysis in qualitative research is the central theme (Bungin, 2020). This study used a qualitative-inductive method to identify building elements as an effort to respond to local climate problems. The initial stage is to conduct a preliminary study by scanning the area to find out the distribution of Kudus traditional houses that still exist today. At the initial stage, the authenticity and completeness of the building are seen. In qualitative research, literature review is carried out to provide background knowledge and ensure that there is no similar research conducted. This inductive qualitative research does not use theory as a research tool

or analysis tool. Theories or findings will be built in the field based on the interpretation of the results from field observations and interviews.

The material studied here was the building elements of Kudus traditional house in the Old City of Kudus. There are 10 traditional Kudus houses which are the research cases. Observations were made in 10 of these houses. Interviews were conducted on users from 10 observed houses. The houses are located in the Kota Lama Kudus, Indonesia. The unit of analysis were the building elements, their arrangement and their placement in Kudus traditional house. The research location was focused and limited only in the Old City of Kudus, Central Java, Indonesia due to the existence of original Kudus traditional house in that area. The research data was collected directly (primary data) using direct observation and interviews. The research case was determined by purposive sampling or case sampling with purpose. Interviews were conducted with 10 house users, as explanatory data for the observations made. Interviews were conducted to obtain data regarding home comfort related to the local climate.

Analysis in qualitative research can be done simultaneously with data collection. Therefore, in collecting data, researchers must do it themselves so that they can analyze directly. The stages in data collection and analysis in this research was begun by transcribing the obtained data. The transcript was in the form of descriptive. If the data were building plans or photos of buildings, they must be transcribed into descriptive data first. After transcribing the data, coding was carried out to find the theme of the findings. Coding steps are carried out based on findings in the field. A discussion of the coding steps carried out is listed in the analysis section. The themes of the findings were then dialogued, resulting in the final findings or memos which are the final interpretation in this research.

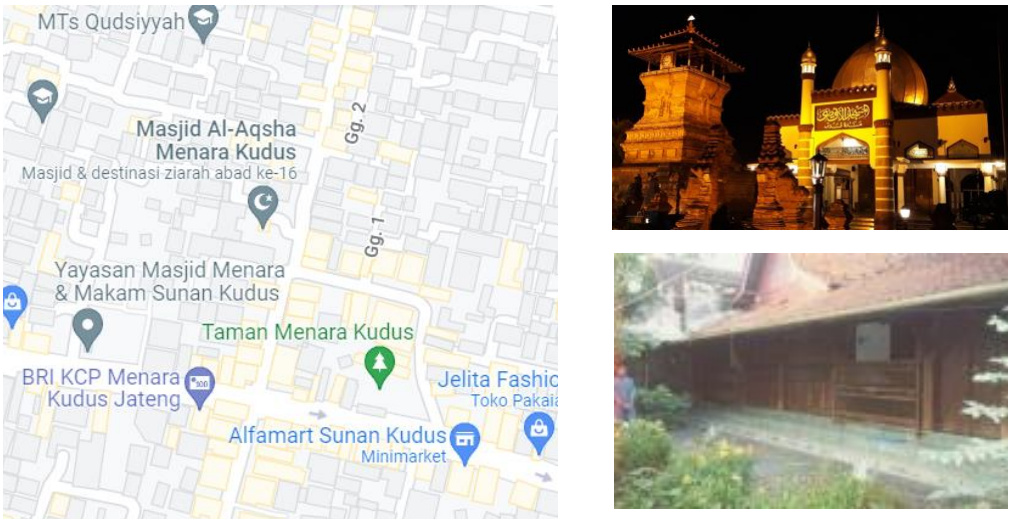

Figure 2. The map of Kudus Old city, Kudus traditional house and Menara Kudus area (Source: Personal Documentation)

The research is located in the Menara Kudus area, Indonesia. The Menara Kudus area is the downtown area of the Old City, which is marked by the presence of the Tower, the Tomb of Sunan Kudus, and the Mosque. The area around the Menara Kudus complex is a residential area. in that area there are still traditional Kudus houses.

RESULTS AND DISCUSSION

Identification of Local Climate

Indonesia is located around the equator. Indonesia's position has a climate with high air temperatures due to the influence of solar radiation that falls on the surface almost perpendicularly during the day throughout the year. High solar radiation causes high evaporation of water. This causes an increase in the water content in the air and increases the humidity and temperature of the air. Indonesia is classified in the humid tropical zone. In general, the tropical climate is divided into two, namely the humid tropics and the dry tropics.

Climate affects human's behavior in regards of the heat that human body expends even though there is no activity done by human. The heat is generated from the metabolism or food burning to produce energy. There are several climatic factors that are considered by humans in building design, namely: (1) Precipitation; (2) solar radiation; (3) air temperature; (4) humidity; (5) wind/air speed.

Climate change is a result of global warming which has negative impacts on people's activities. The negative impacts of climate change including rising sea surface temperatures, extreme weather intensity, changes in rainfall patterns and large waves. Those necessities could be related to their socio-economic life which depends on their work that are highly depending to the uncertain and unpredictable natural conditions (Ulfa cited in Nurhayati, Dhokhikah and Mandala, 2020).

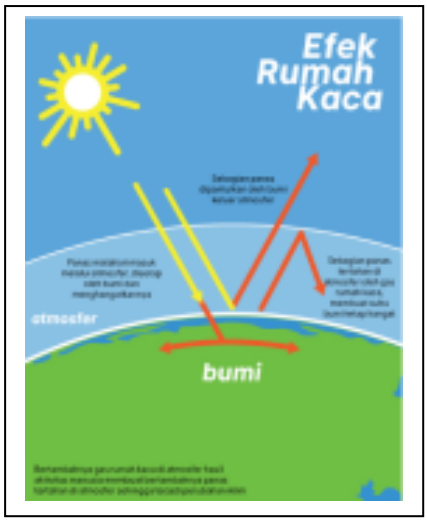

Figure 3. Greenhouse effect

Source: https://www.sdg2030indonesia.org/

Kudus Traditional House Spatial Exploration

Kudus traditional house is a cultural property in the form of a built environment that can be occupied by humans. The original Kudus house is located in the old city of Kudus, Central Java, Indonesia. Kudus traditional house building is a wooden walled house with carvings in all parts of the house. The complete type of Kudus traditional house has 2 building masses. The two building masses are the main building and the supporting buildings. The main building and supporting buildings are facing each other. There is a courtyard between the main building and supporting buildings. The main building consists of a large building mass contained with three rooms. The three rooms are *jogosatru*, *gedongan* and *pawon*. The three rooms have wooden walls and *pencu* roof. There are some Kudus traditional house that have two *pawon* on the right and left side of the *gedongan*. *Jogosatru* is a public space in Kudus traditional house. *Jogosatru* is used to receive guests. At the back of *jogosatru*, there is a large room called *gedongan*. *Gedongan* is a private room in Kudus traditional house that consists of family room and bedroom. *Pawon* is located on the next side of *jogosatru* and *gedongan*. *Pawon* in Kudus traditional house is used as a place for daily activities.

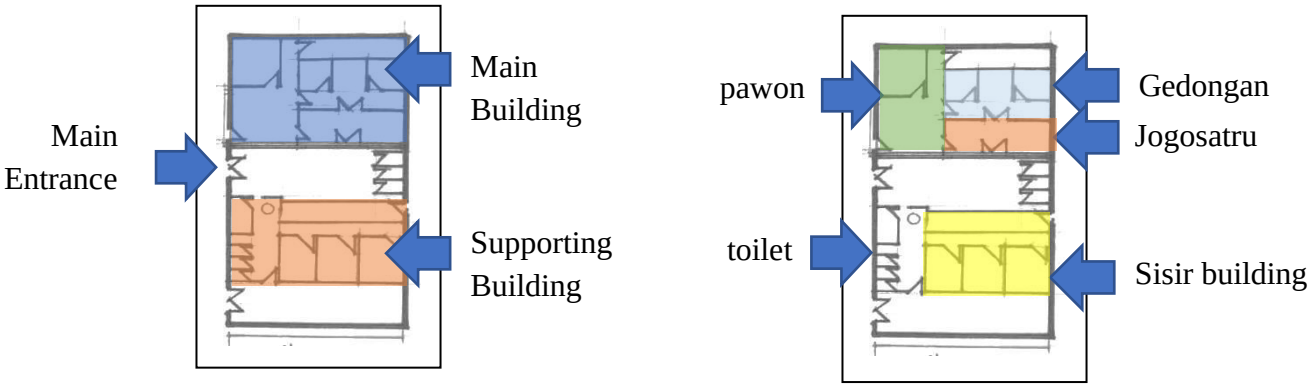

Figure Main Building and Supporting Building in Kudus Traditional House

Source: Field Observation, 2022

The main building in Kudus traditional house generally faces south. The courtyard lays between the main house and supporting buildings. The courtyard becomes the center of orientation or direction towards the main building and supporting buildings. The supporting building is located in front of the main building. The supporting building faces north, which facing the courtyard in front of it. In addition to the two dominant building masses, there are two other building masses with smaller sizes. The two masses of the building are sewers and wells. *Gotakan* and wells are next to the supporting buildings. *Gotakan* is a building mass used as a kitchen and as a place to store firewood.

Although every Kudus traditional houses have different location with the road, each of the house has the same building structure, namely the house is in the south, the *sisir*-building is in the north, and the site is in the middle. The site that is used as the building's orientation or as the direction facing the main building, the *sisir* building, *pawon* and *gotakan*. Figuratively, it can be explained that the site is a building's binding, not only physical binding but also activity binding in Kudus traditional house. As the old city of Kudus said, Kudus community have two main activities, that are *ngaji* (reading holy-book) and *dagang* (trading) or people call it as *jigang* (*ngaji-dagang*). Both of these activities are done in Kudus traditional house in a separate section from the courtyard. Most of Al Qur'an reading activity are carried out in the main building and trading activities are carried out in the *sisir* building (Anisa, Finta Lissimia, 2019).

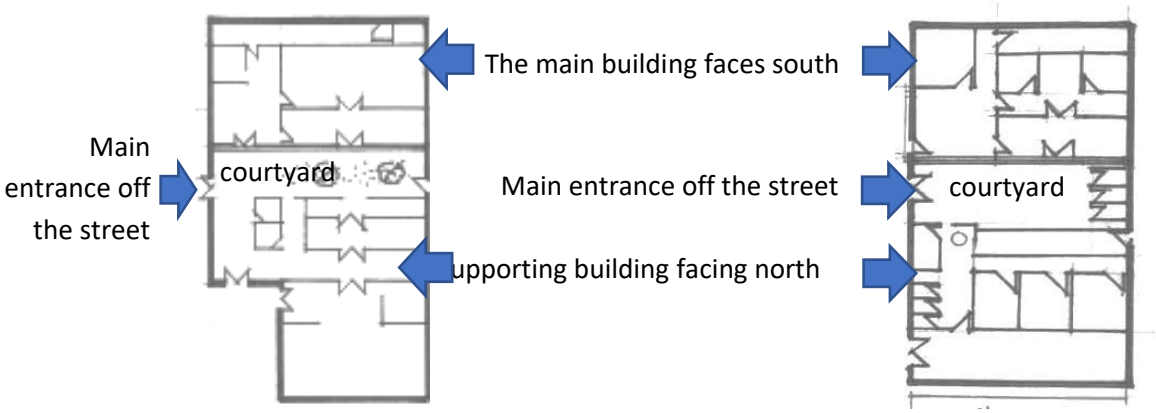

Figure The Direction of the main building and supporting building

Source: Field Observation, 2022

Kudus traditional house consists of main building on the north side facing to the south side. This is the direction which the rule is still firmly held, very few traditional houses facing north, let alone facing the other direction. The main building consists of *dalem*, *pawon* and *jogosatru*. *Dalem* is used for rest and sleep. Inside *dalem*, there is a room in the middle which called as *gedongan*, used to store treasures and as a place to pray. The space on the right and left of *gedongan* are used for sleeping. Next to *dalem*, lays *pawon*, a place to spend day-to-day activities of the family. *Pawon* can be located on the left or right of *dalem*. Even in some houses, there are three *pawons*, which the third *pawon* is located behind *dalem* and used exclusively for cooking. In front of the main building, there is an open courtyard that is used for outdoor activities (Sarjono, Hardiman and Prianto, 2016).

The supporting building is a mass of elongated building located in front of the main building. Supporting building—in local terms are called *sisir* building—have a main function as a place to do business. Architecturally, the supporting building has a shape like a warehouse. This supporting building is a public building, which can be accessed by outsiders. During the time when Kudus became a busy city due to its secondary-plants (palawija) trade, this supporting building was used as palawija warehouse. Apart from being a warehouse, the supporting building is also used as a place for palawija transactions. In a Kudus traditional house with 2 *pawons*, one of the *pawons* is used as a place for trade transactions. In the late 18th century, Kudus became a city with a high tobacco trade and home-industry cigarette factories. At that time, supporting buildings were used as tobacco warehouses and a place to produce cigarettes. As time went by, supporting buildings' function developed for other businesses such as convection, embroidery and a place for pilgrims to stay.

Figure 4. Kudus traditional house
(Source: Sardjono, Hardiman and Prianto, 2016)

The main building of Kudus traditional house is built with woods on the entire side-enclosure and roof structure. Meanwhile the roof is covered with unit roof tiles. At the bottom part of the house, the floor is covered with tiles that are raised to 2—3 steps. Carvings are able to be made in all parts of side-enclosure because of the wood material. The carvings on Kudus traditional house are found on *jogosatru* and *gedongan*. At current condition, lots of Kudus traditional houses change their material from wood to brick, especially at the *pawon* and supporting buildings.

Figure 5. Photos of Kudus traditional house and the *sisir* building
(Source: personal documentation, 2003)

Pawon and supporting buildings are two parts of the house that have minimal carvings. Only *pawon* with location near the road that is still carved with ornaments. Whereas the inner part of that *pawon* and supporting buildings are made with wood with a small number of carvings in simple shapes. In general, based on the results of exploration, the current Kudus traditional house had undergone many changes, especially in the building materials. These

material changes were implemented due to the complicated maintenance of Kudus traditional house, especially in maintaining the authencity and durability of the woods and the carvings. However, the materials used *jogosatru* and some *gedongan* are still maintained, including *gebyok*, which is a wall carving in *jogosatru* and *gedongan*. The room's function in Kudus traditional house has also changed, but this alteration does not change the zone in the room. For example, the *gedongan* is still used as a bedroom and has another function as a prayer room. The original Kudus traditional house does not use a ceiling. In the *gedongan*, we can actually see complex tall carvings because *gedongan*'s roof has *pencu* shape. While the entrance to Kudus traditional house is divided into two, that are main door and *slorogan* door (similar to a push door). The *slorogan* door has a wide size and is more like a sliding wall.

Kudus traditional house was built and completed with concept of: spatial arrangement, structure and ornaments. The house was destined to all member of society. In Kudus old city, access is less important than the southern-oriented buildings. This is due to their cosmological idealism. The homogenous and business-oriented people of Kudus old city had contributed largely to the pattern of the settlements through the agreements of space (Suprapti et. al, 2014).

Elements of Building as a Response to Climate

Kudus traditional house, which divided into several building masses, can be described as having several important elements that respond to local climate. In this section, the building elements of Kudus traditional house will be divided into three parts as a response to local climate. This explanation is based on the identification and the description that has been extracted based on the results of direct observations and in-depth interviews. The explanation will be carried out starting from macro to micro scale. The three parts are land efficiency, energy efficiency and supporting elements of tropical climate sustainability.

On a macro scale, Kudus traditional house is among other houses in the Kudus old city. Kudus traditional house has a clear territorial boundary to its environment, either in the form of a massive fences or in the form of a hedgerows. This territorial boundary surrounds all building masses in Kudus traditional house. Around Menara Kudus, especially in villages of Kauman and Langgardalem, the territorial boundaries are mostly massive in the form of tall and thick perimeter walls called *kilungan*. This perimeter wall is about 3—4 meters high, physically exceeding human's height so that people from outside cannot see inside the wall and vice versa. The neighborhood road in the villages is surrounded by *kilungan* wall so that it looks like a hallway. From the road, people can only see the part of the roof that rises upwards, called the *pencu* roof.

Figure 6. *Kilungan* wall

(Source: personal documentation, 2022)

The condition inside the wall is different from the outside. When the main door is opened, you will see a large yard planted with trees on the right and left side of the yard. The main building and supporting buildings are placed on the right and left side of the yard. This yard is spacious and almost as big as the main building. Usually, this yard is also functioned as a place to plant vegetation and as a rainwater absorption area.

The back area of the main building is filled with a backyard. This backyard is a private zone and only home owners can access it. The backyard is an open space bordered by the back part of *gedongan*, so it seems like from the front, *gedongan* has no windows. However, all rooms in *gedongan* can still get the lights and air from outside because they are adjacent to the backyard.

Based on the identification and description of the data, it can be analyzed that the arrangement of the building mass in Kudus traditional house responds to local climate in Indonesia, which is tropical climate. The yard or open space exists between the mass of the main building and supporting buildings. There is also an open space behind the main building. These open spaces have some roles as an absorption area, a green area and as the orientation of the building. Land efficiency as a response to local climate can be seen in the arrangement of the building masses in Kudus traditional house and the open spaces in the house. The arrangement of the building masses is divided into several masses with some distances to one another, allowing for air exchange, supported by the natural yards that are still covered with soil, grass, small rocks and filled with some vegetations can help to cool the air in the house.

Figure 7. The layout of the building masses (colored with gray) towards the yards (colored with green)

(Source: Field Exploration, 2022)

Meanwhile, energy efficiency can be seen through three things, which are: (1) the direction of the building towards the sun's path; (2) optimization of openings for lighting (visual comfort) and ventilation (thermal comfort); (3) elements in buildings that transmit heat and cross ventilation.

The path of the sun at the location traversed by the equator is exactly symmetrical between the sides that facing south and north. This means that a building directly on the equator will receive exactly the same amount of sunlight in 12 months on its north and south sides. The further south the location of a building is relative to the equator, the sun's rays on the north side of the building will be greater than the south side. Buildings located around the equator should be endeavored to receive as minimum as possible the heat from the sun and release as much as possible the heat from the sun (Karyono, 2016). In Kudus traditional house, the shape of the building mass extends from north to south. This condition is in accordance with the tropical climate because the building is elongated from the north to south, so the building does not get direct sunlight. This minimizes the heat that enters the building through the side enclosure.

Sunlight produces light and heat. Sunlight and heat are received by the building and transmitted to the spaces within the building. In Kudus traditional house, indirect sunlight is used as house's lighting. This condition is possible to be implemented due to the house facing to the south direction. The main buildings are located in the north and the south sides. Meanwhile in the west and the east sides are used for *pawon*. Direct sunlight hits the west to east side of the building. In addition to light, the sun also causes heat entering the building through the roof. Heat can increase the room temperature of the below spaces. In Kudus traditional house, there is no roof space because there is no ceiling, hence the heat received by

the roof will be directly transmitted to the space below it. This heat increases the room temperature of the space and brings warm into it. In principle, the heat received by the building must be released as soon as possible to maintain the normal temperature in the room.

The solution to maintain normal temperature in aforementioned condition is through the openings at the side of Kudus traditional house. The openings in the main and supporting buildings are located facing the yard between the two buildings. The openings in Kudus traditional house are not only in the form of doors and windows, but also in the form of lattices on the wall. The front wall of Kudus traditional house uses carved wood material. It can be seen that the *gebyok* in front of Kudus traditional house is a two-layers barrier. The inner layer is a sliding wooden wall. The outer layer is a *slorogan* door. The inner layer is used at night, while the *slorogan* door is used in the morning and in the evening. This *slorogan* door is open at the top, and there is a grille at the bottom. So that the shape of this door accelerates the release of heat in the building. The heat received from the roof is transmitted to the sides of the building, especially to the front and back yards of the main building.

Figure 8. Slorogan door

(Source: Personal documentation, 2022)

Optimizing the openings in Kudus traditional house is not only to respond the local climate, but also to make the house more comfortable, especially thermal comfort and visual comfort. Thermal comfort is related to the temperature and the humidity in the house. Thermal comfort comes when the building receives sufficient sunlight and releases the heat quickly. In short, thermal comfort is also related to the ventilation in the building. The ventilation in Kudus traditional house has met the cross-ventilation's criteria, causing the temperature inside the building to be constant and comfortable nuance for indoor activities. Meanwhile visual comfort is related to sunlight that can be used as natural lighting during the day to illuminate inside the

house, so that people can do their indoor activities. The elements in Kudus traditional house, such as the arrangement of spaced masses, the openings and the orientation of the building, collaborate with each other in order to release the received heat and circulating the air transversely. The discussion of land and energy efficiency becomes an inseparable part in response to the humid tropical climate.

Another response of Kudus traditional house to the humid tropical climate is that the building was build elevated from the ground. Kudus traditional house is not a stage-house (*rumah panggung*), but the house has a few distances from the ground. For example, the front room or *jogosatru* has 2—3 steps from the ground. Meanwhile, the *gedongan* room rises about 40—60 cm from *jogosatru*. The *gedongan* or the main room under the *pencu* roof is the room with the highest floor. In *gedongan*, you can also directly see the carvings inside the *pencu* roof. The goal of elevating the floor of the building for a few centimeters from the ground is to reduce the moisture from the soil beneath the building

The final part of this discussion is the building elements that support the sustainability of tropical climate. In the previous section, it has been explained that the arrangement of the building mass, the presence of the yard, the direction of the building and the openings in the building are made in order to respond the climate condition. In addition to the things mentioned above, there are still several building elements that also support the tropical climate, namely the shape of the roof, the wide eaves, the sun shade areas (with layered walls) and the vegetation in open spaces. The shape of the roof of Kudus traditional house is *pencu* roof, this is a roof with a sharp slope and no ceiling at the bottom, creating a large enough space as a medium to let the air and the heat flow from inside to outside (and vice versa) through openings. The eaves—or additional roof—of Kudus traditional house are located on all sides of the building that adjacent to the open spaces. Eaves can reduce solar radiation entering the building and create a shading area. The shape of the roof and eaves also allow rainwater to be transferred more quickly into the ground thus helping in cooling the room inside the building. The wooden walls of Kudus traditional house also support the tropical climate. On the wooden wall on the east to west side, openings are made with the same material (wood), so that at night, the wooden windows can be closed and level up with the wall. Meanwhile, during the day, the wooden windows are opened and serve for cross ventilation and release heat from the roof. Planting vegetation in open spaces in the front and back yards is used to block direct sunlight from entering the building. This vegetation also blocks direct sunlight from hitting the roof of the building. This vegetation and a yard that is covered with soil and grass would logically reduce the temperature of the surrounding environment.

CONCLUSIONS

Based on the discussion above, it can be concluded that several things related to the elements in Kudus traditional house that respond to the local climate, such as:

1. The local climate at the location of Kudus traditional house is a humid tropical climate. The relation of humid tropical climate and house building is related to comfort.
2. The building masses in Kudus traditional house extends from north to south in order to respond to the climate and the path of the sun.
3. Openings optimization for visual comfort (lighting) and thermal comfort (air conditioning) using several elements on the walls and in the roof of the building. Elements on the walls of the building can be wooden walls, doors, windows, lattices and other openings. This opening can help release the heat received by the roof of the building
4. Another element is the sloping roof with a wide eaves that allows solar heat to be received with sufficient shading area from the eaves. The shape of the sloping roof also solves the challenges of tropical climate, namely rainfall.

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