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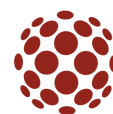
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# Local Wisdom in Reducing Greenhouse Effect on Balinese Traditional Settlement Patterns in Bongli Village, Bali, Indonesia

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## Abstract

In general, housing and settlement development will have the effect of global warming, with different scale of effects. Warming occurs, not only because of the dominant built area but also due to the use of materials and equipment that can increase the comfort of the inhabitants. In Bongli Village, settlement patterns are arranged in such a way based on traditional procedures, by structuring the building period, as well as the shape of the building. Can traditional settlement and building arrangements reduce the greenhouse effect? The article discusses the patterns of settlements and buildings arranged in a traditional way related to the occurrence of the greenhouse effect such as the construction of housing and settlements at the present time. To achieve this, an understanding of the greenhouse effect from housing construction activities was carried out. To get data on traditional Balinese settlement patterns, field observations were made in Bongli Village to observe settlement patterns and the arrangement of buildings and their effects on global warming. Field observations will be narrated qualitatively in relation to the greenhouse effect. The results of field observations and discussions showed that Balinese Architecture and traditional housing and settlement patterns in the Village of Bongli, the building layout, as well as the building period used local materials, open spaces, so as to reduce energy use. Energy reduction due to functional buildings, so that during the day save electricity. Likewise, natural energy can reduce energy usage which means it can reduce the possibility of a greenhouse effect.

**Keywords:** Local Wisdom, Traditional Settlements Patterns, Greenhouse Effect

## INTRODUCTION

Population growth both due to migration and naturally has changed the pattern of land use from extensive use to intensive use. In the past when the land was still sufficient there would be a spread of settlement patterns from existing ones to the surrounding lands (Shils 1971, Sukadana 1983, Ritzer 2007, 2008). This condition causes settlements to grow and develop around the location of existing settlements. However, the rapid population growth, especially in urban areas and the increasingly lack of land for housing and settlement development, the use of land tends to be intensified. Land use is tried as effectively and efficiently as possible so that settlements become jostled using existing space, especially spaces that can increase the comfort of housing. This condition has increased the tightness of settlement space. Crowded residential space has made the air less able to move freely, open space is limited, which reduces occupancy comfort (Dwijendra 2003, 2008, 2014).

To get the desired comfort then the use of electronic devices that can meet the expected level of comfort. Therefore, in a crowded environment the use of room conditioning will increase. This will require energy to operate. This persistence has continuously made the residential environment less comfortable and uses more energy. The use of room conditioning aids has used materials that can interfere with existing environmental conditions, such as preon gas. In addition, the use of electrically powered devices will produce exhaust gases and warm temperatures. Warm temperatures that come out (the result of the cooling process) will increase the temperature in residential neighborhoods where people live. This condition reduces the comfort of the dwelling inhabited (Suryanto 1983, Soemarwoto 1985, Sneyder 1985).

In addition, there is a tendency for the use of artificial or natural building materials in other communities to occur in other places (Wijaya 1986, Wikstrom 1995, Yogantari 2020). This condition will go through the process of its formation, its processing, and its transportation process. In this process will have an impact on the environment, especially on the formation of the greenhouse effect. Transportation will cause flue gas which can disturb the environment. Likewise, the processing of raw materials into finished materials will emit waste and energy that can accelerate the occurrence of the greenhouse effect.

Patterns of settlements in rural areas in Bali generally use traditional patterns handed down from generation to the next generation (Widiastuti 2017, Nurjani 2019, Dwijendra 2019, 2020). However, the tendency for changes in settlement patterns from traditional to modern settlement patterns is already apparent. The use of mass with each function (scattered) has been largely abandoned and replaced with buildings with compact functions. Likewise, the use of building materials which used to use building materials in the surrounding areas, has tended to change in a modern direction. Similarly, the space between buildings tends to be used optimally. The pattern of traditional settlements tends to shift from traditional conditions to modern directions with a practical economic tendency (Adhika 1996, Dwijendra 2010, Dharmayanty 2020).

Energy use in traditional settlement patterns tends to be less than energy use in modern settlement patterns. Traditional settlement patterns optimizing energy use have reduced energy use. On the other hand, modern patterns with a compact span with a wide span will require more energy than traditional. The use of electronic devices for the benefit of residential comfort requires a lot of power. The use of non-natural ingredients tends to cause micro temperatures to increase and increase overall temperature (Poedjawijatna 1983, Wikstrom 1995). Therefore, the use of modern patterns can affect the greenhouse effect conditions. In other words, changes in the use of settlement patterns have changed energy use and can affect environmental conditions.

This paper aims to analyze the traditional patterns of Balinese settlements in the village of Bongli in the use of energy for residential housing, the arrangement of settlement patterns, the regulation of building arrangements, the use of traditional building materials, as well as people's daily life patterns and energy use. This is done considering the tendency of changing settlement patterns from traditional settlements to modern settlements without or little understanding of the underlying. Change is caused by changing times and the effects of globalization and is afraid of being seen as not modern. The ease of information flow, the financial movement, the movement of people, the sophistication of the media, the rapid development of technology called the flow of globalization have changed the outlook of society towards the present. This has an effect on the pattern of settlements, building arrangements and patterns of use of building materials, as well as the daily patterns of life of the people.

## RESEARCH METHODS

To achieve the purpose of study, field observations were made to Bongli Village, which is part of Sangketan Village, Penebel District, Tabanan Regency, Bali, Indonesia (BPS Tabanan 2019). Observations were made using a regional approach in a professional judgment conducted by researchers to describe the existing settlement patterns. In addition to conducting field observations also conducted with key informants who are local community leaders in order to complete the field observation results. In order to obtain information about the use of building patterns/building layout, field observations are carried out and compared with previous studies (secondary data sources). Thus it is expected to obtain settlement patterns and building patterns/building arrangements along with

their changes. In an effort to obtain a pattern of use of building materials, direct observations are made on the use of building materials. The building that was observed was chosen for the building that had the least change in the development to the present, with the hope that traditional building materials would still be visible and observable. Considering that buildings that are still intact (traditional) do not fully exist, they are integrated with interviews with community leaders to obtain information about patterns of use of building materials. Observation starts from the fence of the yard, house, and supporting buildings such as rice barns that are widely available in this village.

In addition, at a glance, it will be observed how people's life patterns in utilizing energy, utilizing existing resources in the context of the greenhouse effect (Anh 1984, Arief 1988, Bryant 1989). With the general view that the more energy used, the higher the greenhouse effect is produced. Similarly, the use of building materials, the more diverse the use of building materials, the higher the greenhouse effect it causes. Included in the pattern of waste management and the resulting waste. Thus also carried out an observation of how the back of the house of the local community which is usually used as a landfill, as well as a place to raise pets, such as pigs and chickens. The pattern of solid waste management is also seen to influence the occurrence of the greenhouse effect (Derek 1991, Department of Education and Culture. 1993, Denzin 2009).

## RESULTS AND DISCUSSION

The research location is Bongli Village which is part of the Sangketan Village, Penebel District, Tabanan Regency, Bali, Indonesia. Located at an altitude of approximately 500 meters above sea level (BPS Bali 2019, BPS Tabanan 2019). It is a remote village and located in a bumpy or hilly area. Around the village are rice fields and plantations which belong to the local community, where they make a living to make a living. Not far from the village, around three to five kilometers is already a Batukaru protected forest. Local people call it the base cover (protected forest). The location of Bongli Village in more detail is as shown in Figure 1.

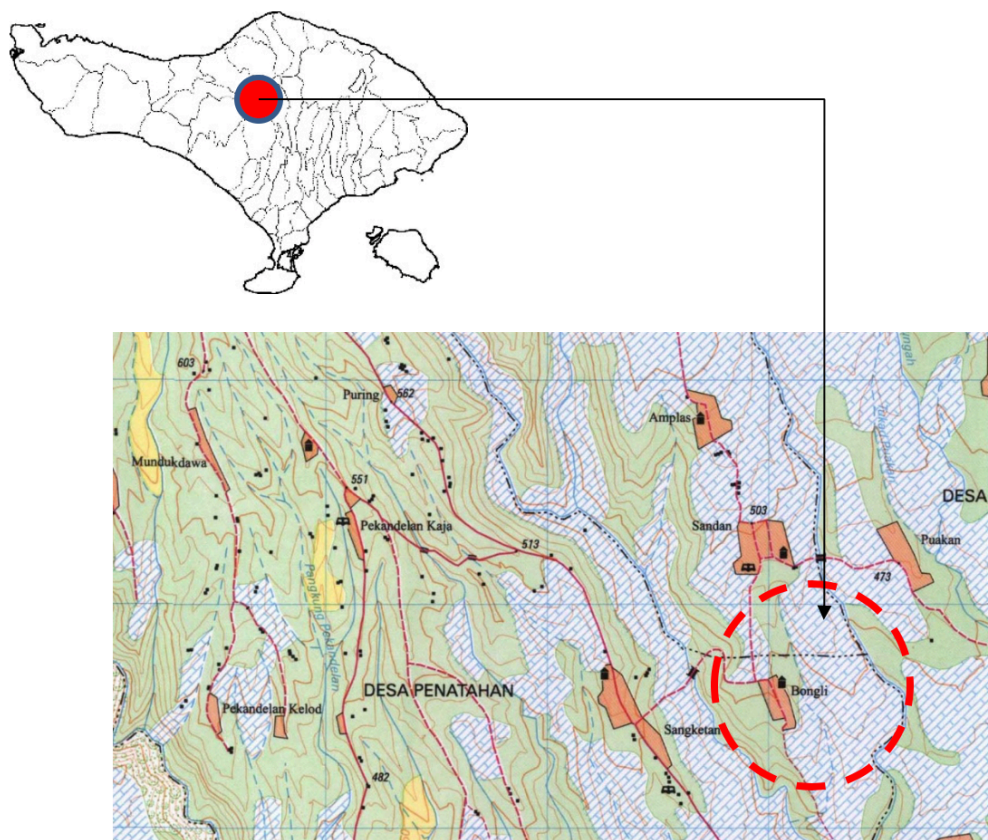


Figure 1. Location of Bongli Village, Tabanan Regency, Bali

Source: RBI Map, 1991.

Field observations show that the settlement patterns of the Bongli Village community are like that of a mountain village generally surrounded by rice fields and plantations. Public facilities for the village are located at the end of the village in the form of the Village Temple and *Bale Agung*, as well as the Dalem Temple which is located downstream of the village. The grave facility is located in the downstream part of the village (south /kelod), while Puseh and Bale Agung temples are located in the upstream (north /*kaja*) village. The two ends of the village are connected by village roads between five and six meters wide. Besides functioning as a link, the village road also functions as a social communication space for the local community. According to public figures that when motor vehicles are not crowded, every day or evening the community will gather in front of *kori* while stroking domestic chickens (confinement), or just participate in a discussion together. Not only are the co-prisoners having a discussion, but other communities also take part in giving their opinions on the issues discussed. Thus, the social problems in the village will get ideas from various groups of society to find suitable solutions (Budiharjo 1983, Dharmayuda 1995, Dwijendra 2009, Nurjani 2020). Such small deliberations can also be only as an expression of views that require collective thought to get a solution.

In addition, the road is also a place to watch shows such as Balinese performance (*arja, jogged*), if there are residents who hold ceremonies at their homes (Bagus 1980, Brubaker 2000). Performances are carried out by building temporary performance venues called *tetaring*. Besides the function of *tetaring* as a place for displaying and hanging lights, it also forms a border that gives boundaries and norms between the audience and the performance organizer.

Village roads are also temporary spaces where religious ceremonies are held for the benefit of the village. The day before *Nyepi* (silent day), the highway was also used as a place to prepare for ceremonies in the form of slaughtering calves, and holding ceremonies by making buildings for ceremonies (*asagan*). Thus new spaces will be formed for the ceremony. But after the ceremony was completed along with the dismantling of the *asagan*, the space will disappear and the road will function as usual. Likewise, during the *ngerebeg desa* ceremony the road will become new spaces formed by the ceremony facility. During the three days of the *ngerebeg* ceremony during which the road space will change its temporary function as a place to hold the ceremony.

However, with the increasing income of the community, more and more people have motorized vehicles both two-wheeled and four-wheeled (cars). On the other hand, traditional spaces do not prepare space for storing vehicles, so that during holidays when the community is moved back to their villages, or when there is a ceremony for a resident, the road will change its function to become a motorized vehicle parking area.

The settlements are located on the left and right side of the road (east-west road) which all go to the village road. At first there were only eight entrances (*kori*) to experts. However, due to population growth, now has increased to ten entrances (*kori*). In each *kori* there are various numbers of family heads who live in it. There is one head of a family of residents, but there is also a group consisting of many heads of families who inhabit the yard. With the development of the number of villagers, then some people have built residential buildings in the fields called *pondok*. Nearly half (50%) of the villagers already live in huts where their fields are located (Alit 1996, Adnyana 1998, Adhika 1996, 2010).

The existing condition of the value system adopted seems to be oriented to the height value system, where the high location is considered to be the main while the lower place is considered an insult value (Adhika 1996, 2010, 2020). More clearly as in Figure 2. This can be seen from the location of the sacred place of the family (*sanggah*) located on the side of the highway which is located on a ridge, while the yard where livestock raising (*teba*) is located eastward for the east of the road, and to west for those located on the west side of the road. In contrast to the plains in Bali that apply the *sanga mandala* values (Figure 3) so that the *sanggah* is generally located in the main space (*kaja kangin*) of its yard. Thus, village settlements are protected by *teba* (green belt) in the east and west of the village.

In addition to *teba*, as a green open space, between the rows of houses and other rows of houses there is also an empty space that is unyielding to build buildings in that location (Parisada 1968, Parimin 1986, Adhika 1996, Dwijendra 2008). Local people call the place as cast corals. For generations the yard owner has not dared to build a building, either later after there is no other choice. In today's modern settlements many also apply empty spaces

such as cast corals, in an effort to anticipate or isolate in the event of a fire hazard. In addition, empty spaces can also be used as space to circulate air so that the environment is not too hot and without air flow. In addition, the limited open space in urban settlements makes green open space very meaningful for the residents. This condition is seen in every green open space that functions for the public in urban areas becomes congested during leisure time in the afternoon.

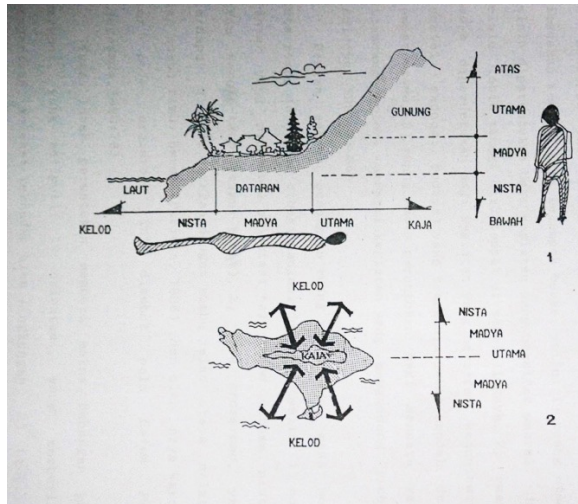


Figure 2. Main Value Based on Height  
Source: Adhika, 1991.

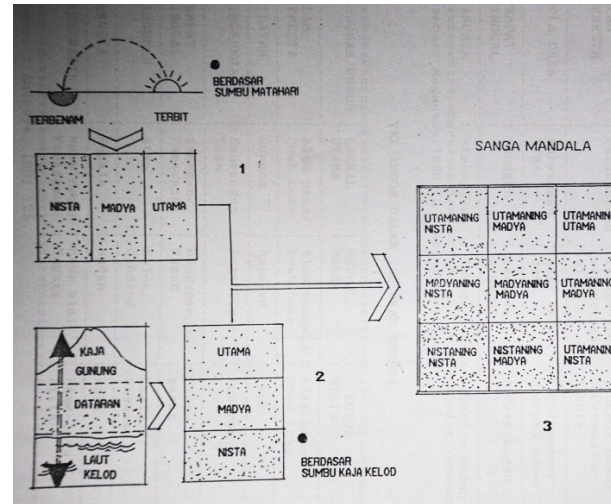


Figure 3. Sanga Mandala  
Source: Adhika, 1991.

Patterns of spatial planning and buildings in the yard units have one system in common with each other. In each unit of the yard from the entrance to the use of its space is a sacred place (*sanggah*), then the number of housing units depends on the number of family heads who occupy, then the open space for gardening and raising livestock called *teba* (First Level 1991, Wood 1983, Eiseman 1989, Gelebet 1986). The condition of spatial planning on the other side of the road will have similarities but opposite from the direction of the road. Thus the road is likened to a mirror from the other side (Pitana 1994, Pichard 2006). The arrangement pattern for yard units can be illustrated as in Figure 4.

In addition to the use of space based on the east-west direction, in one-unit yard is also divided into two zones, namely, in the upstream (north/*kaja*) is a residential building zone, and in the downstream (in the south/*kelod*) is a zone where the granary rice (Hobart 1978, 2001, Hobsbawm 1983, Swellengrebel 1984). In the residential building zone there will be buildings that function as kitchens (*paon*) and multipurpose buildings (*Bale Gede*) in sequence from north to south. Next is the zone where the rice granary is built. In this zone it is a place for rice barns for families who live there, as well as families who live in the garden (*ngubu*). Thus the number of existing granary buildings will be more than the number of family heads who live in the yard. In line with the development of time, the family's granary who lives in the garden has been moved to the garden. However, some still leave the barns in the village.



Figure 4. Yard Unit Arrangement Pattern  
Source: Author Analysis, 2019.

With this pattern, then one household head in one-yard unit will have a building *paon*, *bale gede*, and one or several rice barns. Thus sequentially lined to the side, the amount depends on the number of household heads of residents of one-unit yard. Between the building and the building is an empty space that is wider than the water from the roof of each building. This condition will allow adequate air circulation. In addition, the distance social relations are also used as a place to circulate between buildings, and circulate between yard units. With such arrangement there is no boundary between the yard and between houses. These spaces provide freedom of interconnection, mutual control, and mutual understanding with each other.

Structuring of building units is made in a scattered manner, and each building has a relatively small dimension, thus giving impact to the natural lighting and ventilation system. This contributes to saving energy usage, especially to increase residential comfort. It would be very different when compared with existing buildings in the city. Building conditions that are close to one another and optimization of the use of available spaces, have resulted in obstacles to the movement of healthy and fresh air. To get the flow and condition of fresh air, we need electronic equipment that requires no small amount of electrical energy. In addition to requiring electrical energy, the use of room conditioning has resulted in the surrounding environment becoming hotter due to exhaust gases from the room conditioning machine. This will impact on other occupants who also tend to use room conditioning. The use of more roaring conditioners will cause more heat discharges which result in the use of more energy as well. In addition, the use of engine cooling materials (CFCs) air conditioning and refrigerators will be able to increase the occurrence of the greenhouse effect.

The dimensions of the *paon* (kitchen) building are approximately 4 meters wide and 5 meters long. Relatively small dimensions are used for cooking and bed activities (multipurpose). The upstream part is used as a fireplace, and downstream is used as a porch. For those who have many families will use the porch as a bed. Because in the upstream section as a bed, the building is made somewhat closed with a wall around it. Only those parts that need open wall light, such as near a cooking stove, or near a bed. The building is covered with walls because of its function as a bed that does not require a lot of lighting, while the furnace is made of windows to illuminate cooking activities. In the porch, the building is made semi-enclosed. On the left/right side are generally made half of the wall and the remaining walls can be dismantled pairs. This is done because the porch serves as a multipurpose room. If there is no activity wall insulation is installed, and if there is a ceremony, the wall will be opened. Although the building is closed, the pattern of air circulation is well maintained. Because traditional buildings use poles, between the walls of the building and the roof there is an empty space around the building. This space provides flexibility in the circulation of fresh air from wherever it comes. With this wisdom the use of air conditioning is

not necessary at all. Especially at the height of this village the air is cool, and is comfortable for residential. This condition can reduce the use of electrical energy both day and night.

*Paon* building in addition to functioning as a place to cook is also a place to store goods, also a place for labor. Local people have applied simple technology to avoid humidity and in the context of building functions. Building foundations are generally made using stone and soil as the floor. An altitude of 60 cm to 100 cm above the surface of the yard is predicted as an effort to reduce humidity and the natural process of activities in the kitchen, and childbirth. Activities in the kitchen that are associated with elevated water provide opportunities for the natural process of absorption by the floor element. Therefore, even though they do not use ceramics, the kitchen floor is never muddy. Likewise, in the birth process, there will be adequate absorption with these heights. This certainly can reduce the use of energy in the residential process.

Another traditional building is the *bale gede*. Dimensions range from 4.50 cm x 4.50 cm. Also relatively small dimensions. 12 pillar building. Functioning as a multipurpose building, such as: the place of the death ceremony, the birth ceremony, the marriage ceremony, the bed of the parents, the place to carry out daily activities. The building is only walled on two sides only, the rest is a wall that is not permanent and can be dismantled pairs. If there are ceremonial activities the walls which are not permanent will be demolished so that the ceremonial activities can take place properly. Because the dimensions are relatively small and half-open buildings, then during the day will utilize natural lighting. Likewise, the air conditioning system. Between the roof and the wall there is adequate space for air movement on two sides, while the other two sides are open. Thus no artificial ventilation is required for residential comfort. With this wisdom, the use of electrical energy will be less compared to compact and large buildings, especially those in urban areas. The illustration of the *bale gede* building is shown in Figure 5.

Granary or *jineng*, located in the downstream zone. The main function of the building is as a place to store rice. However, there are daily activities that are often done in this building. There are also those who use this building as a storage place for caged chickens (roosters), especially at night. If the owner of the granary conducts religious ceremonial activities, this building becomes one of the places to prepare the facilities and infrastructure of the ceremony. Included in the activities of proclaiming the interests of the party carried out by the owner or neighbor in the unit yard. The building is open and more often used during the day. Thus this building does not need electricity during the day. If there are ceremonial activities, this building will be equipped with temporary lighting. Therefore, this building is energy efficient and can be called a building that is environmentally friendly. Illustration of the image of the granary/*jineng* is like Figure 6.



Figure 5. Bale Gede Building  
Source: Survey, 2019.



Figure 6. Granary/Jineng Buildings  
Source: Survey, 2019.

The use of building materials in the yard or village unit initially made use of existing local potential. Road and yard dividing walls are made using stone as a foundation material, *popolan* soil as a wall material, and bamboo as



a roof frame, and straw as a roof covering material. These materials are almost all taken from the surrounding environment so that no special transportation is required. Likewise, the *paon* and *bale* building's roof material is thatch grassland, its walls are *popolan* soil which is sometimes mixed with rice husk, and its foundation utilizes river stone and soil. Thus the surrounding material gives color to the architecture of community buildings. Utilization of local materials has reduced the movement of building materials elsewhere. As it is today, buildings are brought in from far away and thus require transportation. Transportation will use petroleum fuels which can affect the exhaust gas output. Exhaust gas will be able to accelerate the greenhouse effect. In addition, the utilization of this energy will affect and can disrupt conditions in the mining area, or generally reduce the quality in the vicinity of the mine environment. Thus there will be a reduction in the use of electrical energy, which also means reducing the generation of the greenhouse effect.

In addition to transportation, the use of natural materials such as *alang-alang* roofs can act as a barrier to the heat of the sun that enters the house during the day, as well as storing warm at night. Thus the occupant's response to the use of building materials is not too hot during the day, and not too cold at night (Parimin 1986, Ngakan 2017, Nutrisia 20180). The use of roofing materials and building wall systems can reduce the use of air conditioning, which also means less use of electrical energy. Reduction in electrical energy also means a reduction in the greenhouse effect.

Likewise, the granary building. Because of its function as a place to store rice, the roofing material technology uses a mixture of reeds and fibers. This material in ancient times was very abundant around the village. There is even an area whose plants are dominated by palm trees called Karang Jaka (land that is overgrown with dominant palm trees). Almost all of the land is overgrown with palm trees, with heights reaching 20 - 30 meters. This roofing material is installed alternately between reeds and fibers. From the results of public speaking, the combination of this material can last up to 60 years. It can be concluded that the use of durable roofing material is due to the function of the building as a place to store the main food. With this material combination it is hoped that the conditions of rice stored in it will be more stable and more durable. In addition to their own interests, rice can also be used when carrying out religious ceremonies. There is a public view, that the longer the rice is stored, the more self-esteem is raised.

With the development of technology and traditional building materials difficult to obtain, the use of modern materials such as asbestos, zinc, and tile has been widely used. In addition to utilizing energy for transporting and accelerating the greenhouse effect, the use of zinc roofs, asbestos and roof tiles are said by the public that the use of modern materials also has weaknesses. In the rainy season the conditions in the building will be more humid, and in the summer it will be too hot for rice storage. Also thankful that now there are not many people who save in large quantities. When using a reed roof and palm fibers there will be a balance of temperature between summer and winter (Kaler 1983, 2005, Koentjaraningrat 2005). This is due to the fact that the roof of the mixture functions more as a coaca isolator, so that the summer music is not too hot, and in winter it is not too cold.

The traditional use of yard pavement is also done by utilizing materials around the village. Building materials used are river stones that are installed in such a way as to cause aesthetic value in addition to functioning as pavement. The stones are just installed in such a way, so that among them there are still sidelines for water absorption in the rainy season. Aside from being absorbed by water, this condition still allows the growth of grass between the stones. Thus, in the rainy season the surface water flow is not too much because some of it seeps into the ground, while in the dry season it is not too hot because there are still gaps between the rocks.

The most downstream part of the road is *teba*. The *teba* section serves as a place to dispose of garbage, keep livestock (pigs, chickens, ducks, sometimes cows), as well as household plants. Because it is a hilly mountainous area, the local people are familiar with the simple technology of holding land (*taku*) and making sledges (*parigi*). *Taku* are generally made from natural materials, such as trees, while *parigi* is made using stone and palm fiber. The stone is used as a barrier, while the fibers are used as water pores in the rainy season. This will prevent the landslide in the rainy season, which means it can save energy in it. Another advantage is that plants can still live on the sidelines of the rocks arranged. This and reduces the impression of hard and stiff on the joint.

## CONCLUSION

The results of the discussion show that in the spread settlement pattern there will be open spaces between elements of the settlement. This will provide spaces for wind movement so that energy use can be reduced. With the reduced use of energy, the greenhouse effect can qualitatively be reduced. Open spaces have also provided an exchange between the needs of residents and the environment so that they can support each other's survival.

In addition, structuring buildings based on local local wisdom can also reduce the amount of energy used. Utilization of closed and open spaces in accordance with their functions has been able to reduce qualitatively the amount of energy used in utilizing local environmental/climate conditions.

Based on the results of field searches and discussions with community leaders, the use of building materials in the local village environment will reduce the amount of movement needed to mobilize these materials. Thus the use of energy for movement will be less too. Therefore, the use of energy will be less too.

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