Sustainable Architectural Investigations on Bugis Vernacular House: Case Study of Tenun Tourism Village, Samarinda Seberang, East Kalimantan, Indonesia

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Abstract. Sustainability is a global problem, and architecture can contribute through vernacular architecture. To find out the potential of vernacular architecture to contribute, it is necessary to study sustainable architecture in vernacular houses. In this study, an investigation of sustainable architecture in Bugis vernacular houses will be carried out with a case study of the Tenun Tourism Village. We find that to contribute to the field of architecture, an approach through the concept of sustainable architecture is needed, one of which is green architecture. Thus, we conclude that there is a need for a sustainable architectural investigation of Bugis vernacular houses with green architecture approach and through the assessment of EDGE indicators. The results of this study indicate that the Bugis vernacular architecture in the Tenun Tourism Village can contribute to the issue of sustainability. However, it needs some renovations and additional technology. In addition, the material efficiency can still be maintained even though the material is replaced with the latest material.

1. Introduction

Various issues of sustainability are happening all over the world. The issue of sustainability is influenced by human civilization. The activities of human civilization cause environmental damage, such as the increase in albedo, Urban Heat Island (UHI), the effect of greenhouse gases, and ozone depletion[1-4]. As gaseous stratosphere in the atmosphere, the ozone will deplete faster if it continues to be exposed to gaseous compounds formed by chlorine, fluorine, and carbon. The depletion of the ozone layer will cause ultraviolet (UV) radiation that may penetrate the earth's surface more easily. So that all phenomena of human civilization will cause climate change and global warming [3]. Climate change and extreme global climate change will cause ice melting which is now starting to occur and is proven by various researchers in the world [1,5-6]. These various phenomena will have an impact on various aspects, ranging from changes in habitat and biodiversity, to pose a threat to human health [3]. Apart from being related to the environment,
these phenomena will also affect social and economic problems [7]. The various problems above show that the issue of sustainability become very important to discuss.

Buildings have a significant role as the cause of the emergence of sustainability problems and the field of architecture must have a contribution to solve these sustainability problems. To be able to contribute to the field of architecture, an approach through the concept of sustainable architecture is needed. Until now, there are many sustainable architectural concepts. At least three concepts have been developed, including Bioclimatic Architecture, Eco Architecture and Green Architecture. Bioclimatic architecture has the main principle of protecting the building against the climate and focuses on the thermal comfort of the building [8-11]. Eco Architecture has the principle of reducing energy and material use, as well as managing buildings or the environment by balancing building construction with the natural and cultural environment around it [12-14]. The concept of Green Architecture has the principle of paying attention to all aspects of sustainability, starting from how to design buildings, paying attention to human health, the environment, climate, even energy savings and the use of renewable materials [15-16]. This research will use the concept of Green Architecture because it provides very complete benefits to sustainability issues, namely environmental, social and economic benefits.

Based on various concepts that have been developed around the world, it is necessary to have indicators or benchmarks to apply them to buildings and the environment. Until now various countries have made a standardized model of assessment and certification for green buildings. Some examples of these boards and standardization models are GRIHA Council from India, LOTUS from Vietnam, GBCA from Australia, and so on [17-21].

Indonesia also has a standardization model for green buildings. In 2009, Indonesia created a board called GBCI (Green Building Council of Indonesia) which was assimilated with GBCA. Then GBCI created a model rating tool named GREENSHIP TOOLS. This model tool is used to address sustainability issues and to certify highly complex green buildings and environments in Indonesia [22-28].

GBCI also cooperates with IFC (International Finance Corporate) which is a member of the World Bank. IFC made an innovative model rating tool called EDGE (Excellence in Design for Greater Efficiencies) which was inaugurated in 2014. EDGE aims to democratize the green building market, which was previously reserved for high-end buildings that are relatively located in developed countries [29].

This study uses the model rating tools EDGE. The choice of this model is because EDGE can reach the types of lower-middle class buildings. The results of the EDGE calculation will inform the most economical path to achieve green buildings [30-31]. EDGE software can be used to calculate utility savings and carbon footprint reduction based on the base case. The data obtained can show how much it will cost to build a green building or environment and how short it will take to recover capital through operational savings [29,31]. In addition, EDGE also has other advantages, namely it is equipped with supporting data from several cities in various countries, including Indonesia [29].

The issue of sustainability is not only about the sustainability of nature, but consists of three pillars, namely environmental, economic, and social. The World Conference on Environment and Development (WCED) in 1987 stated that sustainability includes three components, namely environmental protection, economic growth, and social justice [32].

The problem of the loss of architectural cultural heritage is one of the sustainability issues. Historical value will be lost along with the loss of cultural heritage because the nature of the damage will not be repaired [33]. The loss of architectural cultural heritage will also eliminate knowledge of local wisdom. Architecture in Indonesia has a distinctive and diverse local wisdom, this uniqueness can be seen from the shape of the
roof, spatial arrangement, construction, material, under, even from the philosophical side [34-35]. One of these local wisdoms is in the vernacular house which has been known to have a very good ability to survive from time to time [36]. One of the vernacular houses that has the ability to survive until now is the Bugis vernacular house. Bugis Vernacular House in the Tenun Tourism Village of Samarinda Seberang since the 17th century [37].

As an effort to contribute to sustainability, this research will investigate the Bugis Vernacular House in the Tenun Tourism Village in Samarinda Seberang, East Kalimantan. The investigation was carried out through Green Building approach using a model rating tools EDGE. The location of this research case study is in Samarinda Seberang. However, because the EDGE application does not contain data for that city, it will use the input data of the closest city that is still in East Kalimantan, namely Balikpapan. In this study, in addition to conducting investigations, it will also make design recommendations or simulations virtual of Bugis vernacular houses in the Tenun Tourism Village through the EDGE application to become a green building.

2. Literature Review

2.1. EDGE Assessment System and Variables

EDGE is essentially a machine for calculating performance using mathematics with the principles of climatology, heat transfer, and building physics. After the data about the building to be investigated is entered in the EDGE application, the EDGE calculator will map the potential performance of the building on the energy, water, and material aspects [29].

EDGE has three variables in the assessment of green building, namely energy, water, and materials. EDGE certification will be awarded to building projects that demonstrate a minimum savings of 20% in each variable i.e., operational energy, water, and energy contained in the material [29].

2.2. EDGE Parameters and Indicators

EDGE is divided into six categories, namely Homes, Hospitality, Retail, Offices, Hospitals and Education. This study will use the category Homes. parameters Homes in EDGE include 24 parameters for energy, 8 parameters for water, and 6 parameters for materials [29].

Indicators in the assessment of green buildings on EDGE are seen based on the percentage of each variable, namely energy, water, and materials. Each variable must have a minimum value of 20% to be declared a green building [29].

2.2.1. Energy.

There are 24 criteria for assessing energy savings in EDGE applications [29], including HME01 Reduced Window to Wall Ratio, HME02 Reflective Paint/Tiles for Roof, HME03 Reflective Paint for External Walls, HME04 External Shading Devices Annual Average Shading Factor (AASF) , HME05 Insulation of Roof, HME06 Insulation of Walls, HME07 Low-E Coated Glass, HME08 Higher Thermal Performance Glass, HME09 Natural Ventilation, HME10 Ceiling Fans in All Habitable Rooms, HME11 Air Conditioning System, HME12 High-Efficiency Boiler for Space Heating, HMET3 Sensible Heat Recovery from Exhaust Air, HME13 High-Efficiency Boiler for Hot Water, HME14 Heat Pump for Hot Water, HME15 Energy-Efficient Refrigerators and Clothes Washing Machines, HME16 Energy-Saving Light Bulbs - Internal Spaces, HME17 Energy-Saving Light Bulbs - Common Areas and External Spaces, HME18 Lighting Controls for Common Areas and Outdoors, HME19 Solar Hot Water Collectors, HME20
Solar Photovoltaics, HME21 Smart Energy Meters for Electrical Energy, HMET4 Consumption Based Energy Meters for Both Cooling and Heating Energy, HME22 Other Renewable Energy for Electricity Generation.

2.2.2. Water.

There are 8 criteria for assessing water savings in the EDGE application [29], including HMW01 Low-Flow Showerheads, HMW02 Low-Flow Faucets for Kitchen Sinks, HMW03 Low-Flow Faucets in All Bathrooms, HMW04 Dual Flush for Water Closets in All Bathrooms, HMW05 Single Flush for Water Closets, HMW06 Rainwater Harvesting System, HMW07 Recycled Gray Water for Flushing, HMW08 Recycled Black Water for Flushing.

2.2.3. Material.

There are 6 parameters for assessing material savings in EDGE applications [29], including HMM01 Floor Slabs, HMM02 Roof Construction, HMM03 External Walls, HMM04 Internal Walls, HMM05 Flooring, HMM06 Window Frames.

3. Materials and Methods

The method of this research is a quantitative approach. The data are obtained from secondary and primary source and collected using several stages. The first stage is collecting data through observation, interviews, and documentation in the field. The second stage is to input data into the application rating tools EDGE and evaluate the data. Data evaluation is carried out by entering data into a three-variable EDGE scoring system, namely energy, water, and materials. Each variable will have its own parameters. A detailed description of what these parameter criteria are can be seen in the literature review. Each variable has a minimum indicator of 20% to be declared a green building. After the evaluation is carried out, it will be seen whether the research object building is ‘green’ or not. After evaluating the database, the next step is to re-simulate with the EDGE application to obtain design recommendations for existing buildings to achieve green buildings to survive in the future.

3.1. The Case Study Data

The case study or object in this study is a Bugis vernacular house in the Tenun Tourism Village of Samarinda Seberang, East Kalimantan, Indonesia. The choice of location for this research is because the house in this village has survived until now since the arrival of Bugis nomads in the 17th century [37]. The Bugis vernacular house building which is the object of research is located in Samarinda Seberang with the coordinate position of latitude \(-0.49167^\text{N}\), longitude \(117.14583^\text{E}\) [38]. The location of Samarinda Seberang is not included in the EDGE application data, so the evaluation will use data from the nearest city, namely Balikpapan. Balikpapan City is located at the coordinate position of latitude \(-1.265386^\text{N}\), longitude \(116.8236^\text{E}\) [39]. Based on these data, it can be seen that Balikpapan City is located \(-0.773716^\text{N}\) further north than Samarinda Seberang and is located \(0.32223^\text{E}\) further east. Then the distance between Samarinda Seberang and Balikpapan City is as far as 104 km [40]. Based on these data, the Balikpapan City data on the EDGE is still relevant and can be used for the evaluation of Bugis vernacular houses in Samarinda Seberang.

The object selected as the sample is a vernacular house that has not changed much from its initial construction. The number of objects selected in this study were 3 houses. The houses were chosen to represent 3 types of houses based on the type of construction and the shape of the house, namely (1) Type
1 house with wooden construction with a gable roof, (2) Type 2 house with wooden construction with a shield roof, and (3) Type 3 houses with wooden construction with a gable roof with timpalaja/sambulayang or terraced ridge covers typical of Bugis houses.

![Figure 1. Bugis vernacular house type 1](image)

![Figure 2. Bugis vernacular house type 2](image)

![Figure 3. Bugis vernacular house type 3](image)

### 3.1.1. Case Study Data of Bugis Vernacular Houses.

The case study data of the Bugis vernacular house which is the object of research will be measured in this study and refers to standard data from EDGE as follows:

- **Design Data**

  Contains data about building descriptions. Data on the design of Bugis vernacular houses in the Tenun Tourism Village can be seen in the table below.

| No. | Name of Data                  | Data and Size                  | Vernacular House Type 1 | Vernacular House Type 2 | Vernacular House Type 3 |
|-----|-------------------------------|--------------------------------|-------------------------|-------------------------|-------------------------|
| 1.  | Name of Project               | Vernacular House Type 1        |                         |                         |                         |
|     | Vernacular House Type 2       |                                |                         |                         |                         |
|     | Vernacular House Type 3       |                                |                         |                         |                         |
| 2.  | Number of Buildings           | 1 (one)                        | 1 (one)                 | 1 (one)                 |                         |
| 3.  | Country                       | Indonesia                      | Indonesia               | Indonesia               |                         |
| 4.  | City/Province of              | Samarinda Seberang East Kalimantan | Samarinda Seberang, East Kalimantan | Samarinda Seberang, East Kalimantan |                         |
| 5.  | type Project                  | House (House)                  | House (House)           | House (House)           |                         |
| 6.  | High walls are                | 3.4 m                          | 3.5 m                   | 2.5 m                   |                         |
| 7.  | Size whole Floor              | 145 m²                         | 147.46 m²               | 423.12 m²               |                         |
| 8.  | Interior Floor Area           | 125 m²                         | 137.46 m²               | 400 m²                  |                         |
| 9.  | Living Room Area              | 20 m²                          | 20 m²                   | 10 m²                   |                         |
| 10. | Living Room Area              | 38.25 m²                       | 38.41 m²                |                         |                         |
| 11. | Dining Room Area              | 19.75 m²                       | 10.4 m²                 |                         |                         |
| 12. | Bedroom 1                     | 9.25 m²                        | 11.57 m²                |                         |                         |
13. Bedroom 2 7.5 m² 11.57 m² -
14. Bedroom area 3 7.5 m² 6.09 m² -
15. Kitchen area 2.5 m² 7.56 m² -
16. Bathroom area 1 2.5 m² 2.6 m² -
17. Bathroom area 2 - 2.72 m² -
18. Drying room area 7.5 m² 16.56 m² -
19. Terrace room area 15 m² 10 m² 23.12 m²
20. Roof Area 211.38 m² 224.332 m² 624.72 m²

4. Results and discussion

4.1. Comparison of EDGE Evaluation Results and Recommendations

Comparison of evaluation results and recommendations on the EDGE application, which includes three criteria, namely energy, water, and materials can be shown in the table 2 until table 10.

4.1.1. Energy Criteria

Comparison of evaluation results and recommendations on the EDGE application in energy, can be shown in the table 2 until table 4.

House Type:1

Table 2. Evaluation results and recommendations on the EDGE application of house type 1

- In the evaluation results of energy criteria at EDGE, type 1 houses have low energy savings which is only 16.77%. So, improvements are needed to reach the EDGE standard.
- It is recommended to add Insulation of External Walls: U-value of 2.11 and Low-E Coated Glass: U-value of 1.6 W/m².K and SHGC of 0.6, showed an increase of 22.70%. This improvement give the highest evaluation results.
House Type: 2

Table 3. Evaluation results and recommendations on the EDGE application of house type 2

| Evaluation Result | Recommendation result |
|-------------------|-----------------------|
| Base Case | Virtual Energy for Comfort | Improved Case | Virtual Energy for Comfort |
| Heating Energy | Cooling Energy | Fan Energy | Water Energy | Home Appliances |
| Base Case | Virtual Energy for Comfort | Improved Case | Virtual Energy for Comfort |
| Heating Energy | Cooling Energy | Fan Energy | Water Energy | Home Appliances |

- In the evaluation results of energy criteria at EDGE, type 2 houses have low energy savings which is only 4.15%. So, improvements are needed to reach the EDGE standard.
- It is recommended to add Insulation of External Walls: U-value of 2.11 and Low-E Coated Glass: U-value of 1.6 W/m².K and SHGC of 0.6, showed an increase of 20.29%. This improvement gave lowest evaluation results.

House Type: 3

- In the evaluation results of energy criteria at EDGE, type 3 houses have low energy savings which is only 18.36%. So, improvements are needed to reach the EDGE standard.
- It is recommended to add Insulation of External Walls: U-value of 2.11 and Low-E Coated Glass: U-value of 1.6 W/m².K and SHGC of 0.6, showed an increase of 22.28%. This improvement gave an evaluation results 2nd position.

Table 4. Evaluation results and recommendations on the EDGE application of house type 3
4.1.2. Water Criteria
Comparison of evaluation results and recommendations on the EDGE application in water, can be shown in the table 5 until table 7.

House Type: 1

Table 5. Evaluation results and recommendations on the EDGE application of house type 1

| Evaluation Result | Recommendation result |
|-------------------|-----------------------|
| Base Case | Improved Case |
| Base Case | Improved Case |

- Bugis vernacular house type 1 does not use EDGE’s water saving technologies at all. So that the evaluation results in an evaluation of 0.00%.
- It is recommended to add following items: shower: 1 pc low-flow showerheads - 13.3 L/min, kitchen: 1 pc low-flow faucets for kitchen sink - 7.5 L/min, water faucets: 1 pc single flush for water closet - 4.8 L/min, and washing and cleaning: rainwater harvesting system - 2% of roof area used for rainwater collection. The results showed an increase of 20.38%.

House Type: 2

Table 6. Evaluation results and recommendations on the EDGE application of house type 2

| Evaluation Result | Recommendation result |
|-------------------|-----------------------|
| Base Case | Improved Case |
| Base Case | Improved Case |
Bugis vernacular house type 2 does not use EDGE's water saving technologies at all. So that the evaluation results in an evaluation of 0.00%.

It is recommended to add the following items: shower: 1 pc low-flow showerheads - 13.3 L/min, kitchen: 1 pc low-flow faucets for kitchen sink - 7.5 L/min, water faucets: 1 pc single flush for water closet - 4.8 L/min, and washing and cleaning: rainwater harvesting system - 2% of roof area used for rainwater collection. The results showed an increase of 22.43%.

Table 7. Evaluation results and recommendations on the EDGE application of house type 3

### Evaluation Result

![Evaluation Result Chart]

### Recommendation result

![Recommendation result Chart]

- Bugis vernacular house type 3 does not use EDGE’s water saving technologies at all. So that the evaluation results in an evaluation of 0.00%.

- It is recommended to add the following items: shower: 1 pc low-flow showerheads - 13.3 L/min, kitchen: 1 pc low-flow faucets for kitchen sink - 7.5 L/min, water faucets: 1 pc single flush for water closet - 4.8 L/min, and washing and cleaning: rainwater harvesting system - 2% of roof area used for rainwater collection. The results showed an increase of 22.02%.

4.1.3. **Material Criteria**

Comparison of evaluation results and recommendations on the EDGE application in materials can be shown in the table 8 until table 10.

**House Type:1**

In the evaluation of material criteria for EDGE, type 1 house has a high material saving aspect of 79.15%.

The recommendations below are not intended to increase the value of standard EDGE materials, but rather to predict what will happen if the material is replaced. Material replacement may occur due to technological developments and the availability of wood materials which are already very limited.
Table 8. Evaluation results and recommendations on the EDGE application of house type 1

Table 9. Evaluation results and recommendations on the EDGE application of house type 2

It is recommended to add floor slabs - in-situ reinforced concrete slab (thickness 100 mm, steel rebar 8,638 kg/m²), roof construction - asphalt shingles on steel rafter (proportion 100%, thickness 193 mm), external walls - common brick wall with internal and external plaster (proportion 100%, thickness 150 mm), internal walls - re-use of existing wall, flooring - ceramic tile (proportion 100%), and window frames - aluminum (proportion 100%) showed a decrease to 55.33%. But this result is still above the EDGE standard.
In the evaluation of material criteria for EDGE, type 2 house has a high material saving aspect of 78.58%.

The recommendations below are not intended to increase the value of standard EDGE materials, but rather to predict what will happen if the material is replaced. Material replacement may occur due to technological developments and the availability of wood materials which are already very limited.

It is recommended to add floor slabs - in-situ reinforced concrete slab (thickness 100 mm, steel rebar 8,638 kg/m²), roof construction - asphalt shingles on steel rafter (proportion 100%, thickness 193 mm), external walls - common brick wall with internal and external plaster (proportion 100% , thickness 150 mm), internal walls - re-use of existing wall, flooring - ceramic tile (proportion 100%), and window frames - aluminum (proportion 100%) showed a decrease to 57.51%. But this result is still above the EDGE standard.

**House Type: 3**

**Table 10.** Evaluation results and recommendations on the EDGE application of house type 3

| Evaluation Result | Recommendation result |
|-------------------|-----------------------|
| In the evaluation of material criteria for EDGE, type 3 house has a high material saving aspect of 83.52%. | The recommendations below are not intended to increase the value of standard EDGE materials, but rather to predict what will happen if the material is replaced. Material replacement may occur due to technological developments and the availability of wood materials which are already very limited. |
| It is recommended to add floor slabs - in-situ reinforced concrete slab (thickness 100 mm, steel rebar 8,638 kg/m²), roof construction - asphalt shingles on steel rafter (proportion 100%, thickness 193 mm), external walls - common brick wall with internal and external plaster (proportion 100% , thickness 150 mm), internal walls - re-use of existing wall, flooring - ceramic tile (proportion 100%), and window frames - aluminum (proportion 100%) showed a decrease to 69.34%. But this result is still above the EDGE standard. | |
while the type 1 vernacular house showed the lowest value. While the results of evaluation and recommendation on the material aspect showed the highest value in type 3 vernacular house, the second position in type 1 vernacular house, while type 2 vernacular house showed the lowest value.

5. Conclusion

The results of the evaluation of Bugis vernacular houses type 1, type 2 and type 3 indicate that to become a green building, it is necessary to increase the energy and water aspects. After evaluating the recommendations by making greater savings and applying energy and water saving technology, the houses can meet the standard criteria from EDGE.

As for the material aspect, Bugis vernacular houses type 1, type 2 and type 3 show very good values and produce low embodied energy. Then after evaluating the recommendations by replacing renewable materials, the house can still meet the standard criteria for material value from EDGE.

After a more detailed analysis, evaluation results and recommendations on the energy aspect, Bugis vernacular house type 1 shows the highest value. On the water aspect, Bugis vernacular house type 2 shows the highest value. In the material aspect, type 3 vernacular house shows the highest value.

Then the results of the evaluation and recommendations on the energy aspect, Bugis vernacular house type 2 shows the lowest value. On the water aspect, Bugis vernacular house type 1 shows the lowest value. In the material aspect, type 2 vernacular housing shows the lowest value.

Based on the evaluation of the green building on the Bugis vernacular house using the EDGE application that has been carried out, the results show that the Bugis vernacular house in the Tenun Tourism Village, Samarinda Seberang, East Kalimantan is able to contribute to the issue of sustainability. However, some renovations and additions to energy and water efficiency technologies need to be carried out and are still able to survive even though some of the materials are replaced with building materials that follow materials that are often used or grown in the community in the Tenun Tourism Village and the current community.

The results of evaluation and recommendation on the energy aspect showed the highest value in type 1 vernacular house, the second position in type 3 vernacular house, while type 2 vernacular house showed the lowest value. Then the results of evaluation and recommendation assessment on the aspect of water showed the highest value in the type 2 vernacular house, the second position in the type 3 vernacular house, while the type 1 vernacular house showed the lowest value. While the results of evaluation and recommendation on the material aspect showed the highest value in type 3 vernacular house, the second position in type 1 vernacular house, while type 2 vernacular house showed the lowest value.

Acknowledgement

The author would like to thank the Master of Architecture study program at the Islamic University of Indonesia.

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