## DETERMINANTS IN THE MEASUREMENT OF GREEN CAMPUS

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## ABSTRACT

Campus has become a basis of education and learning for various things related to sustainability such as education about environmental sustainability and sustainable living. In line with that, a green concept is important to be implemented on campus, both in the building as well as the environment. The application of the green concept on campus requires support from the rector as the decision maker and the architect as the designer. This includes the awareness of the users such as the students, lecturers, and staff. This research aims to compile a green campus index based on the perceptions of architects as the planners and students as the users. The campus area consists of environment and buildings. The green concept that will be the basis of this research is based on the UI GreenMetric, derived from the Greenship assessment tool from the Green Building Council Indonesia (GBCI) and previous studies. This research was conducted at the Universitas Sumatera Utara (USU). The research population in this research are architects in Medan City and students from USU, aiming to compile a Green Campus Index which was obtained from the structured interview with the architects and self-administered questionnaire from the students. The research sample was 10 registered architects in Medan city and 394 undergraduate students from USU. Basically, this study is mixed-method by using an interview and questionnaire. The interview results were analyzed descriptively and factor analysis was used to analyze the questionnaire. The results showed that there were eight variables that need to comply as a green campus index. Those are education, environment and connectivity, transportation, material, energy conservation, water conservation, building, and waste management. If applied, these green concept indexes will be beneficial for the campus. Although the initial investment is quite large, it will reduce the operational costs as well as to provide better quality for the users in the future.

**KEYWORDS:** green concept, green campus, green campus index, green campus measurement

## INTRODUCTION

University has become a role model in the implementation of sustainable concepts in terms of the education about environmental sustainability and sustainable living(Huyuan and Yang, 2012). According to Barth (2007), a university is a place for learning sustainable concepts that can be done formally or informally through organizational or extra-curricular activities. This is also agreed by Velazquez et. al (2006) in Too and Bajracharya (2015) that sustainable universities must begin with the formation of a vision and mission of sustainability, then construct and validate the sustainability policies, targets and objectives, which must be coherent with the sustainability mission. The

sustainable strategy consists of education, research, outreach and partnership cooperation and cooperation to waste management, energy, water, and transportation (Too and Bajracharya, 2015). Hence, this research aims to create a model for applying green campus design, which will be labeled the Green Campus Index.

Sustainable development should be provided for development of activities and become an umbrella for human activities (Emanuel and Adams, 2011). It is also an effort for campuses, institutions as well as students to prepare their future decisions locally and globally (Horhota et al., 2014).Based on Bilodeau, Podger and Abd-El-Aziz (2014), sustainability can be a driving force in innovation that will produce efficient work and business process, low costs and impacts on the environment. In this case, universities can act as representatives of sustainable development within the campus and community. The sustainable approaches in the university are related to economic considerations, provincial legislative, and regulatory requirements.

## 1.1 Green Campus

The university that is well-designed with the environmentally friendly concept will influence the student's stress level. According to the students as the campus users, the quality of life is positively related to green campus (Farland, Waliczek, and Zajicek, 2008). This is in line with the previous study by Tamiami et. al (2018) regarding the green concept application within the campus. Students' quality of life will be increased if the campus where they studied is applying the green concept. There are several indicators that should be applied to the buildings, such as good natural lighting in the classrooms, good ventilation, clean air, and the presence of the greeneries. Buildings that have applied the green concept will significantly improve the quality of life of the students, provide a sense of optimism, and produce good interaction among their friends and lecturers. A recent study by Fachrudinand Fachrudin (2016) stated that a campus that has a green concept can provide a sense of comfort and improve the quality of life of its users. The green campus should provide a campus bus, clean water source, and free from air pollution. In addition to that, there are other six elements required to be applied to buildings with green concepts. Those are environmental impacts, material, waste, energy, water, and human health (Brown, 2006).

Campus or university represents an entity that uses a lot of energy, and energy-saving institutions that are lower than the housing environment. There are two aspects of the green campus building. First, focus on the physical environment in reducing energy and carbon consumption, including land use, green buildings, and green features. Second is the socio-cultural aspect, which involves management, education, practice, and relationships with local communities for effective plans and the use of physical elements on the green campus (Choi et al.,2017). A sustainable campus reflects the center of knowledge related to sustainability. Professionals are needed to engage in green campus planning that is relevant to their field (Balachander, 2015).

Based on the research conducted by Zhang et. al (2016), the campus landscape, such as building, can be seen as a physical manifestation of values in universities and in the future it can be utilized as a 'living laboratory'. Moreover, the campus landscape could improve the campus sustainability in the future. Campus landscapes in the universities consists of1) physical evidence of commitment to the sustainability and application of the university's vision and mission; 2) resources to enhance student learning and involvement in the sustainability process. Landscapes can be inherited for future generations. The UI Green Metric (2015) assesses green campus in Indonesia using six different weighting indicators. The six indicators are structuring and infrastructure, energy and climate change, waste management, water use, transportation and education. Too and Bajracharya (2015) also formulated six sustainable campus frameworks, namely psychological, physical, personal, public perception, price and policy. These factors can be applied on campus towards the green campus. Meanwhile, according to Fu et. al (2012), universities have the resources to develop a green campus. There are six indicators in measuring the green campus, namely green education, green campus, green science and technology, green culture, green services and green consumption.

Yeh (2006) compiles a Green University Evaluation Index System (GUEIS) in which there are three main components, namely the environmental system, environmental management, and environmental education. The environmental system consists of the atmospheric environment, water pollution, waste management, toxic waste management, and ecosystems. Environmental management consists of environmental policies, green buildings, green consumption, and transportation. For environmental education consists of learning and curriculum; guidance and activities as well as research and teaching. The green campus is not only related to physical matters such as the buildings, landscapes, and waste but also the non-physical matter, such as the curriculum taught. In addition, it also relates to the operations, management and green purchases, which in universities are often associated with investment on campus. Students and staff also participated in the application of green concepts on campus.

Since this study is conducted in Indonesia, therefore the indicator used in this research refers to the Green Building Council Indonesia (GBCI) which has several indicators for assessing green buildings and green areas. For GBCI green building assessment, the indicators are Appropriate Site Development, Energy Efficiency and Conservation, Water Conservation, Material Resources and Cycles, Indoor Health and Comfort, and Building Environment Management (GBCI, 2015). Whereas to measure green application in an area, GBCI (2016) measures seven indicators: Innovation and Future Development, Building and Energy, Community Well-being Strategy, Solid Waste and Material, Land Ecological Enhancement, Movement and Connectivity, and Water Management and Conservation. Based on Brown (2006), Yeh (2006), UI Greenmetric (2015), GBCI (2015), Fachrudin and Fachrudin (2016), and Zhang et al., (2016), there are several variables related to the measurement of green campus both in buildings and the environment. Those are energy, water, waste, building, transportation and landscape. However, in this research, the variables that will be

used are environment and connectivity, materials, buildings, water conservation, energy conservation, waste management, transportation, and education management.

## 2. METHOD

This study uses a mixed method, qualitative and quantitative. Qualitative method is used to obtain input from architects who understand the green concept of buildings, regions, and campuses. Qualitative data obtained through a structured interview and analyzed by using inductive descriptive analysis. The quantitative method was carried out to obtain input from the students as the campus users by using a self-administered questionnaire survey and analyzed by factor analysis. The results of the analysis factors are used to compile the Green Campus Index which later can be used to measure the application of green campus on other campuses.

This study was conducted in Universitas Sumatera Utara (USU) campus, Medan-Indonesia. a public university which was established in 1957 and was ranked on the 11thposition as the Indonesian green campus in the year 2017. USU has 40% building space and 60% open space of total area. USU has seven fields of specialty in the field of research, one of it is focusing on the sustainability. To obtain the qualitative data, the interview was conducted with registered architects under the Indonesian Architects Association of North Sumatera in Medan city who have attended the GBCI Greenship Associate course. Due to the selection criteria, there were only 10 registered architects who fulfilled the criteria. The number of sample is the same as the target population. The population for the survey with the questionnaire in this study was the undergraduate students in Universitas Sumatera Utara from fifteen faculties who registered between the academic year 2014 to 2017. The total population was 25,127 students. Determination of the number of samples was using the Slovin formula, with a total sample of 394 students.

In total, there are 27 indicators of green campus variables were used relating to the environment and connectivity; material; building; water conservation energy conservation; waste management; transportation and education. The data obtained from the results of the questionnaire were analyzed by analysis factors to generate what type of factors should be applied to buildings inside the green campus. While the data obtained from the interviews were analyzed by descriptive analysis and became input in compiling the Green Campus Index.

## 3. RESULTS

Based on the analysis factors that have been carried out, the KMO and Bartlett's Test values in this study are 0.907 which is above the 0.5 value. The significance value of the Bartlett's Test of Sphericity is 0.000. Based on these results it can be said that the correlation between all of variables meets the requirements and can be continued to the next analysis stage (Table 5.1).

**Table 5.1 KMO and Bartlett's Test**

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.907 |
|---|---|---|
| Bartlett's Test of Sphericity | Approx. Chi-Square | 5842.510 |
| | df | 351 |
| | Sig. | 0.000 |

Based on Table 5.2, all of the variables have been obtained and divided into seven factors, with each member of the variable has>0.5 value in the same column. From the seven factors, the member variables for each factor show almost the same direction. In factor 1, it consists of member variables which are related to education on the green campus. Factor 2 shows the environmental principles and connectivity on a green campus. Factor 3 shows the transportation inside the campus. Factor 4 consists of a discussion of the selection of materials used in the exterior and interior. Factor 5 discussing the energy conservation in the campus. Factor 6 relates to water conservation and factor 7 relates to lighting and building orientation.

**Table 5.2 Rotated Component Matrix[a]**

| | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Minimizing noise pollution | 0.220 | **0.524** | -0.040 | 0.314 | 0.309 | 0.144 | -0.104 |
| Street lighting | 0.078 | **0.535** | -0.019 | 0.205 | 0.268 | 0.054 | 0.141 |
| Minimizing air pollution | 0.190 | **0.637** | 0.019 | 0.163 | 0.302 | 0.137 | -0.076 |
| Availability of green spaces | 0.161 | **0.535** | 0.067 | 0.323 | 0.209 | 0.173 | 0.001 |
| LED lamps on building | 0.050 | 0.274 | -0.021 | -0.085 | -0.314 | 0.197 | **0.622** |
| Ventilation material on the classroom | 0.217 | 0.281 | -0.047 | **0.645** | -0.142 | 0.035 | 0.109 |
| Eco-friendly material | 0.187 | 0.231 | 0.214 | **0.731** | 0.096 | 0.220 | 0.102 |
| Low VOC paint | 0.245 | 0.168 | 0.150 | **0.758** | 0.206 | 0.129 | 0.054 |

| | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| North-South building orientation | 0.101 | -0.082 | 0.121 | 0.229 | 0.323 | 0.146 | **0.623** |
| Double-glazed window panel | 0.025 | 0.035 | 0.062 | 0.091 | 0.204 | -0.101 | **0.764** |
| Rainwater harvesting | 0.132 | 0.105 | 0.073 | 0.105 | 0.099 | **0.847** | 0.062 |
| Drainage | 0.174 | 0.363 | 0.045 | 0.204 | 0.195 | **0.606** | 0.053 |
| Waste water treatment | 0.292 | 0.204 | 0.184 | 0.103 | 0.154 | **0.693** | 0.022 |
| Sensor faucet | 0.102 | 0.268 | 0.246 | -0.057 | **0.568** | 0.144 | 0.159 |
| Solar panel | 0.248 | 0.127 | 0.022 | 0.070 | **0.738** | 0.113 | 0.086 |
| Energy saving street light | 0.254 | 0.293 | 0.163 | 0.140 | **0.594** | 0.228 | 0.100 |
| Connected pedestrian walkway | 0.190 | **0.746** | 0.234 | 0.062 | 0.037 | 0.173 | 0.117 |
| Comfortable pedestrian walkway | 0.218 | **0.779** | 0.203 | 0.088 | -0.019 | 0.172 | 0.107 |
| Provide saf road | 0.244 | **0.712** | 0.084 | 0.099 | 0.018 | 0.054 | 0.026 |
| Provide bicycle lane | 0.076 | 0.366 | **0.540** | 0.270 | 0.192 | -0.005 | 0.009 |
| Reward for campus bicycle users | 0.211 | 0.090 | **0.891** | 0.065 | 0.125 | 0.138 | 0.052 |
| Reward for campus bus users | 0.207 | 0.072 | **0.871** | 0.045 | 0.035 | 0.106 | 0.082 |

| | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Education on sustainable environment | **0.736** | 0.222 | 0.082 | 0.206 | 0.111 | 0.199 | 0.057 |
| Activity to promote recycling activities | **0.821** | 0.218 | 0.179 | 0.173 | 0.202 | 0.104 | 0.023 |
| Activity to promote energy conservation | **0.823** | 0.216 | 0.121 | 0.107 | 0.226 | 0.123 | 0.011 |
| Environment education publication | **0.839** | 0.207 | 0.126 | 0.132 | 0.122 | 0.106 | 0.049 |
| Sustainable environment training | **0.780** | 0.174 | 0.150 | 0.158 | 0.040 | 0.145 | 0.076 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

Based on the interview with the ten selected architects, they stated that green campus provides great benefits to campus and its surrounding area. The green campus will have added value and good image if the green concept is applied to its building and environment. The respondents also strongly emphasized regarding the problem of waste management and giving efforts to reduce the paper usage in every academic activities on campus. Therefore, there are eight factors in total that are related to building and landscape that a campus must provide. Those are building, water conservation, energy conservation, landscape, environment, waste management, transportation, and education.

## 4. DISCUSSION

The survey results from the questionnaires and interview that have been obtained are used to compile the Green Campus Index. Based on the questionnaire results, seven variables were obtained and all are related to the green campus with each indicator, namely education, environment and connectivity, transportation, materials, energy conservation, water conservation and buildings. These results are consistent with the research of Yeh (2006), Brown (2006) and Zhang et al (2016). Whereas from the results of the interview, it was found that one other variable related to the green campus was waste management. There are several indicators obtained from the interview results and

become additions to the Green Campus Index, namely the problem of waste management, wastewater treatment (grey water), the use of materials in buildings and landscaping and the reduction of paper use. These results are consistent with research from UIGreenMetric (2015), GBCI (2016) and Too and Bajracharya (2015). Inputs from students and architects are compiled into Green Campus Index which is tabulated in Table 5.4. Based on the Green Campus Index that has been compiled, there are eight main variables and 43 indicators that can be used to measure the application of green concepts on campus.

**Table 5.4Green Campus Index**

| Variable | Indicator |
| --- | --- |
| Education | 1. Education in a sustainable environment<br>2. Activity to promote recycling activities<br>3. Activity to promote energy conservation<br>4. Environment education publication<br>5. Sustainable environment training<br>6. Paperless activities within the campus<br>7. Research about the environment<br>8. Publication related to the sustainable and green concept |
| Environment and connectivity | 1. Minimize noise pollution<br>2. Provide street lightings<br>3. Minimize air pollution<br>4. Availability of green space on campus<br>5. Vegetation to improve microclimate<br>6. Public space for lecturers, staff and students<br>7. Connected pedestrian walkway<br>8. Comfortable pedestrian walkway<br>9. Provide safe roads<br>10. Provide bicycle lanes |
| Transportation | 1. Provide campus bicycle<br>2. Provide campus bus<br>3. Reward to campus bicycle users<br>4. Reward to campus bus users |
| Material | 1. Ventilation material on the classroom<br>2. Eco-friendly material on building's exterior<br>3. Low VOC paint on building's interior |
| Energy conservation | 1. Sensor faucet<br>2. Solar panel<br>3. Energy saving street lights |
| Water conservation | 1. Rainwater harvesting system<br>2. Storm water drainage system<br>3. Waste water management<br>4. Grey water usage |

| | |
|---|---|
| | 5. The usage of grass block, paving block or biopore hole |
| Building | 1. LED lamps on building<br>2. North-South building orientation<br>3. Double-glazed window panel<br>4. Shading on building's exterior<br>5. Mechanical ventilation on the classroom<br>6. Natural air flow to the classroom |
| Waste Management | 1. Waste segregation<br>2. Self-processing waste<br>3. Waste management with third parties<br>4. Processing waste into energy |

The concept of green campus is a crucial matter to be implemented. In long term, it will provide a sense of comfort and it is known significantly to improve the quality of life of its users. Therefore,campus is considered a very suitable place to become a role model for green concept application. This is because campus can act as a representative of sustainable development which can be implemented by other campuses or other buildings within the campus area. The buildings and areas in the campus were measured by the measurements for green buildings and green areas which was established by the GBCIas well as from theprevious studies about green campus. The results of this study showed that there are eight variables that can be used to measure the application of the green concept on the campus, which is compiled into a Green Campus Index model. Those indexes are education, environment and connectivity, transportation, material, energy conservation, water conservation, building, and waste management. In the future, this Green Campus Index can be used as a measurement tool for existing campuses, both in Indonesia and in other countries.

**ACKNOWLEDGEMENT**

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