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Preface

This LNEE volume contains the papers presented at the International Conference on Industrial Engineering, Management Science and Applications (ICIMSA2015) which was held in Tokyo, Japan on May 26-28, 2015.

ICIMSA2015 received over 350 paper submissions from various countries. After a rigorous peer-review process, 114 full-length papers were accepted for presentation at the conference. This is intended for maintaining the high standards of the conference proceedings.

The conference is intended to bring together the researchers and technologists working in different aspects of Industrial Engineering, Management Science and Applications. In addition to the contributed papers, internationally known experts from several countries were invited to deliver Keynote speeches at ICIMSA2015.

Much of the credit of the success of the conference is due to the topic coordinators who have devoted their expertise and experience in promoting and in general coordination of the activities for the organization and operation of the conference. The coordinators of various session topics have devoted a considerable time and energy in soliciting papers from relevant researchers for presentation at the conference. The Session Chairs of the different session played important role in conducting the proceedings of the session in a timely and efficient manner.

On behalf of the Organizing Committee, we would like to thank Springer LNEE for publishing the proceedings of ICIMSA2015. We also would like to express our sincere and grateful thanks to our Program Committee and Reviewers for providing extra help in the review process. The quality of a refereed volume depends mainly on the expertise and dedication of the reviewers.

Our sincere thanks to the Institute of Creative Advanced Technology, Engineering and Science (iCatse) for designing the conference web page and also spending countless days in preparing the final conference program in time for printing. We would also like to thank the ICIMSA2015 Secretariat and Staff for arranging a large number of the

invitation letters and assisting in the various stages of the editorial work. Finally we would like to thank our organization committee for their several months of hard work in sorting out manuscripts from our authors.

We look forward to seeing all of you next year at ICIMSA2016 in Korea.

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Contents

Key Performance Indicators for Sustainable Campus Assessment: A Case of Andalas University

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Abstract. Sustainable campus has became an important issue amongst universities around the world. Universities can generate a significant impacts to environment due to the high usage of energy, extensive transportation, massive waste, high consumption of materials, and extensive development of buildings and facilities. Thus, there is a need to assess the sustainable campus performance. This paper proposes a set of key performance indicators (KPIs) for sustainable campus assessment consisting of six categories divided into a total of 35 indicators. Analytical Hierarchy Process (AHP) method is applied to determine the importance weight of the KPIs. The results indicated the most important category for the sustainable campus assessment is education with an importance weight of 0.2665, while energy and climate change is regarded as the least important category. It is hoped the proposed KPIs can assist the universities to achieve the higher performance in sustainable campus.

Keywords: Analytic hierarchy process, key performance indicators, performance, sustainable campus, university.

1 Introduction

Nowadays, campus sustainability has become an increasingly issue of global concern for university policy makers and planners as a result of the realization of the impacts the activities and operations of universities have on the environment [1]. Like manufacturing, an university can also generate a significant impact to environment. It might becaused of the high usage of energy, extensive transportation, massive waste, high consumption of materials, and extensive development of buildings and facilities [2]. Increasing concerns to sustainability have forced universities to consider sustainability into their strategies and activities.

A sustainable university defined as a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or global level, the minimization of negative environmental, economic, societal, and helth effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewarship in ways to help society make the

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transition to sustainable lifestyle [3]. According to the definition, sustainable campus must address the integration all the three aspects of sustainability of environmental, economic, and social in a better balance. University has several activities and complex operations which potentially generate significant environmental impacts. Sustainability must affects every sphere of a university, from the classrooms and laboratories, to housing, transportation and other services, and to the entire campus [1]. Therefore, assessing the sustainable campus has become a necessity.

In this study, a literature review was carried out in an attempt to identify key performance indicators (KPIs) used to assess the sustainable campus. One of the most commonly used indicators for the sustainable campus assessment is referred to the UI Greenmetric World University Ranking consisting of six categories and a total of 33 indicators [4]. It is a world university ranking for universities to assess and compare campus sustainability efforts [4]. The UI Greenmetric World University Ranking is the first attempt to make a global ranking of universities' sustainable behavior [5]. This paper proposes a set of Key Performance Indicators (KPIs) to assess the sustainable campus. The Analytical Hierarchy Process (AHP) methodology is applied to weighting the KPIs. It is believed that the proposed KPIs can aid universities to improve their sustainable campus performance.

2 Methodology

The methodology has two main stages. First, the key performance indicators (KPIs) for sustainable campus assessment were identified and derived from the literature. The KPIs were then validated to a case of university. Second, the importance weight of the KPIs is determined using Analytic Hierarchy Process (AHP) methodology.

Analytic Hierarchy Process (AHP) first introduced by Thomas L. Saaty in 1971 has become one of the most widely used methods for multiple criteria decision making (MCDM) problems. It is a decision approach designed to aid in making the solution of complex multiple criteria problems to a number of application domains [6]. It has been known as an essential tool for both practitioner and academics to conduct researches in decisions making and examining management theories [7]. AHP as a problem solving method is flexible and systematic that can represent the elements of a complex problem [8].

AHP method has several benefits [7]. First, it helps to decompose an unstructured problem into a rational decision hierarchy. Second, it can elicit more information from the experts or decision makers by employing the pair-wise comparison of individual groups of elements. Third, it sets the computations to assign weights to the elements. Fourth, it uses the consistency measure to validate the consistency of the rating from the experts and decision makers.

3 Identification of KPIs

This study starts with the development of key performance indicators (KPIs) for sustainable campus assessment through the literature review. The KPIs have been mostly adopted from the UI Greenmetric World University Ranking [4]. Besides, the

KPIs were also taken from the Alshuwaikhat and Abubakar's campus sustainability framework [1], sustainable UKM programme's framework [9], University of Nottingham's campus sustainability indicators [10], and University of Connecticut's campus sustainability indicators [11]. All the six categories and 33 of a total 35 indicators of the proposed KPIs are identified and derived from the UI Greenmetric World University Ranking. Another two indicators of category of the energy and climate change were taken from the other literatures. As a result, the KPIs of sustainable campus assessment consist of six categories divided into a total of 35 indicators were identified as shown in Table 1.

Table 1. The KPIs of sustainable campus assessment

Categories	Indicators
1. Setting and Infrastructure	1. Open space area/total area
	2. Open space area/total people
	3. Area on campus covered in forested vegetation
	4. Area on campus covered in planted vegetation
	5. Non-retentive surfaces/total area
	6. Sustainability budget/total university budget
2. Energy and Climate Change	7. Energy efficient appliances usage
	8. Renewable energy usage policy
	9. Total electricity use/total people
	10. Energy conservation program
	11. Green Building
	12. Climate change adaptation and mitigation program
	13. Greenhouse gas emission reduction policy
	14. Smooking area policy on campus
	15. Sustainable food program on campus
3. Waste	16. Recycling program for university waste
	17. Toxic waste recycling
	18. Organic waste teatment (garbage)
	19. Inorganic waste teatment (rubbish)
	20. Sewerage disposal
	21. Policy to reduce the use of paper and plastic on campus
4. Water	22. Water conservation program
	23. Piped water
5. Transportation	24. Total cars entering/total people
	25. Total bicycles/total people
	26. Transportation policy on limiting vehicles on campus
	27. Transportation policy on limiting parking space
	28. Campus buses
	29. Bicycle and pedestrian policy
6. Education	30. Sustainability courses / total courses
	31. Sustainability research funding/total research funding
	32. Sustainability publications
	33. Sustainability events
	34. Sustainability organizations (student)
	35. Sustainability website

The KPIs of sustainable campus assessment are then validated to a case of university located in Padang, West Sumatra, Indonesia. Established in 1956, Andalas University is the oldest university outside of Java Island, and the fourth oldest university in Indonesia. Currently, Andalas University has 15 faculies and about 25,000 students. In 2014, Andalas University has been accredited by National Accreditation Board for Higher Education with rank A (excellent). In term of sustainable campus, Andalas University has placed rank 146th and become ranked 8th of Indonesian universities in UI Greenmetric World University Ranking 2014.

A total of 5 members of green campus team from the university were consulted to validated the KPIs. The experts suggest that all categories and indicators of the KPIs are highly important. Thus, proposed as the KPIs to assess the sustainable campus.

4 Determining the Importance Weight of KPIs

Analytic Hierarchy Process (AHP) methodology was applied to determine the importance weight of the KPIs of sustainable campus assessment. The methodology consists of constructing the hierarchy, conducting the pairwise comparisons, constructing the pairwise comparisons matrix, computing the consistency ratio, and calculating the importance weight. Details are given as follows.

4.1 Constructing the Hierarchy

The proposed key performance indicators (KPIs) for sustainable campus assessment are then used in constructing a hierarchy. The three groups were defined and constructed in the hierarchy including goal, categories, and indicators. In the

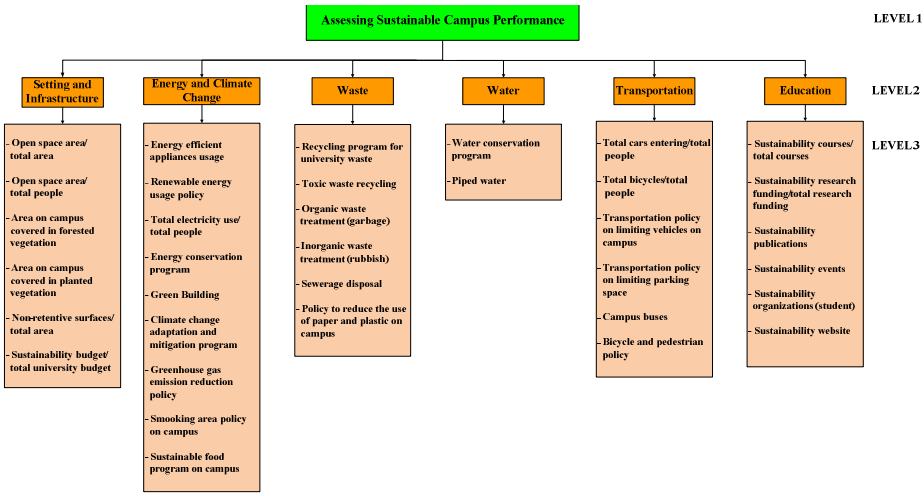

Fig. 1. The hierarchy structure of KPIs

hierarchy, assessing sustainable campus performance is set to be the goal. The next level consists of six categories of setting and infrastructure, energy and climate change, waste, water, transportation, and education. The third level consists of the indicators that described each of categories with a total of 35 indicators. The hierarchy is depicted in Fig. 1.

4.2 Conducting the Pairwise Comparisons

Once the hierarchy has been constructed, the importance weight of the KPIs should be calculated. A pairwise comparison questionnaire was then designed. A total of 30 experts from Andalas University were consulted to give their preferences on the KPIs. Those experts consist of dean and vice dean of each faculty in Andalas University. The pairwise comparisons were determined between categories, and indicators within each category of the KPIs. A Saaty' scale of 1 to 9 (1= equally, 3= moderate, 5= strong, 7= very strong, 9= extreme) was used to reflect these preferences. The consistency ratio (CR) was used to check the consistency of the pairwise comparisons for each expert. The CR values are less than 0.1 which means it matches the consistency test. If it is not yet consistent, the comparison has to be repeated again.

4.3 Constructing the Pairwise Comparisons Matrix

The preferences from the 30 experts were geometrically averaged and the pairwise comparisons matrices were then constructed. For example, the pairwise comparison matrix of the categories of sustainable campus assessment as below:

	Setting & inf *rastructure*	*Energy* & *c*lim*atechange*	*Waste*	*Water*	*Transportation*	*Education*
Setting & inf *rastructure*	1	1.196	0.708	0.716	0.746	0.472
Energy & *c*lim*atechange*	0.836	1	0.687	0.519	1.041	0.473
Waste	1.412	1.456	1	0.825	1.198	0.581
Water	1.397	1.928	1.212	1	1.775	0.689
Transportation	1.340	0.961	0.835	0.563	1	0.497
Education	2.121	2.113	1.720	1.452	2.010	1

All the diagonal elements of the matrix are equal to 1 as the elements are compared with themselves. The values of elements in the upper triangular matrix are obtained from the averaged preferences of pairwise comparisons and the reciprocals of these values are presented in the lower triangular matrix.

4.4 Computing the Consistency Ratio

The consistency ratio (CR) is used to check the consistency of pairwise comparisons and a value of less than 0.1 is acceptable [8]. The consistency test was performed to all the combined pairwise comparison matrixes. The results show that the consistency ratio (CR) values ranged from 0.0000 to 0.0081, which means that all the pairwise comparisons are consistent since the values are within the acceptable level recommended by Saaty [8]. It indicates that the experts have assigned their preferences consistently in determining the importance weights of the KPIs to assess sustainable campus performance.

4.5 Calculating the Importance Weight

The importance weight of KPIs are then calculated using the Expert Choice software. Table 2 presents a summary of the results of the importance weights of the KPIs of sustainable campus assessment. The importance weights show the importance value of one indicator over other indicators. In term of categories, education is the highest importance weight with a value of 0.2665. It is not suprisingly since the main function of an university in education field. Universities have responsibility in sustainable development to promote the sustainability culture to its students, staff, and community [2]. It followed by water with an importance weight of 0.2005. Clean water has become one of the main problems faced by any people in any place of the world. Universities with a high number students, staffs, and communities should be consider the need of clean water for their activities.

Table 2. The importance weights of KPIs

Categories	Weight	Indicators	Weight
1. Setting and Infrastructure	0.1234	1. Open space area/total area	0.0150
		2. Open space area/total people	0.0134
		3. Area on campus covered in forested vegetation	0.0237
		4. Area on campus covered in planted vegetation	0.0170
		5. Non-retentive surfaces/total area	0.0145
		6. Sustainability budget/total university budget	0.0392
2. Energy and Climate Change	0.1156	7. Energy efficient appliances usage	0.0145
		8. Renewable energy usage policy	0.0174
		9. Total electricity use/total people	0.0084
		10. Energy conservation program	0.0172
		11. Green Building	0.0157
		12. Climate change adaptation and mitigation program	0.0121
		13. Greenhouse gas emission reduction policy	0.0131
		14. Smooking area policy on campus	0.0081
		15. Sustainable food program on campus	0.0096
3. Waste	0.1630	16. Recycling program for university waste	0.0398
		17. Toxic waste recycling	0.0191
		18. Organic waste teatment (garbage)	0.0306
		19. Inorganic waste teatment (rubbish)	0.0284
		20. Sewerage disposal	0.0202
		21. Policy to reduce the use of paper and plastic on campus	0.0248
4. Water	0.2005	22. Water conservation program	0.1490
		23. Piped water	0.0510
5. Transportation	0.1309	24. Total cars entering/total people	0.0151
		25. Total bicycles/total people	0.0106
		26. Transportation policy on limiting vehicles on campus	0.0248
		27. Transportation policy on limiting parking space	0.0206
		28. Campus buses	0.0376
		29. Bicycle and pedestrian policy	0.0224
6. Education	0.2665	30. Sustainability courses / total courses	0.0299
		31. Sustainability research funding/total research funding	0.0272
		32. Sustainability publications	0.0510
		33. Sustainability events	0.0513
		34. Sustainability organizations (student)	0.0654
		35. Sustainability website	0.0422

The third category is waste with an importance value of 0.1630. This category is most related to environmental. As mention earlier, universities generate massive waste as a result of their activities and operations. Waste management is needed to solve this problem and to promote sustainability in campus environment. The next categories are transportation with a value of 0.1309, setting and infrastructure (0.1234), and energy and climate change (0.1156).

In term of indicators, water conservation program (0.1490) is regarded to the most important indicator. This indicator is of water category which suggested as the second highest important category. It followed by sustainability organizations (students) with an importance value of 0.0654, sustainability events (0.0513), piped water (0.0510), and sustainability publications (0.0510). Those indicators are categorized in education, and water category of the KPIs. Of all the indicators of KPIs of sustainable campus assessment, smoking area policy on campus with an importance weight of 0.0081 is suggested as the least important indicators.

5 Conclusions

An university can generate a significant environmental impacts due to the high usage of energy, extensive transportation, massive waste, high consumption of materials, and extensive development of buildings and facilities. Thus, it is essential to assess the sustainable campus performance. This paper has developed a set of Key Performance Indicators (KPIs) for sustainable campus assessment. The KPIs are identified and derived from the literature and then validated to a case of university. Based on the results, six categories divided into a total of 35 indicators are proposed as the KPIs of sustainable campus assessment. The importance weight of the KPIs then determined using Analytic Hierarchy Process (AHP) methodology. First, the hierarchy structure is established based on the proposed KPIs of sustainable campus assessment. Next, the pairwise comparisons conducted to the policy makers from the case of university using Saaty's scale of 1-9. The pairwise comparisons matrix are then contructed and the consistency ratio (CR) is computed. Finally, the importance weights of the KPIs is calculated.

The results show the importance value of one indicator over other indicators. Category of education is regarded as the most important category of the KPIs, followed by water, and waste. In term of indicators, water conservation program is suggested to the highest important indicator, followed by sustainability organizations (students), sustainability events, piped water, and sustainability publications. It is hoped the KPIs can aid the policy makers and planners of university to achieve a higher performance in the context of sustainable campus. Future research will focus on developing a tool to assess sustainable campus performance.

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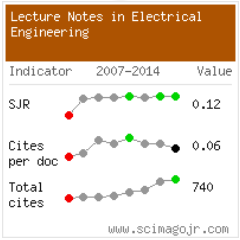

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The SJR indicator measures the scientific influence of the average article in a journal, it expresses how central to the global scientific discussion an average article of the journal is. Cites per Doc. (2y) measures the scientific impact of an average article published in the journal, it is computed using the same formula that journal impact factor ™ (Thomson Reuters).

Citation vs. Self-Citation

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Evolution of the total number of citations and journal's self-citations received by a journal's published documents during the three previous years.

Cites per Document vs. External Cites per Document

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Evolution of the number of total cites per document and external cites per document (i.e. journal self-citations removed) received by a journal's published documents during the three previous years.

Cites per Document in 2, 3 and 4 years windows

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Evolution of Citations per Document to a journal's published documents during the two, three and four previous years. The two years line is equivalent to journal impact factor ™ (Thomson Reuters) metric.

International Collaboration

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International Collaboration accounts for the articles that have been produced by researchers from several countries. The chart shows the ratio of a journal's documents signed by researchers from more than one country.

Journal's Citable vs. Non Citable Documents

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Not every article in a journal is considered primary research and therefore "citable", this chart shows the ratio of a journal's articles including substantial research (research articles, conference papers and reviews) in three year windows.

Journal's Cited vs. Uncited Documents

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Ratio of a journal's items, grouped in three years windows, that have been cited at least once vs. those not cited during the following year.

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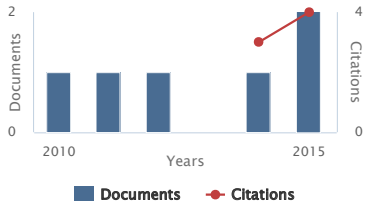

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