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Environmental sustainability of universities: critical analysis of a green ranking

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Abstract

Today, the principles of sustainability and sustainable development represent key points in policy development and activities of the Higher Education Institutions, both for their impact on the environment and the role they play in society. In the wake of the spread of rankings in Higher Education Institutions over the past decades, Universitas Indonesia in 2010 implemented an environmental sustainability ranking, called UI GreenMetric World University Ranking. The aim of this paper is to carry out a constructive analysis of the GreenMetric Ranking in order to improve and strengthen the ranking method. This analysis is based on the review of the scarce literature, the survey of questionnaire and on an evaluation of the guidelines that have been evolving over time. Despite the improvements made over time by the authors, the critical review of the methodology points out that the GreenMetric Ranking still falls short on some issues. Furthermore, the analysis shows the incomplete compliance with the Berlin Principles. The GreenMetric Ranking though, lays a good foundation for the incorporation of the principle of sustainability within the Higher Education Institutions and reflects the need to quantify the efforts towards sustainability. Therefore, there is the need to make this method more scientific and rigorous, suitable to plan sustainability policies in universities.

1. Introduction

The attention to Sustainability in Higher Education (SHE) has its origins in the late nineteenth century, starting from the Stockholm Declaration of 1972 [1]. In 1990, more than 350 universities signed the Talloires Declaration,

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which consists in a "ten-point action plan for incorporating sustainability and environmental literacy in teaching, research, operations and outreach at colleges and universities" [2]. During the last half century, more than 30 SHE declarations have been signed by more than 1400 universities worldwide, fostering the incorporation of the principles of sustainability into education and research policies [3]. However, the signing of sustainability statements does not always translate into the implementation of these principles [4]; SHE declarations confirm the central role of universities in relation to sustainability and represent a serious commitment towards the incorporation of the sustainability principles into their systems and policies.

The concepts of sustainability and sustainable development have been addressed by many authors in different sectors [5-10]. One of the most recognized definition of sustainable development is given in the Brundtland Report which defines it as "development that meets the needs of the present without compromising the ability of future generations to meet their own need" [11].

The concept of sustainability is historically based on the triple-bottom-line theory: the three spheres - social, economic and environmental - have the same importance and they are strongly interconnected. Development must ensure the integration among economy, society and environment to be considered sustainable, achieving balance between them. A similar model is also used for sustainable universities [12].

The rankings have spread widely in HEIs over the past decades, becoming a global phenomenon [13-15]. Most of these rankings evaluate research, academic reputation and quality of education. The UI GreenMetric World University Ranking mostly use environmental indicators instead of research and educational ones [16]. It can be seen as an environmental sustainability ranking. Grindsted [3] affirms that UI Green Metric Ranking (UI-GMR) is the first attempt to make a global ranking of universities' sustainable behavior. Universitas Indonesia (UI), the university that developed this ranking, has included a single tool to assess the level of sustainability in HEIs.

The aim of this paper is to confirm the importance of sustainability in HEIs and to carry out a constructive analysis of UI-GMR. The article proposes some possible changes that would improve and strengthen the ranking method, in the light of awareness of UI-GMR team of possible lacks and imperfections of its method [17]. This analysis proposes a constructive criticism that has to be read in a positive way, it aims at improving a tool that can be very useful in the assessment of the level of sustainability of a university.

2. Sustainability in Higher Education Institution

The need to consider sustainability in academic institutions is twofold. Firstly, universities can be considered as "small cities" which may have heavy impacts on the environment due to their activities, movement of goods and persons inside campuses [18]. Universities can be seen as complex buildings, in terms of waste generation, transportation, water and materials consumption, energy and electricity consumption, given the scientific, social and educational activities that take place within their boundaries [18]. According to this view, it is no longer possible to ignore campuses' externalities on environmental quality and integrity.

Secondly, HEIs play a fundamental role in society, in the formation of future generations and in the preparation of future professionals, with a view to transition toward sustainability [19,20]. The role of education for sustainable development is now universally recognized, also thanks to the European Union Sustainable Development Strategy and the United Nations Millennium Development Goals which have put universities forward as the most suitable disseminators of sustainability principles [21]. Therefore, HEIs have the duty to adopt and promote the principles of sustainability.

There are several definitions of sustainable universities. Velazquez et al. [22] define a sustainable university as ''a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles''. According to Alshuwaikhat and Abubakar [18] "a sustainable university campus should be a healthy campus environment, with a prosperous economy through energy and resource conservation, waste reduction and an efficient environmental management, and promotes equity and social justice in its affairs and export these values at community, national and global levels". Both of these definitions refer to the triple-bottom-line theory of sustainability, according to which a sustainable institution has to safeguard the environment, ensure social justice and support economic growth simultaneously.

3. The UI GreenMetric World University Ranking

The UI-GMR is a useful tool to assess the sustainability of universities. Its aim is to assess policies and activities within green campuses so as to promote a sustainability culture in HEIs. This ranking is suitable for universities in both developed and developing countries and it's therefore considered a global ranking [16]. The ranking is also considered the most important global sustainability ranking for universities [23].

The UI-GMR has been developed and updated by Universitas Indonesia since 2010. The participation to this ranking has increased progressively over the years; more than 400 universities took part in the 2015 Ranking, from 65 countries in the world [23].

The ranking is compiled with data reported by universities that fill in an online questionnaire. The structure of the method is divided into several categories that represent the main environmental aspects. Several indicators are provided for each category and a specific score is assigned to each indicator. The final score is the sum of the scores achieved for each indicator.

The ranking has changed several times over the years, both in the division into categories and in the choice of indicators. There are six main categories in the last questionnaires: *Setting and Infrastructure, Energy and Climate Change, Waste, Water, Transportation and Education*. The available score totals 10'000 points. A total of 39 indicators are used in 2015 and 38 in 2016.

The UI-GMR allows to quantify the level of sustainability of universities and is a simple tool for self-assessment of campus sustainability efforts [23]. The participation in the questionnaire has benefits for Green Campus Universities: the stakeholders of these universities are more satisfied and have significantly better perceived quality of life, compared to stakeholders from Non-Green Campus Universities [24].

4. Methodology and approach

The analysis highlights the presence of some lacks and critical issues in the UI-GMR methodology and suggests some improvements and changes. This analysis is based on the review of the scarce literature, the survey of questionnaire and on an evaluation of the guidelines that have been evolving over time.

The method is studied so as to assess the conformity of UI-GMR to the Berlin Principles. The Berlin Principles provide quality and good practices in HEI rankings [25] and therefore the questionnaire developed by UI should be aligned to these principles.

Furthermore, the paper investigates the evolution of the method from 2011 until today, with the purpose of evaluating differences in categories and indicators. The paper provides a constructive criticism of UI-GMR, based on the comparison between guidelines of the years 2014, 2015 and 2016 and rankings of the years 2014 and 2015, which are available online.

5. Results and discussion

5.1 Critical review of UI-GMR methodology

The critical review of the methodology has led to the identification of some lacks and critical issues that characterize the ranking. Solutions or changes are proposed for each controversial aspect in order to improve and strengthen the ranking method.

- *The lack of a threshold:* the method should provide a threshold below which a university can not enter the ranking as it doesn't achieve a minimum level of sustainability. According to this criterion only the universities that guarantee a minimal attention to the environment could participate in the ranking. In this way the participation to UI-GMR would already be a certificate of sustainability. In addition, the authors of UI should set minimum thresholds for sections and individual questions. The choice of some options should result in the exclusion from the ranking or at least a penalty / reporting in the final ranking. An example is the management of inorganic waste, for which there is the option to burn such waste outdoors. This practice, even if not expressly prohibited by law, should still be banned from universities who declare themselves sustainable. In the absence of

this type of filter, a university can occupy a good position in the ranking by virtue of other good environmental practices, while declaring to burn outdoors inorganic waste.

- *The lack of scoring bands :* currently the method assigns a score based on the environmental performance of the universities and processes the annual ranking on the basis of scores achieved by the participants. The position in the league table though does not provide information about the level of sustainability achieved by a university. Moreover, the introduction of scoring bands would allow expressing an opinion on the degree of sustainability and would make the reading of the ranking easier and more immediate. Bands could provide for example the following sets of qualitative judgments of sustainability: insufficient, sufficient, good, excellent. Each strip should match a certain scoring range, according to which the 10,000 points available would be subdivided. The presence of bands would allow assessing the level of sustainability demonstrated by each university in a clearer and more intuitive way, without the need to compare the score and the ranking obtained by other participants. The choice of these bands and the corresponding scores presents problems of subjectivity; however, the method is already characterized by many subjective aspects, such as the choice of the maximum available score or the score assigned to each indicator and each category. We propose an incorporation of the scoring bands in the existing structure of the UI-GMR.

- *Relativity of score:* the score presents an aspect of relativity because part of it depends on the data provided by the participating universities. As outlined in the guidelines of the questionnaire 2016: "The score of these categories and/or indicators is based in the minimum and maximum numbers from participants. Hence, the score of these categories and/or indicators can only be calculated after all participants have submitted their data" [23]. In reference to the 2016 Questionnaire, a maximum of 1500 points can be assigned to the section Setting and Infrastructure, 600 to Energy and Climate Change (two indicators), 600 to Transportation (three indicators) and 1800 to Education. Depending on the participating universities performance, a maximum of 4500 points can be assigned, i.e. 45% of the total available score. The relativity of the score (45% of the total) makes the ranking of a participating university in consecutive years highly unstable. In fact, while maintaining unchanged its performance (thus communicating the same data for the same questionnaire) a university may be subjected to a change in ranking, in a negative or positive way, according to the improvement or worsening of the other participating universities. However, strictly speaking, if a university does not change its environmental performance, its level of sustainability should not change either. This issue of UI-GMR is quite disputable and problematic. A possible solution to this problem, at least a partial one, is represented by the creation of scoring bands. The change in score due to performance changes of other universities should allow to maintain the same score band to a university that confirms its environmental performance. This situation occurs especially in case of small changes of score. As we can appreciate from the following case, the permanence within the same band is not always guaranteed: score close to the boundary limit (lower or higher) of each band; large variation in score. Therefore, the introduction of scoring bands doesn't completely solve the problem of relativity score. The best solution is represented by a method of scoring which is completely objective and transparent. This methodology is already used for the assessment of most of the questions which account for 55% of the total score in the 2016 Questionnaire. Authors should make an extra effort to make the assignment of the score independent from the environmental performance of all participants.

- *High sensitivity of the ranking:* the method is too sensitive to changes in rating and ranking. The score difference between consecutive positions is very low in relation to the total available score. The study of the 2015 Ranking shows that in more than half of the cases the score difference between two universities is less than 10 points, which represent only 0.1% of the total score (see Figure 1) [27]. The average score difference is 14.3 points. The ranking is very short and small score variations can determine a big position jump. The high sensitivity of the method makes the result obtained from a university in consecutive years uncertain. The high sensitivity of the ranking makes it difficult to interpret the result, the communication to the public, the sustainability policy planning. The comparison between the 2014 and the 2015 Rankings (the only one available online) offers significant food for thought (see Figure 2) [27, 28]. It is evident that there is a general worsening of the performance of the participating universities: 90.2% of the universities received a lower score in 2015 compared to 2014. A university could achieve the same position in the 2015 ranking scoring an average of 583 points less than the previous year (or 625 points if only the first 200 positions are considered). There are cases where despite

a lower score a university has improved its ranking. In about a quarter of the cases, universities received a lower score but gained a better position.
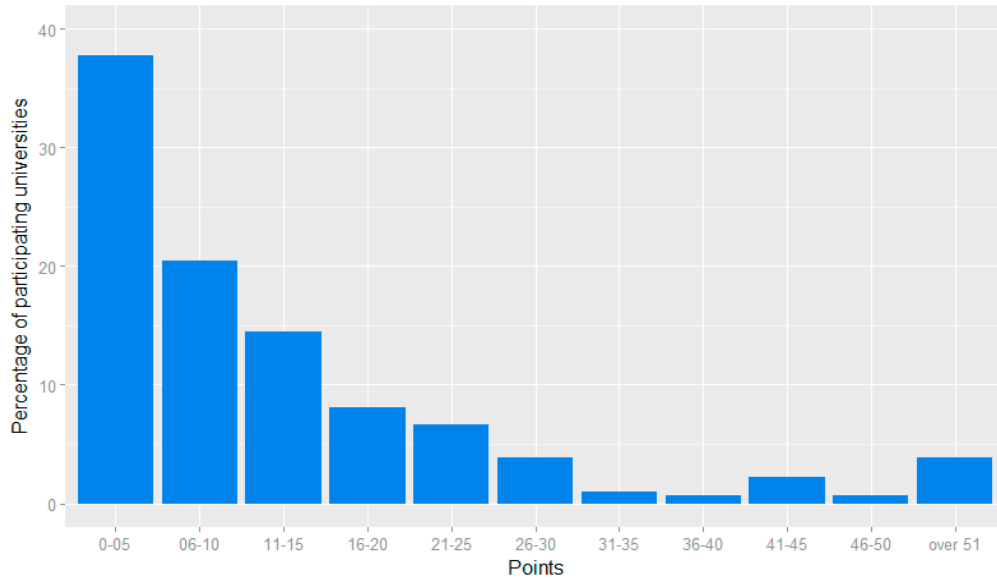

Fig. 1 Score difference between consecutive positions in the 2015

Fig. 2 Comparison between the 2014 and the 2015 Rankings

- *Incompleteness of the ranking:* the UI-GMR is based on the sustainability concept of three pillars, i.e. environmental, economic and social [16,23]. However, this tool is not comprehensive according to the analysis conducted by Bullock and Wilder for existing higher education sustainability assessment framework on the basis of Lozano's Global Reporting Initiative for Higher Education (GRI-HE) framework [19]. The GRI-HE analysis showed the lack of completeness of the indicators and criteria used, especially for what concerns the social and

economic aspects; the ranking also appears biased towards the environmental aspect. According to these authors, the UI-GMR does not provide fully accurate assessments of the sustainability performance of HEIs and fail to cover several categories of environmental criteria [28].

5.2 Berlin Principles

The Berlin Principles on Ranking of Higher Education Institution were declared during a meeting in Berlin in 2006 by the International Ranking Expert Group, founded by the UNESCO European Centre for Higher Education. The goal was to establish a set of principles of quality and good practice in HEI rankings, which were becoming a global phenomenon [25]. This article compares the UI-GMR and the sixteen Berlin Principles.

Suwartha and Sari [16] affirmed that the methodology used in the UI-GMR of the year 2011 followed the Berlin Principles. Most of the indicators were already consistent with the Berlin Principles. There are some doubts about the conformity of the UI-GMR to principles n. 5, 6, 9.

- *The fifth principle* recommends to specify the linguistic, cultural, economic and historical contexts of the educational systems being ranked, especially for international rankings. The UI-GMR is claimed to be a global method, suitable for universities in both developed and developing countries [16]. There are objective difficulties in using the questionnaire internationally because of the legal, cultural and social, geographical and territorial, technical and educational differences. The areas in which the biggest differences emerge are: geography and climate, urban and country setting, the development status of the country, regional and local characteristics, the university's size and the type of mission [17]. The most controversial questions concern waste management, wastewater and drinking water management, where main discrepancies arise between countries with different development. The introduction of a minimum threshold would be desirable in order to use the same method for assessing sustainability in such different contexts, preventing however participation to universities that do not meet minimum sustainability standards.

- *The sixth principle* refers to the transparency of the methodology used for creating the ranking, which include the calculation of indicators [25]. The authors of the UI-GMR have never disclosed in the past years the calculation method of each indicator and the rules for assigning scores. The 2016 Guidelines only contain details of the scoring in appendix, where the instructions for assigning the score according to the answer are explained for each indicator [23]. The scoring rules are explained for indicators that can be calculated independently by the participating universities. In the other cases, the method is not transparent enough. The score of these indicators is based on the minimum and maximum numbers communicated from participants, but the calculation of the indicator is not explained in detail.

- *The ninth principle* invites to limit changes to indicators, which "make difficult for customer to discern whether an institution's or program's status changed in the rankings due to an inherent difference or due to a methodological change" [25]. The continuous change of UI-GMR, especially in the selection of indicators and in their score, contrasts with this principle.

The update of the questionnaire makes comparability difficult. The revision of the questionnaire is a laudable operation as it aims to improve the ranking system, overcoming criticisms and shortcomings of the method. However, the change of questionnaire and indicators results in a change of score, which makes comparison difficult both between universities and consecutive years for the same university.

The authors of UI-GMR have changed several times their method from 2011 to date [23,24, 26-33]. Categories have remained the same since 2012, when the section of Education was added (see Figure 3). The situation remained stable until 2014. In 2015 there was an increase in the number of both indicators and questions, confirmed also for the year 2016. In particular, the number of questions and the number of indicators has increased. This means that the questionnaire has become more complicated, thorough, detailed, allowing to collect more information, which are not always used for the calculation of the indicators.
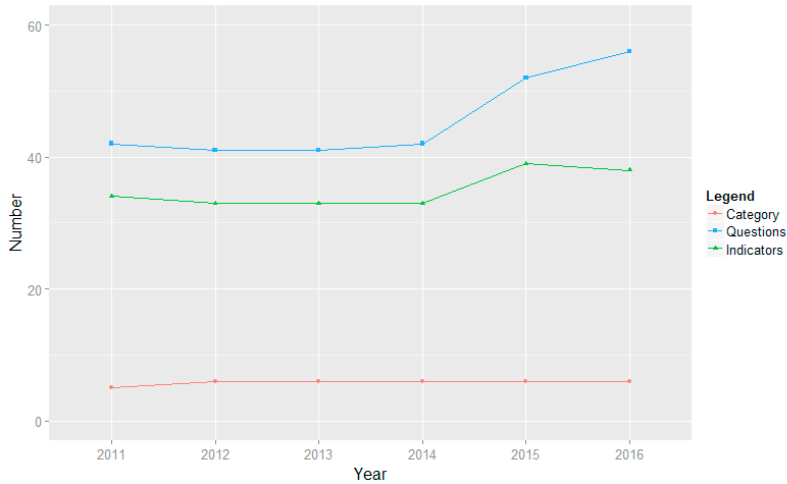
Fig. 3 Change in UI_GMR in 2011-2016

The change in the number of indicators for each category provides information on the level of detail assigned to each environmental issue (see Figure 4). The 2011 Questionnaire is neglected, considered an "adjustment" of the ranking method with the lack of the category Education, added only in 2012. The situation remained stable from 2012 until 2014. The authors have introduced the most significant changes in 2015 and 2016 [23, 33]. The number of indicators of the category Energy and Climate Change increased in 2015 and then decreased again in 2016. The transport sector has become gradually more important, as well as the water issue.

The method has undergone major changes in 2015, although it was already the fifth edition. For this reason, the modification of the methodology has been studied more in detail between 2014 and 2015 and between 2015 and 2016. The indicators used and the corresponding score have been modified between 2014 and 2015 in the following categories: Energy and Climate Change (EC), Water (WR), Transportation (TR) (see Table 1) [32,33]. The changes are significant, especially for water-section, for which two new indicators were inserted in 2015 and there has been a consequent redistribution of the points. The category Education highlights a lack of proportion and consistency in the allocation of weights: indicators, which in 2014 had the same score, had a different reduction in 2015.
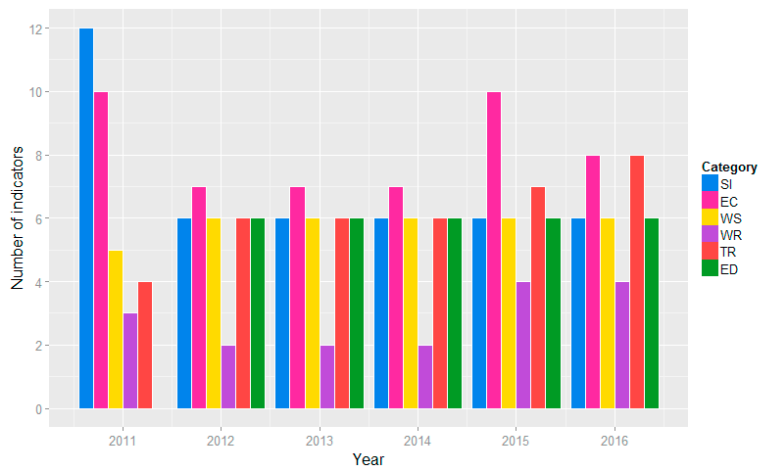

Fig. 4 Change in UI_GMR in 2011-2016 in each category

Table 1. Change in UI_GMR indicators in 2014 and 2015

	Indicator *	Points in 2014	Points in 2015	Variation points 2014-2015
EC	Smart building program implementation	0	100	+ 100
	The ratio of total electricity usage towards campus population	300	200	-100
	Greenhouse gas emission reduction policy	300	100	-200
	Carbon footprint policy	0	100	+ 100
	The ratio of total carbon footprint towards campus open space and population	0	200	+ 100
	Total	600 points	700 points	600 points **
	The ratio of the score of modified indicators toward the total of the category	**29 %**	**39%**	**29%**
WR	Water conservation program	500	300	- 200
	Water recycling program	0	300	+ 300
	The use of water efficient appliances	0	200	+ 200
	Treated water consumed	500	200	- 300
	Total WR	1000 points	1000 points	1000 points **
	The ratio of the score of modified indicators toward the total of the category WR	**100%**	**100%**	**100%**
TR	The ratio of campus bus service towards campus population	0	200	+ 200
	Transportation policy on limiting vehicles on campus	400	300	- 100
	Transportation policy limiting parking space on campus	400	300	- 100
	Total TR	800 points	800 points	400 points **
	The ratio of the score of modified indicators toward the total of the category TR	**44%**	**44%**	**22%**

* Terminology used in 2015 Ranking
** Variations points in absolute value between 2014 and 2015

Changes between 2015 and 2016 cover only the categories Energy and Climate Change (EC) and Transportation (TR) (see Table 2). The category Education highlights the disappearance of important indicators, for a total of 700 points, which can lead to a significant worsening for those universities who obtained good scores in these aspects the past year.

Table 2. Change in UI_GMR indicators in 2015 and 2016

	Indicator *	Points in 2015	Points in 2016	Variation points 2015-2016
EC	Smart building implementation	100	300	+ 200
	The ratio of total electricity usage toward campus population	200	300	+ 100
	The ratio of renewable energy produce toward energy usage	0	200	+ 200
	Greenhouse gas emission reduction program	100	200	+ 100
	Carbon footprint policy	100	0	- 100
	The ratio of total carbon footprint toward campus population	200	300	+ 100
WR	Energy conservation program	300	0	- 300

	Climate change adaptation and mitigation program	300	0	- 300
	Total EC	1300 points	1300 points	1400 points **
	The ratio of the score of modified indicators toward the total of the category EC	**62 %**	**62%**	**67%**
TR	Parking area type	0	200	+ 200
	Initiative to decrease private vehicles on campus	300	200	- 100
TR	Parking area reduction for private vehicles within 3 years	300	200	- 100
	Total TR	600 points	600 points	400 points **
	The ratio of the score of modified indicators toward the total of the category TR	**33 %**	**33%**	**22%**

* Terminology used in 2016 Ranking, except for deleted indicators
** Variations points in absolute value between 2015 and 2016

6. Conclusions

The UI-GMR can be a useful tool to assess sustainability in HEIs and it's recognized as "the first and only world university ranking on sustainability" [23]. The UI-GMR can be a standard guideline for constructing a green university and help universities to green their activities and policies [16].

This tool however has some lacks and critical issues, despite the efforts made by the authors and the improvements made over time. Some problems are common to the rankings themselves and their solution is not so simple and straightforward, as for example the choice of indicators and their weights. Other aspects could instead be improved through some modifications of the method, as for example the introduction of thresholds or scoring bands.

The updating of the questionnaire makes it difficult to adopt this tool in planning the strategic choices in HEIs in the long term, as advocated by the authors.

The UI-GMR lays a good foundation to incorporate the principle of sustainability within the HEIs and to implement a technical tool to quantify the efforts made in this direction. However, the method should become more stable, transparent and objective.

This paper emphasizes the strong potential of the ranking, demonstrated also by the broad participation of universities from around the world.

To end with, we believe that there is still the need to make this method more scientific and rigorous, suitable to plan sustainability policies in universities.

References

[1] UNESCO. The Stockholm Declaration, 1972. http://www.unep.org/documents.multilingual/default.asp?documentid=97&articleid=1503
[2] ULSF. The Taillores Declaration, 1990. http://www.ulsf.org/programs_talloires.html
[3] Grindsted TS, Sustainable universities - from declarations on sustainability in higher education to national law. Environ Econ 2011, 2: 29-36.
[4] Bekessy S, Samson K, Clarkson R, The failure of non-binding declarations to achieve university sustainability – a need for accountability. Int. J. Sust. High. Educ. 2007, 8, 301-316
[5] Belu R, Chiou R, Tseng T.L, Cioca L, Advancing sustainable engineering practice through education and undergraduate research projects, ASME 2014 International Mechanical Engineering Congress and Exposition, 14 - 20 November 2014, Montreal, Canada, Volume 5: Education and Globalization, ISBN: 978-0-7918-4950-7
[6] Ivascu AL, Cioca LI, From theory to practice: Evolution of sustainable development in organizations, IBIMA 2015- 25th International Business Information Management Association Conference - Innovation Vision 2020: From Regional Development Sustainability to Global Economic Growth, 7-8 May 2015, Amsterdam, Netherlands, 725-733.
[7] Biasutti M, Frate S, A validity and reliability study of the Attitudes toward Sustainable Development scale, Environ Educ Res 2017, 23(2): 214-230.

[8]   Holdsworth S, Thomas IA, Sustainability education academic development framework (SEAD), Environ Educ Research 2016, 22 (8): 1073-1097.
[9]   Cioca LI, Ivascu L, Rada EC, Torretta V, Ionescu G, Sustainable development and technological impact on CO_2 reducing conditions in Romania, Sustainability 2015, 7(2): 1637-1650
[10] Scott R, Education for sustainability through a photography competition, Sustainability 2015, 6(2): 474-486
[11] World Commission on Environment and Development. Our common future – Brundtland report. Oxford University Press, 1987.
[12] Lukman R, Kranjc D, Glavic P, University ranking using research, educational and environmental indicators. J Clean Prod 2010, 18: 619-628.
[13] Moed HFA, critical comparative analysis of five world university rankings, Scientometrics 2016,1-24
[14] Yudkevich M, Altbach PG, Rumbley LE, Global university rankings: The "Olympic Games" of higher education? Prospects 2015, 45(4): 411-419.
[15] Jajo NK, Harrison J, World university ranking systems: an alternative approach using partial least squares path modelling, J Higher Educ Policy Manag 2014, 36(5): 471-482.
[16] Suwartha N, Sari RF, Evaluating UI GreenMetric as a tool to support green universities development: assessment of the year 2011 ranking. J Clean Prod 2013, 61: 46-53.
[17] Lauder A, Sari RF, Suwartha, N., Tjahjono, G. Critical review of a global campus sustainability ranking: GreenMetric. J Clean Prod 2015, 108: 852-863.
[18] Alshuwaikhat HM, Abubakar I, An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. J Clean Prod 2008, 16: 1777-1785.
[19] Corcoran PB, Wals AEJ, The problematics of sustainability in higher education: an introduction. In Higher Education and the Challenge of Sustainability: Problematics, Promise, and Practice; Corcoran, P.B., Wals, A.E.J., Eds.; Kluwer Academic Publishers: Dordrecht, The Netherlands, 2004, 3-6.
[20] Disterheft A, Caeiro S, Azeiteiro UM, Leal Filho W, Sustainability science and education for sustainable development in universities: a way for transition. In Sustainability Assessment Tools in Higher Education Institutions: Mapping Trends and Good Practices Around the World; Caeiro, S., Filho, W.L., Jabbour, C., Azeiteiro, U.M., Eds.; Springer International Publishing: Switzerland, 2013, 3-28.
[21] Lukman R, Glavič P, What are the key elements of a sustainable university? Clean Techn Environ, Policy 2007, 9: 103-114
[22] Velazquez L, Munguia N, Platt A, Taddei J, Sustainable university: what can be the matter? J Clean Prod 2006, 14: 810-819.
[23] Guideline of UI GreenMetric World University Ranking 2016. Universitas Indonesia. Available online: http://greenmetric.ui.ac.id/wp-content/uploads/2015/07/UI_Greenmetric_Guideline_2016_V12.pdf.
[24] Tiyarattanachai R, Hollmann NM, Green Campus initiative and its impacts on quality of life of stakeholders in Green and Non-Green Campus universities. Springerplus, 2016, 5-84.
[25] UNESCO-CEPES. Berlin Principles on Ranking of Higher Education Institutions. 2006. Available online: www.che.de/downloads/Berlin_Principles_IREG_534.pdf.
[26] Overall Ranking 2015 of UI GreenMetric World University Ranking . Available onlinr: http://greenmetric.ui.ac.id/overall-ranking-2015/
[27] Overall Ranking 2014 of UI GreenMetric World University Ranking . Available onlinr: http://greenmetric.ui.ac.id/overall-ranking/
[28] Bullock G, Wilder N, The comprehensiveness of competing higher education sustainability assessments. Int J Sust High Educ 2015, 17: 282-304.
[29] Guideline of UI GreenMetric World University Ranking 2011. Universitas Indonesia. Available online: http://greenmetric.ui.ac.id/web/upload/_pdf/Guideline2011GREENMETRIC%20WORLD%20UNIVERSITY%20RANKING%20Revisi%201.5%2010092011.pdf
[30] Guideline of UI GreenMetric World University Ranking 2012. Universitas Indonesia. Available online: http://greenmetric.ui.ac.id/web/upload/_pdf/Guideline2012_GREENMETRIC%20WORLD%20UNIVERSITY%20RANKING_Revised%201.8_02072012.pdf
[31] Guideline of UI GreenMetric World University Ranking 2013. Universitas Indonesia. Available online: http://greenmetric.ui.ac.id/web/upload/_pdf/Guideline2013_GREENMETRIC%20WORLD%20UNIVERSITY%20RANKING_1.2_23052013.pdf
[32] Guideline of UI GreenMetric World University Ranking 2014. Universitas Indonesia. Available online: http://greenmetric.ui.ac.id/web/upload/_pdf/Guideline2014_GREENMETRIC%20WORLD%20UNIVERSITY%20RANKING_1.4_17062014_2.pdf
[33] Guideline of UI GreenMetric World University Ranking 2015. Universitas Indonesia. Available online: http://greenmetric.ui.ac.id/web/upload/_pdf/UI_Greenmetric_Guideline_2015%20.pdf