Providing Solutions to Improve Environmental Performance of Universities Based on GreenMetric System

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ABSTRACT

Today, the focus on the sustainability issue in universities has become of significance considering the climatic and environmental issues. Therefore, universities are moving toward uniting the sustainability methods in their systems. Currently, many universities in Iran are performing essential activities in relation to environmental issues. This study is to determine the share of universities in sustainability quantitatively, and then it analyzes their activities. This research evaluates their activities in two steps based on the clustering and the efficiency of their performance. In the first step, the universities are grouped into homogenous clusters based on hierarchical clustering method with regards to their activities in sustainability area. Following that, the Comparative Table is used to calculate the gained percentage in each index based on the mean of the scores of each group using the data of the year 2021. This is done to have a better understanding of the performance of each cluster and the universities priorities for becoming greener and more successful in green-metric system. By evaluating the productivity and the efficiency of the universities, this study represents the most sustainable universities in group one (as the highly sustainable) and group two (as moderately sustainable) which have achieved the maximum grade in energy, transportation, research and instructive areas. These results also show that environmental variables (including water management, waste and infrastructure management) need to be taken into account by universities.

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INTRODUCTION

The term "green" has been introduced in various fields such as agriculture, energy, production, technology, etc., even in a wider context; it is also used as "green economy". The spread and expansion of this term in higher education goes back to the early 90s with the introduction of the concept of "greening of universities" and at the beginning of the 2000s, especially after 2010, this term has been changed to refer to more specific concepts such as "green university", "green campus", even it refers to "green curriculum" [1].

Today, energy conservation is an important international issue, leading architects to environmentally sustainable projects [2]. Universities and campuses have been conceptualized as "small cities" to achieve sustainability due to their area and the impact their activities have on the environment and society [3].

Universities are neutral and reliable stakeholders in the community. Therefore, universities have the capacity and responsibility to guide sustainable development goals at the local, national, and international levels through dialogue and participation [4].

As a result of an increase in sustainability and environmental concerns, universities are now not only through research, but also through improving their campus infrastructure in an environmentally friendly environment as well as updating their curricula covering sustainable environmental education from the environmental sustainability sector.

The role of university in promoting sustainable development is widely recognized, and the university

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campus is considered an ideal environment for exploring and practicing sustainability [5]. Universities are considered to be as predicting touchstones of change and to be of positive reactive agents. Higher education is seen by some as a responsibility to society regarding the issue of sustainability. Meanwhile, sustainability assessment has been cited as the potential for creating organizational change towards sustainability [6].

University campuses are complex systems in which educational and research processes are carried out with the consumption of materials, energy, and water. In China, the education sector is responsible for 40% of the total electricity consumption in the public sector [7].

Therefore, studies to reduce anthropogenic effects in universities have been considered. Today, in addition to their scientific achievements and reputation, universities compete with each other to reduce the human impact on environmental problems such as climate change. Considering the importance and role of universities in the sustainability of societies, this article examines the performance and efficiency of Iranian universities in the field of sustainability and the GreenMetric ranking system.

RESEARCH BACKGROUND

One of the vital issues facing the world today is less environmental pollution, less energy consumption, and minimize carbon emissions [8]. Climate change, global warming, and the increase of environmental pollutants are the main factors in the movement of today's societies in order to support clean energy and preserve the environment. In this regard, a significant effort was made at global level to define a sustainable university in the Talvers statement. The leaders of 22 universities gathered in Talvers, France to share their concerns about the state of the world and compile a document that identifies key activities needed by universities to create a sustainable future [9].

In this statement, recognizing the lack of experts in the field of environmental management and related fields, as well as the lack of understanding by experts in other fields about their impact on the environment and public health, the role of universities is defined as follows:

Universities educate people who build and manage society's institutions. For this reason, universities play a profound role in raising awareness, in the knowledge of technologies, and in the tools to build an environmentally sustainable future [9]. After that, in 2005, groups named Consortium (HEASC) were formed in the direction of sustainability with the goals of cooperation in the direction of universal education and the formation of sustainable education [10]. It is under the supervision of a larger association named the Association for the

Advancement of Sustainability in Higher Education (AASHE) [11].

In 2006, the Sustainability Consortium of Higher Education Associations focused on these conditions and emphasized that the need for a ranking system for sustainable universities is undeniable. This system should be able to respond to various aspects of sustainability and numerous activities of university complexes, including infrastructure management, education, interaction, guidance, and community guidance. When this topic was raised, he introduced the association (STARS) [12].

This system originated from the existing world experience and various ranking systems of universities and higher education. This model provides a framework for understanding sustainability in all aspects of the academic environment; on the one hand, it specifies the possibility of comparing the status of each university with others and provides international interaction.

In the last decade, an online "green" ranking of the world's universities was presented by the University of Indonesia, as an emerging university globally, to provide a picture of the current conditions and policies related to green campus and sustainability in universities around the world. In this system, instead of using research and educational indicators, more environmental indicators have been used. Due to this, the GreenMetric rating has played a different role from other surveys, scorecards, and sustainability rating systems [13].

Figure 1 shows the time history of the green university concept [14].

Many studies have been conducted regarding sustainability assessment and the use of various sustainability ranking tools in universities. In this regard, Shriberg [15] examines the criteria of some evaluation tools and draws conclusions about the status of sustainability performance. He has highlighted a number of important considerations based on this analysis: consumption reduction, the centrality of sustainability education, inter-functional integration, inter-organizational integration, and incremental and systemic improvement. These rankings and indicators are not the only types of sustainability evaluation in universities [15].

Pope et al. [16] compared some various approaches to sustainability measurement to find out their prospective function to sustainability. They put that many
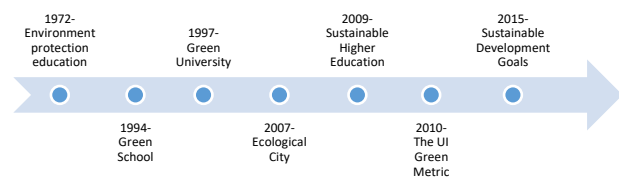

Figure 1. Timeline summary of Green Campus Concept

of these indicators are instances of (integrated assessment) resulting from the Environmental Impact Assessment (EIA) or the Strategic Environmental Assessment (SEA), and they broadened them to social and economic concerns. They assumed that (assessing sustainability) necessitates a wel-defined definition for the concept of sustainability, and that principles-based methods to creating sustainability criteria are more proper than other methods [16]. Boer [17] argued and disapproved of the concept of sustainable development and sustainability education. He has evaluated a number of evaluation models. Some works provide ground-breaking methods to present evaluation systems that can obtain social targets [17].

There are also many case studies on sustainability implementation in universities. Bautista-Puig and colleagues [18] have analyzed the performance of sustainability in public and private universities in Spain from three social, economic and environmental perspectives. The findings of this study show that some production institutions provide more scientific activity in this field and others are more specialized with less production. But this study shows clearly that although the issue of sustainability of universities is very important for society, it has not yet been incorporated into the overall strategies, activities, and policies of the system [18].

Eduardo and his colleagues [19] investigated the impact of the use of unmanned vehicles on the infrastructure index. Also, the potential of aerial biomass, carbon, and carbon dioxide stored in the green space of the university campus was estimated using photogrammetric data analyzed in a geographic information system (GIS) [19]. Also, in 2020, studies were conducted on the special global rankings of universities and the evaluation of the performance of universities around the world in the GreenMetric system, and it was found that Asian universities performed better in the field of sustainability [20].

As you can see, a lot has been written about sustainability, sustainability in higher education and evaluation, and measures and ranking of sustainability. However, most of these cases are in regional, national or local contexts or case studies of a single university's efforts to create and to measure sustainability in other countries, and there are still relatively few studies in this field in Iran. Figure 2 shows the research framework.

Greenmetric rating system

The Green metric university ranking published in 2010, it was inspired by the STARS, Greenship, and Holcim systems, with the purpose of measuring and evaluating the degree of sustainability in higher education institutions and universities; and since there are no prerequisites and costs for the programs, it is not practical. It has been met with increasing interest from all over the world. This rating system contains three aspects of sustainability including environment, economy, and
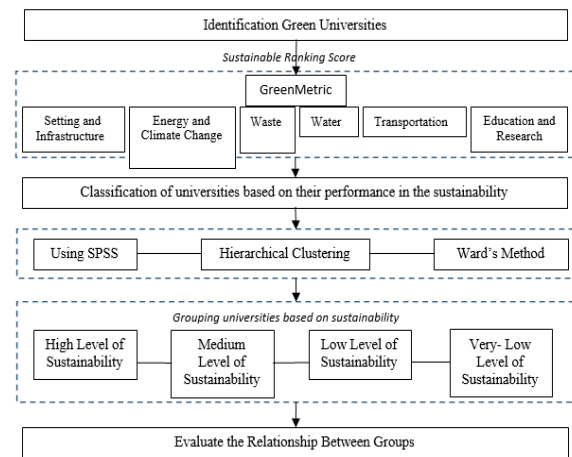

Figure 2. The research framework

society [20]. The environmental dimension encompasses the use of natural resources, environmental supervision and pollution prevention. The economic aspect pnpoints cost savings and benefits. While the social aspect focuses on education, society and social participation. The Greenmetric system consists of six main index, which are location and infrastructure (15%), energy and climate (21%), waste (18%), water, (10%), transportation (18%), and education and research (18%) as described in Table 1 [21].

STUDY AREA

Iran, officially named of the Islamic Republic of Iran, is a country in West Asia and in the Middle East. With an area of 1,648,195 square kilometers, this country is the second largest country in the Middle East. In Iran, there are 2,569 universities in the country, 141 are public (Ministry of Science, Research and Technology) and are registered in 31 provinces of the country. According to their area and activities, universities and campuses have a significant impact on the environment and society.

The green metric rating system has become very popular in Iran. Zanjan University is the first university

Table 1. UI GreenMetric sub-dimensions [21]

Factors	Score	Weights (%)
1 Setting and Infrastructure (SI)	1500	15
2 Energy and Climate Change (EC)	2000	21
3 Waste (WS)	1800	18
4 Water (WR)	1000	10
5 Transportation (TR)	1800	18
6 Education and Research (ED)	1800	18
Total	10000	100

in Iran that has participated in this ranking since 2014 and has been ranked first among Iranian universities from 2014 to 2021. Every year, the number of Iranian universities participating in this ranking has increased and reached 42 universities in 2021 (Table 2). However, much research has not been done regarding the determination of the contribution of Iranian universities in the sustainability and evaluation of their performance. To fill this gap, this research has been done by focusing on identifying and comparing the performance of Iranian universities from the point of view of using the best sustainability methods of the green metric rating mortar system. In short, this study helps to rank the sustainability of Iranian universities. In addition, the above categories help to identify the campuses that have the most involvement and effort in the area of sustainability.

MATERIAL AND METHODS

In this research, data analysis and SPSS software have been used for the purpose of creating homogeneous samples to recognize strong results. In this regard, this study conducts a cluster analysis in which six index of the Green metric (location and infrastructure, energy and climate, waste, water, transportation, and education and research) are used to classify the sample universities into homogeneous groups in terms of their sustainability level. Among all available hierarchical algorithms, Ward's method is selected in this article. Because of Kuiper and Fisher's theory, it is a powerful compound method that combines different elements and tries to lower the variance within them as much as possible [22].

Table 2. The number of Iranian universities participating in the Green Metric ranking system from 2014 to 2021

Rank	2014	2015	2016	2017	2018	2019	2020	2021
1_99	-	1	1	1	1	1	2	1
100_199	1	-	-	2	1	2	-	4
200_299			1	3	2	1	4	3
300_399			-	2	4	2	7	2
400_499			1	2	4	7	2	6
500_599					2	4	9	7
600_699					1	3	8	4
700_799					1	2	3	4
800_899							5	9
900_999							1	2
The number of Iranian participants	1	1	3	10	16	22	41	42
Total number of participants	361	407	515	619	718	780	911	956

Cluster analysis is a branch of multivariate analysis that categorizes a collection into groups with similar characteristics. The difference between this method and other methods for determining the number of multivariate is that, first, the clusters are not known from the beginning. Secondly, the relationship between clusters is justified and measured with the help of mathematical relationships [23]. Clustering in some methods is the distance between the data, which is measured by defining the metric as the distance, and the degree of their similarity. But if it is in such a way that part of each data is input and part of it is output, outputs are produced by using inputs, then the relationship between inputs and outputs can be defined production function and made it the clustering criterion [24].

While the number of Iranian universities participating in the GreenMetric ranking system was one university in 2014, this number has increased and reached 42 universities in 2021. New universities may affect the overall results either in an increasing or decreasing way. The ratio of the highest score obtained for each category and the score of all universities is given in Figure 3. The evaluations have been done for the years 2016-2021 according to the number of participating universities.

The performance index (location and infrastructures) significantly decreased in 2018 with 16 participants, and in 2021 it has decreased to some extent, and the trend has increased. Energy and climate change Indicators have decreased in 2018, but have been increasing in recent years. Waste management index in 2019, the downward trend can also be seen in 2021. Water management index, except for the years 2018 and 2019, has been increasing and has always been above 40%. Transportation index has increased except for the year 2018. Education and research index has also had several increasing trends. Table 3 shows the total points of each index based on the rank obtained in the Green Metric of 2021.

In order to be better and more successful in the GreenMetric rating system, the scores of certain rating ranges were calculated using the data of 2021; Also,
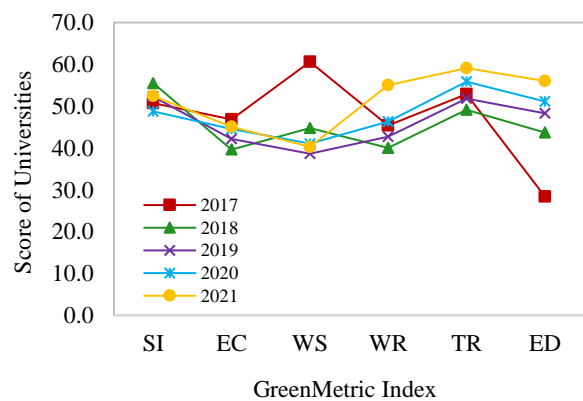
Figure 3. The average scores of universities based on the weight of each index

Table 3. Total points of each index based on the obtained rank

Rank	SI	EC	WS	WR	TR	ED	Total
	1500	2000	1800	1000	1800	1800	10000
1_99	1375	1125	1500	1000	1150	1700	7850
100_199	925	1425	1125	700	1575	1475	7225
200_299	1100	1242	1075	767	1375	1325	6883
300_399	950	725	1200	775	1350	1237.5	6237
400_499	804	1083	713	633	1342	1225	5800
500_599	811	843	750	557	1100	1139	5200
600_699	781	713	600	550	1100	950	4694
700_799	556	831	581	388	988	613	3956
800_899	603	692	383	378	628	656	3339
900_999	563	475	225	175	550	363	2350

using six GreenMetric ranking indicators (including location and infrastructure, energy and climate, water, transportation, and education and research) and scores of Iranian universities in 2021, and finally using hierarchical clustering method through software App.

SPSS defined four distinct groups of universities and higher education institutions according to their level of involvement in different aspects of sustainability. Table 4 summarized the distribution of 42 universities based on the degree of sustainability (high, low and very low).

Table 4. Grouping universities based on their performance level in the area of sustainability

Group 1: High Level of Sustainability (8 Universities)					
	SI	EC	WS	WR	TR	ED
Max	1375	1875	1500	1000	1575	1700
Min	875	1125	975	600	1150	1050
Mean	1090.62	1331.25	1237.5	793.75	1390.62	1462.5
St. Error	194.42	238.40	171.84	140.17	129.26	183.28
Group 2: Medium Level of Sustainability (5 Universities)					
	SI	EC	WS	WR	TR	ED
Max	1025	1225	1350	800	1500	1450
Min	775	725	750	650	1275	875
Mean	910	885	975	730	1385	1200
St. Error	93.00	183.43	212.13	50.99	78.42	198.11
Group 3: Low Level of Sustainability (14 Universities)					
	SI	EC	WS	WR	TR	ED
Max	975	1350	1050	700	1425	1500
Min	425	425	375	400	775	625
Mean	783.92	876.78	675	557.14	1137.5	1114.28
St. Error	140.02	244.12	198.43	84.21	181.94	238.99
Group 4: Very- Low Level of Sustainability (15 Universities)					
	SI	EC	WS	WR	TR	ED
Max	750	1075	825	600	1125	1075
Min	350	350	225	0	325	225
Mean	585	700	415	353.33	713.33	605
St. Error	126.75	215.44	164.01	165.79	247.46	229.70

The above table demonstrares that the distribution regarding the number of universities in each group was not equal; and groups 3 and 4 which have low and very low performance in the field of sustainability, have a large percentage. Table 5 shows the percentage of each group.

According to the results obtained from the clustering analysis, the largest cluster was related to universities that had a very low level of sustainability (36% of all analyzed universities). This result clarifies that most higher education institutions and universities have to make essential improvements in this field. From another view, there was the bottom group, which formed 33% of all universities, and finally, the group of universities that showed the highest commitment to concentrate on all aspects of sustainability, including 19% of all evaluated universities and its analysis. University leaders and

Table 5. Shows the percentage of each group

Name of Group		Number of University
Group 1	High Level	8
Group 2	Medium Level	5
Group 3	Low Level	14
Group 4	Very- Low Level	15

Table 6. Showing the universities of group 1 (high stability) and the scores obtained in each index

Weights	Total	SI	EC	WS	WR	TR	ED
Name of University	**10000**	**0.15**	**0.21**	**0.18**	**0.1**	**0.18**	**0.18**
University of Zanjan	7850	1375	1125	1500	1000	1150	1700
University of Kashan	7725	875	1875	1275	900	1425	1375
University of Mohaghegh Ardabili	7550	1250	1200	1350	850	1350	1550
Alzahra University	7450	1000	1300	1425	600	1500	1625
Kashan University of Medical Sciences and Health Services	7225	925	1425	1125	700	1575	1475
Razi University Kermanshah	7075	1075	1125	975	950	1500	1450
University of Isfahan	6875	1350	1450	1050	700	1275	1050
Ferdowsi University of Mashhad	6700	875	1150	1200	650	1350	1475

higher education institutions are trying to change these results and reach greater participation and dedication to sustainability rules that are currently being carried out around the world. Table 6 shows the main statistics that allow us to characterize the characteristics of each group.

Group 1, the most sustainable group includes universities that scored the highest in all areas covered by GreenMetrics indicators. The total maximum points of this group are 7850 points registered by Zanjan University. Among these 8 universities, one university has obtained maximum points in the water category (1000 points).

In order to better understand the performance of each group and the priorities of universities to become greener and be more successful in the Green Metric rating system in the coming years, the percentage of points obtained in each index based on the average points of each group can be calculated.

According to Figure 4, It was found that in the first three groups, the highest percentage of points are related to the three indicators of education and research, transportation, and water management, and in the fourth group, the indicators of transportation, location and infrastructure, and then the indicators of energy and water management are the highest percentage.

Using these scores, it is possible to focus on the indicators that have the least difference with their higher group in order to place the universities in the higher range. For example, group 2 has a performance similar to its higher category (group 1) in the transportation index, and the lowest difference between these two groups is in the water management index with 6%. For this purpose and to find the answer "What action should universities take to be in the upper range?" A Comparative Table is created. According to Table 7, the difference between the average performance scores of each is specified.
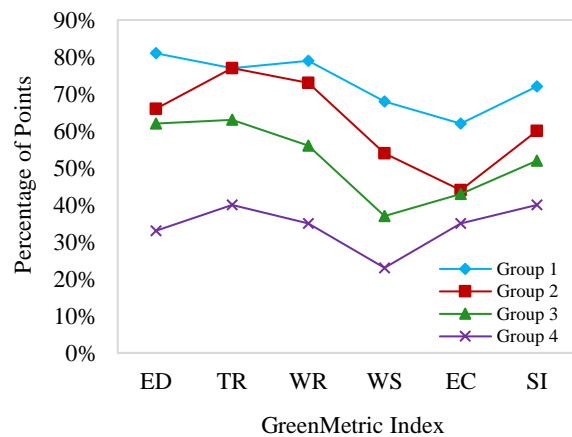

Figure 4. Performance evaluation chart of groups in each index

Table 7. Comparative table based on the difference between the average scores of each category

Difference between ranges (%)	SI	EC	WS	WR	TR	ED
Groups (1 & 2)	12	18	14	6	0	15
Groups (1 & 3)	20	19	31	23	14	19
Groups (1 & 4)	32	27	45	44	37	48
Groups (2 & 3)	8	1	17	17	14	4
Groups (2 & 4)	20	9	31	38	37	33
Groups (3 & 4)	12	7	14	21	23	29
Difference between ranges (%)	1-10	11-20	21-30	31-40	41-50	

DISCUSSION

This article aims to evaluate the efficiency and performance of 42 Iranian universities that participated in the ranking of the GreenMetric system in 2021. At first, using existing hierarchical algorithms and Ward's technique. Universities participating in the GreenMetric ranking were divided into four categories in terms of their performance in the field of sustainability. Cluster analysis gave us the opportunity to recognize four levels of sustainability that characterize different degrees of commitment revealed by universities (high, medium, low, and very low sustainability). This evaluation shows the relative strengths and weaknesses of universities in six green metric indicators. Meanwhile, the last two groups, which make up 69% of the total and have lower scores in the area of sustainability should consider taking necessary actions in all the variables analyzed, especially in the area of energy and transportation. however, the most devoted universities (high and medium) could obtain the highest points in the field of energy, transportation, research, and other related educational aspects. These results also showed that environmental variables (water, waste, and infrastructure) are categories that should be given more attention by universities.

Also, in order to better understand the performance of each group and the universities' priorities for becoming greener and more successful in the GreenMetric ranking system in the coming years, the percentage of scores obtained in each index was calculated based on the average scores of each group using the data of 2021, and based on that a table Thermal is created. This table allows universities to know which indicators they should focus on in order to be in the higher range.

In short, by evaluating the productivity and efficiency of universities, this research states that universities should consider some significant approaches to advance their performance in the field of sustainability. scince greater attentiveness on behalf of the public about sustainability entails a high degree of transparency, the rules in place are clearly understood and provide a model for the institutions and universities that are yet lagging behind the whole process.

CONCLUSION

The results show that Iranian universities have performed better in the energy, transportation and education indicators among the six GreenMetric indicators. These results also showed that environmental variables such as water, waste, and infrastructure; are categories that should be given more attention in the future programs of universities.

CONFLICT OF INTEREST

There is no conflict of interest.

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Persian Abstract

چکیده

امروزه با توجه به مشکلات اقلیمی و زیست‌محیطی، توجه به پایداری در دانشگاه‌ها از اهمیت زیادی برخوردار است. از این رو دانشگاه‌ها به طور پیوسته به سمت ادغام شیوه‌های پایداری در سیستم دانشگاهی خود در حال حرکت هستند. در حال حاضر بسیاری از دانشگاه‌های ایران نیز در حال انجام فعالیت‌های مهمی در زمینه مسائل زیست‌محیطی می‌باشند. این پژوهش با هدف تعیین کمیت سهم دانشگاه‌ها در پایداری، به تحلیل عملکرد دانشگاه‌های ایران می‌پردازد. پژوهش حاضر در دو مرحله به خوشه‌بندی و ارزیابی عملکرد و کارایی دانشگاه‌های ایران می‌پردازد. در مرحله اول با استفاده تکنیک خوشه‌بندی به تفکیک دانشگاه‌ها براساس عملکردشان در حوزه پایداری در دسته‌هایی همگن پرداخته می‌شود. سپس با استفاده از جدول مقایسه‌ای به منظور درک بهتر عملکرد هر دسته و اولویت‌های دانشگاه‌ها برای سبزتر شدن و موفقیت بیشتر در سیستم رتبه‌بندی گرین‌متریک در سال‌های آینده، درصد نمره اخذ شده در هر شاخص براساس میانگین نمرات هر گروه با استفاده از داده‌های سال ۲۰۲۱ محاسبه شده‌است. این پژوهش با ارزیابی بهره‌وری و کارایی دانشگاه‌ها، بیان می‌کند پایدارترین دانشگاه‌ها که در گروه ۱ (سطح بالا پایداری) و گروه ۲ (سطح متوسط پایداری) قرار دارند، موفق به کسب حداکثر امتیاز در زمینه انرژی، حمل و نقل و همچنین در زمینه تحقیقاتی و سایر جنبه‌های آموزشی مرتبط شدند. این نتایج همچنین نشان داد که متغیرهای محیطی (مدیریت آب، مدیریت پسماند و زیرساخت) باید بیشتر مورد توجه دانشگاه‌ها قرار گیرند.