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GreenMetric ranking calculation by using satellite imageries: A Case Study from Türkiye

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Abstract

GreenMetric (GM) is universally used to determine the sustainability levels of universities. In this study, it is recommended to use satellite imageries in calculating the scores of the setting and infrastructure category, which is the first category of GM. Also, it is suggested to use thematic maps derived from satellite imageries as evidence presented to the system for the calculated scores. For this purpose, a Sentinel-2B satellite image of the Tokat Gaziosmanpasa University Tasliciftlik Campus area from Turkey was exposed to digital image processing techniques to derive statistical values regarding greenery. Score calculations were made by using numerical information derived from the satellite image, and the values of the attributes such as population on the campus. Based on these data and information, the total score of the setting and infrastructure category was calculated as 925, and those officially claimed was 825. Considering the controversial evidence presented to the GM system for the first category, it has been determined that thematic maps are more consistent and reliable. The results proved that the use of satellite imagery in calculations for the first category of GM could set a standard.

1. Introduction

Universities represent much more than closed areas where students receive occupational education from academic staff. A university is a complete living space with its facilities and the environment it provides (Alshuwaikhat and Abubakar, 2008). Universities, which are no different from a small cities with their versatile nature, have to be sustainable in line with their goals. Many universities around the world are trying to improve themselves and increase their popularity for this purpose.

The educational aspect of sustainability was first alleged at the Stockholm Conference in 1972. Studies on the sustainability of universities have been discussed in the literature mostly in the field of social sciences (Velazquez et al., 2006; Alshuwaikhat and Abubakar, 2008; Lozano et al., 2013; Lauder et al., 2015; Ragazzi and Ghidini, 2017). Various metrics were used to determine the sustainability levels of universities. However, this is now determined by GreenMetric (GM) at a universal level. The emergence and development process of GM was examined in detail by Suwartha and Sari (2013). The ranking of the participating universities is carried out according to the total score obtained from different categories with various criteria. Universities also upload documents proving the values they present to the system.

GM consists of six main categories. These are setting and infrastructure (SI), energy and climate change (EC), waste (WS), water (WR), transportation (TR), and education and research (ED), respectively (GM Guideline, 2019). The scores obtained separately from each category constitute the total score and then, universities are ranked in terms of being a green campus. The percentage of each category in the total score is presented in Figure 1.

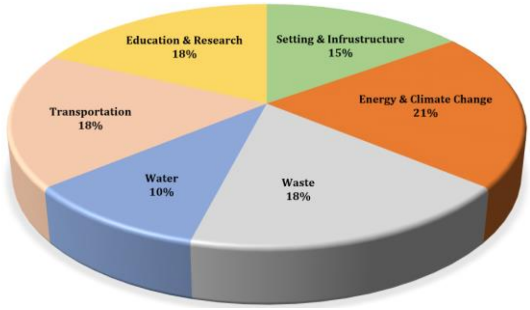

Figure 1. The six categories used in the ranking and their distributions as a percentage.

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The first among six categories provide information about the university's opinion on the environment (GM Guideline, 2018; GM Guideline 2019). SI has its sub-categories as presented in Table 1. Scores of each indicator affect the final score depending on the percentile ranges specified in the guide.

There are a total of 5 percentiles or areal slice for each indicator and since it is not possible to show the scores corresponding to 30 slice spacings in a table form in this study, the readers are recommended to refer to the GM guideline. Calculation for SI-5 is based on slicing in square meters. For others, ranges created according to percentiles are used. For example, if the calculated proportional value for SI-1 is between 1% and 80%, 300 point is multiplied by a coefficient of 0.25. This coefficient is 0.50 for the percentile value between 80 and 90, and 0.75 for the 90 to 95 value. If the percentile is greater than 95%, it is directly multiplied by 1. If the calculated proportional value corresponds to the first of 5 percentiles, zero point is taken regardless of which category it is. The coefficient values corresponding to these percentiles are not the same in each category. Therefore, it is necessary to calculate separately for each sub-category.

Details of other indicators related to other categories can be reached through GM guidelines. In the last published guide, the number of sub-indicators in the SI category has increased (GM Guideline, 2021). Therefore, the maximum scores of the indicators discussed in this study were also updated. However, it is immaterial which of the guidelines for the last 4 years has been used to determine the possible contribution of satellite imagery to the GM ranking.

Table 1. Indicators of SI and their maximum points

No	Category SI	Max. Points
SI-1	The ratio of open space area to the total area	300
SI-2	Total area on campus covered in forest vegetation	200
SI-3	Total area on campus covered in planted vegetation	300
SI-4	Total area on campus for water absorption besides the forest and planted vegetation	200
SI-5	The total open space area divided by the total campus population	300
SI-6	Percentage of university budget for sustainability efforts within a year	200
	TOTAL	1500

2. Methodology Used

In this study, sub-categories of SI were determined using image processing techniques. The aim of this study is that the techniques used at a basic level can take GM, which is mostly handled by social sciences, a little further. The selected study area was Tokat Gaziosmanpasa University (TOGU) located in Turkiye. The names of the main campus where they joined the GM is Tasliciftlik. The methodology applied for the study area was briefly visualized in Fig. 2.

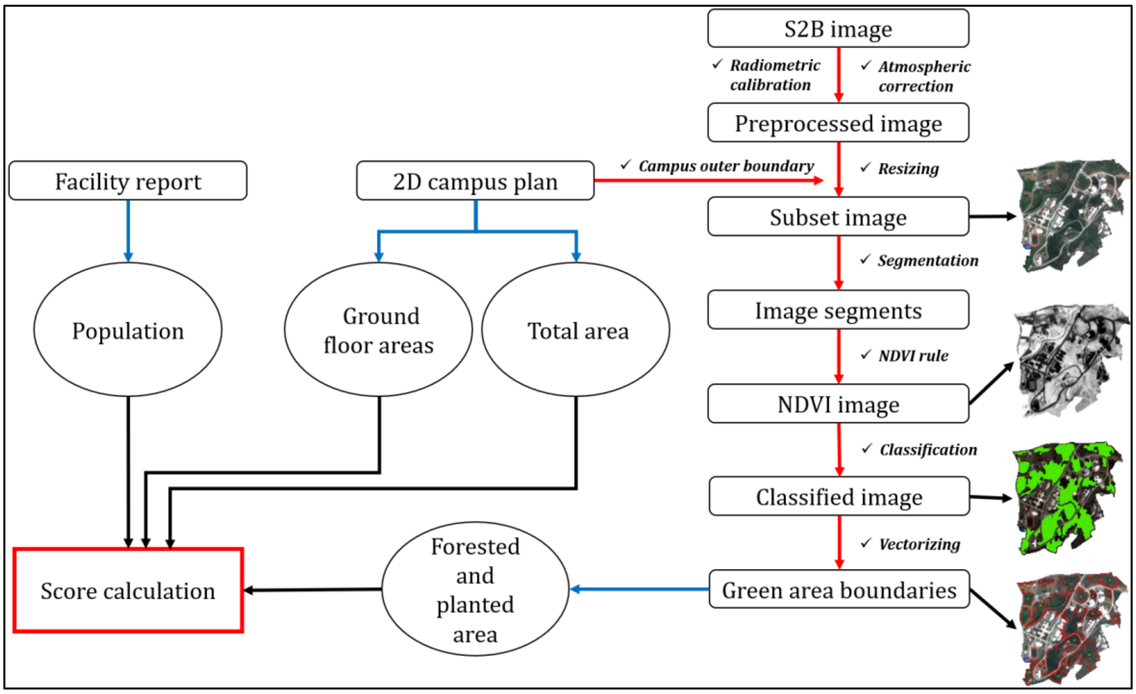

Figure 2. Applied workflow

Sentinel 2 satellite image was used to derive information about the greenery level of the university. Satellite imagery used in this study was S2B image with the acquiring date of April 24. The reason why the image used belongs to 2018 is that the guide referenced in the study belongs to 2019.Object-oriented classification technique was applied to the pre-processed satellite image which covered only the current campus area. The rule created based on Normalize Difference Vegetation Index (NDVI) (Rouse et al., 1973) value was applied to produced segments. Thus, green and non-green areas were separated from each other to determine the level of greenery. The study area and its NDVI image for TOGU is presented in Fig. 3. The status of green area on campus and the enclosed outer boundaries of green areas on campus are presented in Fig. 4. The extent of the area covered by each green area became evident in this fully scaled dataset.

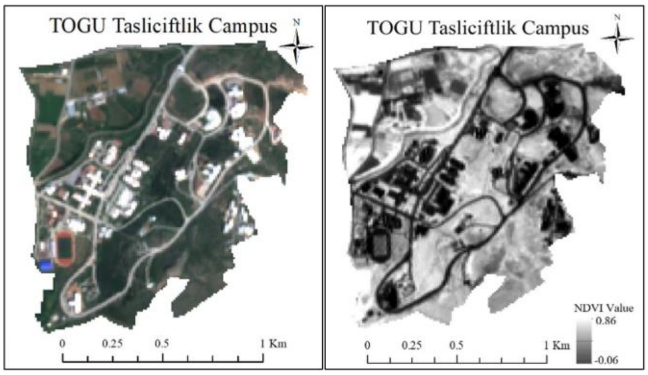

Figure 3. Study area and NDVI image

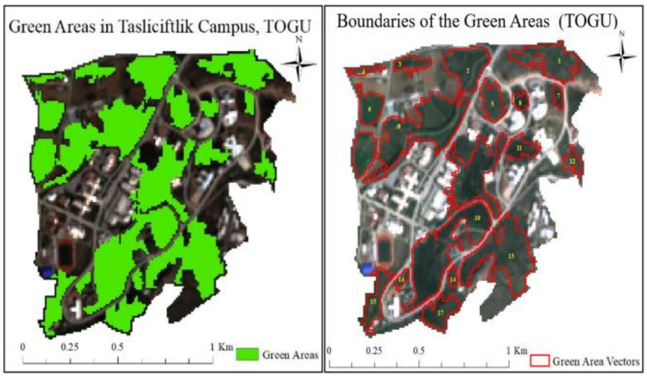

Figure 4. Green areas and outer boundaries of the green areas

2.1. Score calculations

Recommendations for GM score calculation are limited in the literature. The effect of campus morphology (Marrone et al., 2018) on the calculated score and the evaluation of data envelopment analysis (Marti, 2019) in calculations are a few of them. However, most of the studies have already researched evaluating the current situation rather than taking GM forward with new ideas.

Green areas in GM are evaluated in two different sub-categories as forested and planted. In this study, SI-2 and SI-3 were evaluated together in a single category, as the university's relationship with greenery was determined by sustainability. In other words, the total amount of green space was evaluated regardless of its type. The calculation was made over 500 points with the combined sub-category. Also, it is the satellite image used in the majority of the score calculation in the SI category. For SI-4, structures such as roads and walkways that are shown as water-absorbing surfaces other than green areas by GM were not considered in the same concept. These are not structures created specifically to absorb water, but for transportation purposes. Except for the forest and planted vegetation areas, which are already natural water absorption surfaces, a separate surface is generally not constructed. Therefore, the university's relationship with greenery was handled through more realistic parameters and the score was calculated in this way.

The ones required to calculate the scores of the sub-categories mentioned in Table 1 are presented in Table 2. Ground floor areas of buildings were extracted from the scaled ownership status plans of the campuses. The difference between the total area and total campus ground floor area of buildings gives the open space area. The population values involving the academic and administrative staff and students on the campuses were obtained from the annual facility report published by the university (Url-1).

Table 2. Values required for calculations

Information	Value
Total area (m^2)	1.448,599
Total campus ground floor area of buildings (m^2)	78074
Open space area (m^2)	1.370,525
Green area (Forested + Planted) (m^2)	549000
Population (m^2)	37187

3. Results and Discussion

The scoring is presented in Table 3. SI-4 is not an indicator that can be extracted from a Sentinel image due to its spatial resolution. However, main water absorption surfaces are generally forested and planted vegetation areas. Apart from these, no specific surface or structure is usually created for absorption. Thus, the percentile selected for TOGU corresponds to zero points. SI-6 is the indicator related to the budget and the percentile used for SI-6 is the value submitted by TOGU to the system.

Table 3. Score calculations for TOGU

SI Id	Calculation	Percentile	Range Score
SI-1	(1.370,525 m^2 / 1.448,599 m^2)*100	> 90% and 95%	0.75*300 = 225
SI-2&3	(549000 m^2 / 1.448,599 m^2)*100	> 35%	1*500 = 500
SI-4	-	-	-
SI-5	(1.370,525 m^2 / 37187)	> 20 - 40 m^2	0.5*300 = 150
SI-6	-	> 1% - 3%	0.25*200 = 50
	Total Score		**925**

The score calculated for TOGU based on information derived from satellite image was 925. In contrast, the official score depending on the evidence presented by the university was 825. There may be various reasons for the differences between the scores calculated in the study and the officially announced ones. The 2nd and 3rd of sub-categories were combined and considered as a single category. This category recommended by the authors is used to evaluate the green area as a single category representing greenery rather than separating it as forested and planted vegetation. A score difference may have occurred due to the percentile range corresponding to the proportional value calculated with the combined category.

Another possible reason is the image data used directly in the study. There are sample evidence templates on the GM official website for the metric values to be submitted. A composite section from the template with examples of what the evidence might look like is presented in Figure 5. Most of the universities superficially form polygons on Google Earth when calculating areal values. Moreover, sample evidence in these templates for building floor areas and planted vegetation areas does not give any information about how the values presented to the system are calculated. An ordinary photograph of the relevant building or planted vegetation area is demonstrated as evidence and the corresponding areal value is written below. Therefore, it is expected that there will be a difference between the scores calculated with the data submitted to the system but whose reliability is controversial, and the values calculated more consistently with more professional evidence in this study.

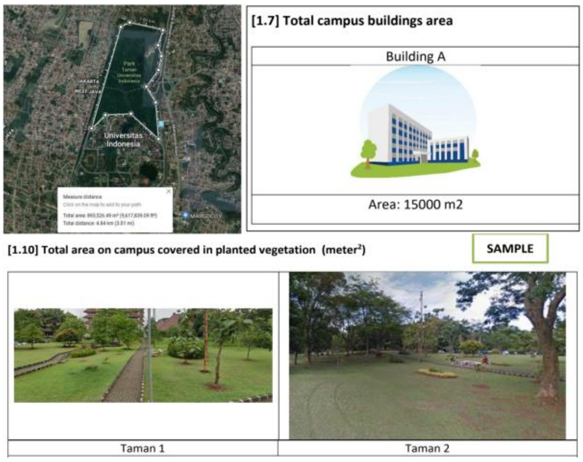

Figure 5. Sample pieces of evidence accepted by GM

4. Conclusions

In the study, the possible contribution of satellite images to the GM rating system was examined. Depending on the image type used, two indicators related to greenery were gathered under a single heading. The resulting products produced using satellite imagery proved to be more reliable and consistent evidence for the values presented to GM. There should be a standard for the evidence to be presented and the thematic map in Fig.4 is the suggested evidence for the greenery of the campus in this study.

The image processing steps used are simple but effective in terms of the scope of the study. Therefore, thematic maps can be requested as evidence in the next GM guidelines. Although satellite images were used specifically for the SI category in the study, it is also possible to evaluate them in subcategories of other main categories. One of the indicators under the transportation category is related to the ratio of the ground parking area to the total campus area. To produce similar information to the SI category, satellite imageries can be used with classifications where the number of classes is more than one.

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