

## GREEN UNIVERSITIES: BIBLIOMETRIC ANALYSIS OF THE CURRENT STATE OF THE ART AND FUTURE RESEARCH SCENARIOS

Justyna BERNIAK-WOŹNY<sup>1\*</sup>, Małgorzata RATAJ<sup>2</sup>, Alina YAKYMCHUK<sup>3</sup>

<sup>1</sup> University of Information Technology and Management, Rzeszów; justyna.berniak@gmail.com,  
ORCID: 0000-0002-3156-5755

<sup>2</sup> University of Information Technology and Management, Rzeszów; mrataj@wsiz.edu.pl,  
ORCID: 0000-0002-0469-2687

<sup>3</sup> University of Information Technology and Management, Rzeszów; ayakymchuk@wsiz.edu.pl,  
ORCID: 0000-0002-5038-5215

\* Correspondence author

**Purpose:** Sustainable development, and in particular aspects related to the natural environment, including energy management, is one of the key problems of the last decades. All organizations and institutions have been called upon to solve these problems. However, a special role is played by universities, which should not only become green organizations, but also disseminate knowledge about problems and possible solutions, develop the required green competencies of society, including current and future decision-makers, and conduct research aimed at defining specific problems and developing optimal solutions. The article aims to present the current state of the art and future research scenarios in the field of green universities.

**Design/methodology/approach:** This article presents a systematic review of the literature on green universities using the Preferred Reporting Items for Systematic Reviews Meta-Analyses (PRISMA) method associated with a bibliometric analysis of papers published in 2009-2022. For this purpose, the Web of Science Core Collection (WoSCC) database was used. A total of 82 papers were included for meta-analysis and categorized into 8 fields: author(s), title, published year, country, university, journal, paper citations, and journal citations. In addition, VOSviewer software supported the bibliometric analysis and allowed analysis of the citation link between authors and universities as well as co-authored documents by country.

**Findings:** In the years selected for analysis, there are no clear relevant research problems, leading research teams, and research centres. Moreover, the dynamics of research in this area are starting to decline. To support universities in their green transformation, it is, therefore, necessary to create a research program and tools to support them at the national and regional levels.

**Originality/value:** The results of the analysis prove that the concept of green universities, although widely discussed and present in global politics and rankings, does not find a corresponding level of reference in scientific research.

**Keywords:** sustainable development, green university, green campus, green curriculum, PRISMA, VOSviewer.

**Category of the paper:** Literature review.

## 1. Introduction

Our planet produces clean air, water, and essential food, but people are increasingly disrupting its natural processes. Growing pollution of water, air, and land resources on the one hand and the loss of natural resources on the other are caused by human behaviour. Some scientists say we have entered a new geological epoch known as the Anthropocene - an age where humans are increasingly influencing the planet (Lewis, Maslin, 2015; Steffen et al., 2011; Stevens et al., 2022; Tong et al., 2022). Therefore, only humans can stop the devastation process leading to self-destruction. As climate change intensifies, humanity experiencing the negative effects of these changes attaches greater importance to the topic of sustainable development, defined in the World Commission on Environment and Development's 1987 Brundtland report *Our Common Future* as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987).

Sustainable development is currently one of the biggest global trends and challenges. In 2015, the United Nations established the 2030 Agenda for Sustainable Development agreed upon by 195 countries and consisting of 17 goals and 169 measures related to economic, environmental, and social goals (Biggeri et al., 2019; Pradhan et al., 2017; Pedercini et al., 2019). As a result of a global commitment to these goals, and the scale of the effect that humans were having on the climate system (Pörtner et al., 2022), in the European Union alone, environmental protection expenditure increased by 54% from 2006 to 2021 (EC, June 2022).

Sustainable development, climate change, and energy management are also widely discussed at the higher education level. Over time, a new phenomenon has emerged, so-called green universities, that's to say higher education institutions involved in sustainable development, with particular emphasis on its environmental aspects. Although the term green university was coined in 1972 in the Stockholm Declaration, which was the first declaration of the sustainable development of higher education (UNEP, 1972), it was introduced to higher education at the institutional level in the early 1990s with the introduction of the concept of greening universities. Globally, the colloquial meaning of the term green university refers to various activities of universities, whose vision is the concept of sustainable development and the environmental responsibility assumed by them and other representatives of higher education (WU, 2021). More specifically, a green university implements environmental sustainability in all its dimensions - institutional framework, campus activities, teaching, research, community involvement, accountability, and reporting (Fissi et al., 2022; Bekessy et al., 2007; Biasutti, Frate, 2017). Since 2000, and especially in the last decade, the term has evolved and diversified to include more specific terms such as green campus referring to the university's infrastructure and administration, or green curriculum referring to the educational aspects of higher education. The term green university includes both academic and administrative subsystems and

infrastructure, as well as their related synergies (Beringer, Adomßent, 2008). Moreover, a green university seeks structural transformation to meet the challenges of sustainable development, recognizing that the university has the potential to learn and change (Albrecht et al., 2007; Gough, Scott, 2007). Green culture, created and developed in green universities, has become an important way of promoting several aspects of sustainable development in environmental activities. As a result of growing awareness of sustainability and environmental issues, universities are now part of environmental sustainability not only through research but also through the upgrading of campus infrastructure and processes to be more environmentally friendly, as well as updating curricula to include courses on the environment and sustainability development.

Scientists increasingly emphasize the role that universities can play in achieving sustainable development goals. Jardali et al. (2008) write: "Universities are in a unique position to lead the cross-sectoral implementation of the sustainable development goals and the implementation of the 2030 agenda". According to a QS survey (2019), 94% of students believe that universities "can do more to be environmentally friendly". They also believed that institutions should take further measures to reduce the negative impact on the environment. In 2021, Forbes argued that Gen Z is emerging as the "generation of sustainable development". In the case of research conducted by the UK National Union of Students (2018), as many as 81% of students are interested in the idea of sustainable development. Research by Deloitte (2021) shows that environmental concerns are the most important personal concern of 26% of Generation Z. These attitudes of young people are increasingly being supported by action. A study by Mastercard (2021) showed that concern for social and environmental issues is reflected in real support for foundations and non-governmental organizations (58%).

Universities should be pioneers in green transformation due to their significant contribution to environmental impacts, high level of social responsibility, and the crucial role they play in the development of social behaviours. (Heravi, Aryanpour, 2021) In 2012, the United Nations Conference on Sustainable Development confirmed the leading role of higher education with its educators and researchers, know-how, influence, and resources. Researchers have also confirmed that universities are viewed as having a deep responsibility to raise public awareness of social issues, increase knowledge and skills, promote ethical values, and guide society's transformation towards sustainable development (Cortese, 2003; Corcoran, Wals, 2004). Sustainable and green universities are also at the heart of the European strategy for universities, with an emphasis on interdisciplinary and transdisciplinary education and tackling contemporary and future global challenges. Universities are playing a role in educating future leaders in sustainable development and informed and sustainable consumers and citizens who are active actors in regional green transformation by sharing opinions, testing, and exploiting the results of SDG R&D activities. In November 2020, the ministers of the European Higher Education Area (EHEA) signed the Rome Communiqué, which emphasizes the key role of higher education in achieving the UN's Sustainable Development Goals (SDGs) and noted the

support and skills development of higher education institutions (universities) and the ability to prepare students for green work and other activities that achieve the SDGs. According to the communiqué, learners should be offered up-skilling and re-training opportunities within the Lifelong Learning Plan and should be encouraged to develop and apply new technologies and approaches (Rome Communiqué).

The development of green universities is also supported by several international initiatives. The United Nations Environmental Education and Training Unit (EETU), as part of its flagship program, GUPES, works with universities to develop and implement national and regional green university networks. It is a network of higher education institutions that incorporate low-carbon climate resilience development strategies and sustainability aspects in their education, training, campus activities, and increased student engagement. The network also aims to support universities in introducing the Greening Universities Toolkit and Greening Universities Toolkit V.2.0 in their day-to-day operations through Green Campus Development and Practices, Curriculum Development, Community Engagement, and Student Engagement. An important role in the development of green universities is played by the Higher Education Sustainability Initiative (HESI) - an open partnership between several United Nations entities and the higher education community launched in preparation for the Rio + 20 conference in 2012. With a strong link to the United Nations, HESI aims to provide higher education with a link between higher education, science, and policy-making by raising the profile of the higher education sector in supporting sustainable development, convening multilateral discussions and activities, and sharing best practices. HESI already represents over 30 networks with a reach of 18,000 universities around the world. The initiative also has over 300 signatories (universities). It is currently chaired by the United Nations Department of Economic and Social Affairs (UN DESA) and the Sulitest Association, a non-profit organization and online platform dedicated to improving knowledge on sustainable development for all. Other UN partners include UNESCO, the United Nations Environment Program, the UN Global Compact's Principles for Responsible Management Education, UN University, UN-HABITAT, UNCTAD, UNITAR, and the United Nations Office for Partnerships.

Also, the rankings of green and sustainable universities play a huge role in promoting and developing the concept of green universities. Alonso-Almeida et al. (2015) emphasize the importance of reporting on sustainable development (necessary for participation in the rankings) due to the analysis of the current situation and the presentation of prospects for the future, based on both qualitative and quantitative methods. Four leading rankings deserve special mention here:

- UI GreenMetric aimed at ranking world universities in terms of their activities related to green university and sustainable development (2022).
- Academic Ranking of World Universities (ARWU) - an academic ranking system of world universities introduced by the Center for World-Class Universities (CWCU) at the Graduate School of Education of Shanghai Jiao Tong University (SJTU) (2022).

- QS World University Ranking (QS), introduced by Quacquarelli Symonds (QS) (2022), and
- Times Higher Education World University Rankings (THE), one of the most famous academic rankings of world universities (2022).

Growing interest in environmental issues at the higher education level has led to the emergence of a research stream on green universities. A huge amount of research has been carried out, especially after 2009, concerning discussions on how to institutionalize the greening of university campuses, as well as how to evaluate and compare universities in terms of green activities (Okanović et al., 2021). Therefore, the aim of this study is a bibliographic analysis of scientific publications relating to the issues of green universities in the years from 2009 to 2023 (early access). More detailed knowledge on this issue will give a helicopter view of the current state of the art. Scientific relationships on the international and authorship levels will also prompt research agendas for the years to come that would support the HEIs in the green transformation (Holdsworth, Thomas, 2016)

The current paper is organized as follows. In the introduction, global trends in the topic of sustainability related to green universities are given. Attention is drawn to the international initiatives undertaken on this topic. Section 2 describes the methodology and data sets. In Section 3, the main findings of the reviews and the results of additional analyses are presented. Section 4 discusses the implications of the empirical results and concludes the paper.

## 2. Search Method and Procedure

This article presents a systematic review of the literature on green universities published in 2009-2022 using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (Moher et al., 2009) associated with bibliometric analysis. A bibliometric analysis is used in this study as a well-established and reliable method of providing a full picture of research trends in the literature. The definition proposed by Laengle's team reflects the concept of bibliometric methods: "Bibliometrics is a research area of library and information sciences that studies bibliographic documents by using quantitative methods. It is very useful for collecting a set of documents to provide a general overview of leading trends" (Laengle et al., 2021). Bibliometrics involves applying various approaches to identify the quantitative and qualitative changes in a theme of scientific research, establishing the profile of publications on a particular topic, and determining structural aspects within a subject (Rey-Martí et al., 2016). According to Bjork et al. (2014), the advantage of bibliometric analysis lies in gaining a general overview of a specific research field.

The search was carried out in August 2022. The search process used the Web of Science (WoS) Core Collection database, which is the leading database for classifying academic research. The Web of Science Core Collection (WoS) contains over 21,100 peer-reviewed, high-quality scholarly journals published worldwide in over 250 scientific disciplines. Conference proceedings and book data are also available. The WoS Core Collection from 2009 to 2023 (early access) was analyzed to find related publications based on the keyword combination “green university”. We searched for articles that have this phrase anywhere (not just in keywords or titles). The results of these searches contributed to the selection of a database consisting of 268 documents that matched our query. The WoS database was downloaded as a file in TXT format because we planned to use it for visualization in VOSviewer software, which requires CSV or TXT files.

All research results were also exported into the spreadsheet program Excel. However, it was decided to limit the search to articles in English only, which allowed for substantive verification. We therefore deleted 4 records with articles in Russian, Turkish, and Portuguese.

To focus on scientific contributions and avoid editorials and other related material, reviews, editorial materials, and notes were excluded. The database was narrowed to articles, proceedings, and book chapters only, which limited the database to 256 records. All unpublished early-access articles for 2023 were collected.

Additionally, publications were excluded if they neither corresponded to the research interest nor covered the university context. As shown in Figure 1, the final database consisted of 82 documents including 42 articles, 2 early access articles, 4 book chapters, and 33 proceedings papers. Scientific results regarding green universities are therefore mostly communicated via journal articles.

A visualization was prepared with the help of the VOSviewer 1.6.11 software. Since its introduction in 2010, VOSviewer software has been widely used in the scientific community.

In this study, to analyze the information in a bibliometric way, several bibliometric indicators were considered including the following calculated in Excel:

1. The total number of articles published in the years 2009-2022 (and 2023 early access).
2. The total number of publications per university.
3. The total number of publications per journal.
4. The total number of citations per journal.
5. The total number of citations per paper.

In addition, VOSviewer allowed analysis of the following:

1. The citation link between the authors.
2. Citations between universities.
3. Co-authored documents by country.

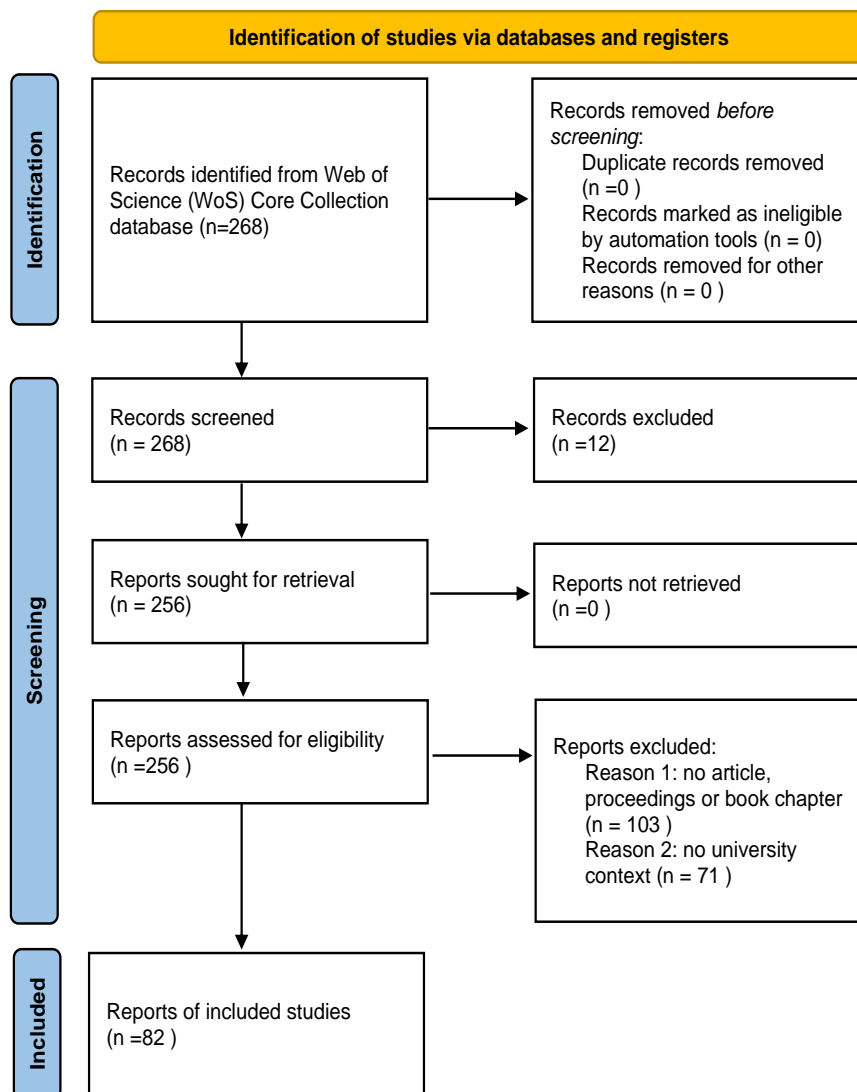
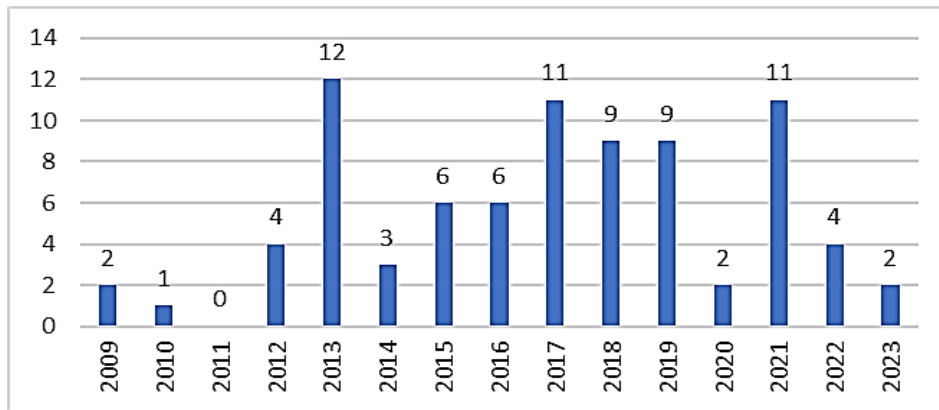


Figure 1. PRISMA flow chart (Page et al., 2020).

### 3. Results

#### 3.1. Results - the total number of publications

Eighty-two articles were published in the last 14 years including 2 early access articles. In the final database, the oldest article is dated 2009 (Figure 2). The growth of annual numbers of published articles in 2013 reflects the growing popularity of the subject of green universities around the world.



**Figure 2.** Number of articles published in the years 2009-2022 (and 2023 early access).

Unfortunately, subsequent fluctuation shows that this subject is not receiving much attention despite many international initiatives, which we have listed and described in Section 2.

**Table 1.**

*Article titles by the publication year*

Date of Publication	Titles of the papers selected for the review
2009	<ul style="list-style-type: none"> <li>• Research on the Process Evaluation of <b>Green University</b> Based on Concordance Analysis (Li <i>et al.</i>, 2009)</li> <li>• Study the Statistical Indicators System of the Process of Building <b>Green University</b> (Tao <i>et al.</i>, 2009)</li> </ul>
2010	<ul style="list-style-type: none"> <li>• Study on the Access Assessment on the Process of Building <b>Green University</b> (Li <i>et al.</i>, 2010)</li> </ul>
2011	-
2012	<ul style="list-style-type: none"> <li>• Measuring whole-building performance with dynamic LCA: a case study of a <b>green university</b> building (Collinge <i>et al.</i>, 2012)</li> <li>• Integrating operations and research to demonstrate bioenergy heating at the University of Northern British Columbia (Claus, 2012)</li> <li>• An Exploratory Study of Readiness and Development of <b>Green University</b> Framework in Malaysia (Hooi <i>et al.</i>, 2012)</li> <li>• Eco-campus: applying the ecocity model to develop <b>green university</b> and college campuses (Finlay and Massey, 2012)</li> </ul>
2013	<ul style="list-style-type: none"> <li>• Evaluating UI Green Metric as a tool to support <b>green universities</b> development: assessment of the year 2011 ranking (Suwartha, Sari, 2013).</li> <li>• A vision on the role of environmental higher education contributing to the sustainable development in Malaysia (Foo, 2013)</li> <li>• Indoor environmental quality in a dynamic life cycle assessment framework for whole buildings: Focus on human health chemical impacts (Collinge <i>et al.</i>, 2013)</li> <li>• Smart Mobility for <b>Green University</b> Campus (Longo <i>et al.</i>, 2013)</li> <li>• Moving towards an ecologically sound society? Starting from <b>green universities</b> and environmental higher education (Wang <i>et al.</i>, 2013)</li> <li>• To Build a <b>Green University</b> Library - Architectural Design of Hefei Institute Library (Guo <i>et al.</i>, 2013)</li> <li>• The Evaluation of <b>Green University</b> Based on Analysis Hierarchy Process (Liu <i>et al.</i>, 2013)</li> <li>• The Empirical Study on Evaluation of <b>Green University</b> (Liu <i>et al.</i>, 2013)</li> <li>• Creating a <b>green university</b> in China: a case of Shenyang University (Geng <i>et al.</i>, 2013)</li> <li>• Research on Evaluation Index System and University's Green Degree Evaluation Model (Chen <i>et al.</i>, 2013)</li> <li>• <b>Green Universities</b> in China - what matters? (Yuan <i>et al.</i>, 2013)</li> <li>• <b>Green University</b> Star Rating Evaluation Based on the Multi-Level Grey Approach (Chen <i>et al.</i>, 2013)</li> </ul>



Cont. table 1.

2014	<ul style="list-style-type: none"> <li>• The environment in post-secondary education and the '<b>green university</b>' in China McBeath <i>et al.</i>, 2014)</li> <li>• Tentative Analysis on Fundamental Thinking and Realizing Approach of the Construction of <b>Green University</b> (Li and Chao, 2014)</li> <li>• Green Campus Culture Construction of <b>Green University</b> (Wang <i>et al.</i>, 2014).</li> </ul>
2015	<ul style="list-style-type: none"> <li>• <b>Green university</b> initiatives in China: a case of Tsinghua University (Zhao and Zou, 2015)</li> <li>• Developing a Green Computer Science Program (Zalewski and Sybramanian, 2015)</li> <li>• Study on The Correlation of Web Repository Ranking to the Green Campus Ranking of Indonesian Universities (Rochim and Sari, 2015)</li> <li>• Encouraging sustainability in the workplace: a survey on the pro-environmental behaviour of university employees (Blok <i>et al.</i>, 2015).</li> <li>• Theory and Practice of Sustainability in Higher Education - From the Perspective of <b>Green University</b> (Mu <i>et al.</i>, 2015)</li> <li>• Comparing Sustainable Universities between the United States and China: Cases of Indiana University and Tsinghua University (Zou <i>et al.</i>, 2015)</li> </ul>
2016	<ul style="list-style-type: none"> <li>• Analyzing the Efficiency of a <b>Green University</b> Data Center (Pegus <i>et al.</i>, 2016)</li> <li>• The University of Northern British Columbia's Green Fund: Crafting a Tool for Sustainability Transformation (Wilkening, 2016)</li> <li>• E-Mailed Prompts and Feedback Messages to Reduce Energy Consumption: Testing Mechanisms for Behavior Change by Employees at a <b>Green University</b> (Pandey <i>et al.</i>, 2016).</li> <li>• Valuation supports <b>green university</b>: case action at Mediterranean campus in Reggio Calabria (Massimo <i>et al.</i>, (2016).</li> <li>• Strategic planning for the transformation of a university campus towards smart, eco and green sustainable built environment: a case study from Palestine (Hijazi, 2016)</li> <li>• Water reuse possibilities at students dormitories (Valentukeviciene and Rynkun, 2016)</li> </ul>
2017	<ul style="list-style-type: none"> <li>• Green Campus Study by using 10 UNEP's <b>Green University</b> Toolkit Criteria in IPB Dramaga Campus (Sisriany and Fatimah, 2017).</li> <li>• Design and Operational Analysis of a Green Data Center (Sharma <i>et al.</i>, 2017)</li> <li>• Integrating Between Malay Culture and Conservation In Green Campus Program: Best Practices From Universitas Riau, Indonesia (Suwondo and Yunus, 2017)</li> <li>• The Application of green construction in the Universities in South China (Xiong, 2017)</li> <li>• <b>Green University</b>: A New Perspective on Construction of Heterogeneous Competence of Application-Oriented Universities (Huang, 2017)</li> <li>• Building on Management Model of Modern <b>Green University</b> (Tu and Hu, 2017)</li> <li>• Research on <b>green university</b> operation mode based on Mercedes-benz models (Zhao and Zhao, 2017)</li> <li>• Research on the Advantages of Local Universities to Establish <b>Green University</b> Taking Linyi University as an Example (Zeng and Zeng, 2017)</li> <li>• Using emoticons to encourage students to recycle (Meng and Trudel, 2017)</li> <li>• The Strategy of <b>Green University</b>: Russian Experience of Implementation Lukina <i>et al.</i>, 2017)</li> <li>• The Role of Non-academic Staff in Designing the <b>Green University</b> Campus (Katiliūtė <i>et al.</i>, 2017)</li> </ul>

Cont. table 1.

2018	<ul style="list-style-type: none"> <li>• Supporting Sustainability and Healthy Learning Environment through Smart Green Management System (SGMS) ( Abdullah <i>et al.</i>, 2018)</li> <li>• Predictors of behaviour intention to develop a green university: a case of an undergraduate university in Thailand (Ounsaneha <i>et al.</i>, 2018)</li> <li>• What about greenhouse gas emissions from students? An analysis of lifestyle and carbon footprints at the University of Applied Science in Konstanz, Germany (Sippel <i>et al.</i>, 2018)</li> <li>• Management of Ecologization of Professional Education (Dlimbetova <i>et al.</i>, 2018)</li> <li>• Measuring food waste and creating diversion opportunities at Canada's <b>Green University</b> (TM) (Rajan <i>et al.</i>, 2018)</li> <li>• Variation of greenness across China's universities: motivations and resources ( Zhao and Zou, 2018)</li> <li>• Promoting and implementing urban sustainability in China: An integration of sustainable initiatives at different urban scales (He <i>et al.</i>, 2018)</li> <li>• What does environmentally sustainable higher education institution mean? (Freidenfelds <i>et al.</i>, 2018)</li> <li>• Sustainability at universities: Students' perceptions from <b>Green and Non-Green universities</b> (Dagiliūtė <i>et al.</i>, 2018)</li> </ul>
2019	<ul style="list-style-type: none"> <li>• Key strategies of sustainable and energy-saving development for <b>green universities</b> (Cai, <i>et al.</i>, 2019)</li> <li>• Reflections of a <b>green university</b> building: from design to occupation (Moore and Iyer-Raniga, 2019)</li> <li>• Understanding Undergraduate Students' Perceptions on <b>Green University</b> (Siregar and Tenoyo, 2019)</li> <li>• Environmental education policy for pursuing sustainable campus: experience from Taiwan Higher Education (Tsai, 2019)</li> <li>• Formation of Youth Readiness to the Development of Environmental Volunteering at University (Dlimbetova <i>et al.</i>, 2019)</li> <li>• An applied framework to evaluate the impact of indoor office environmental factors on occupants' comfort and working conditions (Andargie and Azar, 2019)</li> <li>• Getting a drink: An experiment for enabling a sustainable practice in Thai university settings (Thongplew and Kotlakome, 2019)</li> <li>• Environmental sustainability features in large university campuses: Jordan University of Science and Technology (JUST) as a model of a <b>green university</b> (Qdais <i>et al.</i>, 2019)</li> <li>• Evolutionary Game Analysis of Green Building Promotion Mechanism Based on SD (Xue <i>et al.</i> 2019)</li> </ul>
2020	<ul style="list-style-type: none"> <li>• Corporate Governance and Sustainability in HEIs (de Oliveira <i>et al.</i>, 2020).</li> <li>• The Impact Assessment of Campus Buildings Based on a Life Cycle Assessment-Life Cycle Cost Integrated Model (Xue <i>et al.</i>, 2020)</li> </ul>
2021	<ul style="list-style-type: none"> <li>• Diversity and causality of university students' energy-conservation behaviour: Evidence in hot summer and warm winter area of China (Wang <i>et al.</i>, 2021)</li> <li>• <b>Green University</b> and academic performance: An empirical study on UI GreenMetric and World University Rankings (Atici <i>et al.</i>, 2021)</li> <li>• An empirical study on discussion and evaluation of green university (Wu <i>et al.</i>, 2021)</li> <li>• Developing a <b>green university</b> framework using statistical techniques: Case study of the University of Tehran (Heravi <i>et al.</i>, 2021)</li> <li>• Internet of Things (IoT) as Sustainable Development Goals (SDG) Enabling Technology towards Smart Readiness Indicators (SRI) for University Buildings (Martínez <i>et al.</i>, 2021)</li> <li>• An integrated photovoltaic/wind/biomass and hybrid energy storage systems towards 100% renewable energy microgrids in university campuses (Al-Ghussain <i>et al.</i>, 2021)</li> <li>• Romanian Students' Environment-Related Routines during COVID-19 Home Confinement: Water, Plastic, and Paper Consumption (Gherheș <i>et al.</i>, 2021)</li> <li>• The path toward a sustainable <b>green university</b>: The case of the University of Florence ( Fissi <i>et al.</i>, 2021)</li> <li>• Developing the Ecological Footprint Assessment for a University Campus, the Component-Based Method (Vaisi <i>et al.</i>, 2021)</li> <li>• Addressing plate waste and consumption practice at university canteens: realizing <b>green university</b> through citizen-consumers (Thongplew <i>et al.</i>, 2021)</li> </ul>

Cont. table 1.

2022	<ul style="list-style-type: none"> <li>• Possibilities of Adapting the University Lecture Room to the <b>Green University</b> Standard in Terms of Thermal Comfort and Ventilation Accuracy (Kosiński and Skotnicka-Siepsiak, 2022)</li> <li>• <b>Greening Universities</b> with Mode 3 and Quintuple Helix Model of Innovation-Production of Knowledge and Innovation in Knowledge-Based Economy, Botswana (Liyange and Netswera, 2022)</li> <li>• Are university living labs able to deliver sustainable outcomes? A case-based appraisal of Deakin University, Australia (Martek <i>et al.</i>, 2022)</li> <li>• Sustainable <b>Green University</b>: Waste Auditing, German Jordanian University as a Case Study (Hindiyeh <i>et al.</i>, 2022)</li> </ul>
2023 (early)	<ul style="list-style-type: none"> <li>• Development of assessment framework for environmental sustainability in higher education institutions (Menon and Suresh, 2023)</li> <li>• Moving towards <b>green university</b>: a method of analysis based on multi-criteria decision-making approach to assess sustainability indicators (Yadegaridehkordi and Nilashi, 2023)</li> </ul>

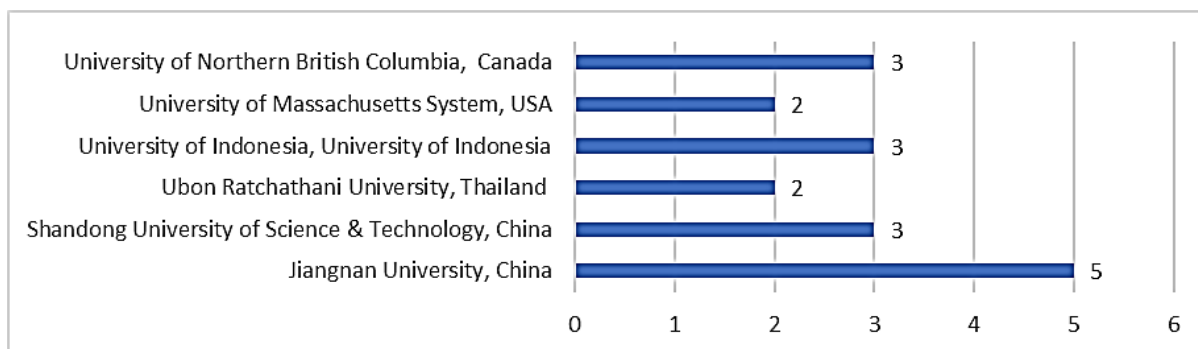
Source: Own studies.

When analyzing the titles of articles sorted by the year of publication (Table I), it can be noticed that throughout the period analyzed they focus on the search for the framework, model, methods, tools, and measures of building and managing campuses and universities. Often the research is based on the case study method illustrating solutions at the level of a selected university, campus or country. However, it is difficult to observe clear trends in research issues. On the other hand, there is a very limited number of cross-sectional studies examining selected aspects of green universities, such as energy, water, waste, biodiversity management, and so on. The publications also do not use the potential of the data of various rankings and sustainability reports, which could indicate trends, barriers, and challenges to the green transformation of HEIs.

### 3.2. The total number of publications per location

To provide a more general picture of the most productive regions of green University initiatives, Figure 3 presents the 6 most productive universities with more than 1 publication in the database we have worked on. The country selection criterion for a publication with multiple authors was the corresponding author's country.

We can say that Chinese scientific centres constitute pro-environmental initiatives at the university level, followed by universities in Canada and Indonesia. Certainly, this number is influenced by the number of researchers in such a huge country as China. In 2020, about 1,585 people per million inhabitants worked in research and development in China. (Statista statistics/239158, 2022) It is interesting to note that universities in Europe have output on this subject scattered across the continent and we cannot speak of a leading scientific center. In alphabetical order, the European countries can be listed in the database we are working on as Austria, England, Germany, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, and Spain.



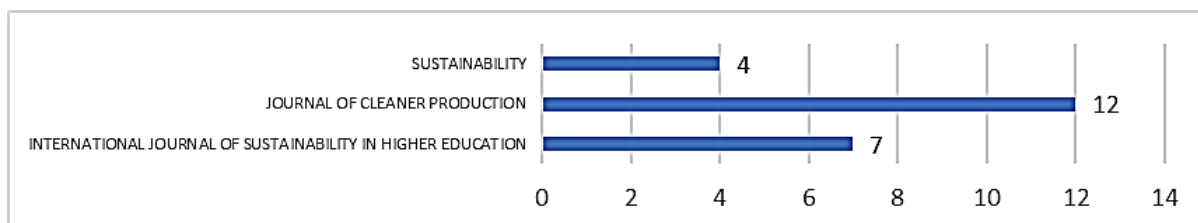
**Figure 3.** Number of articles per university.

You should avoid embedding OLE objects from custom programs, i.e. AutoCAD, and MathCAD.

Caption placed under figures should be justified, TNR 12 pt. font with single line spacing. Complex captions consisting of the main caption and explanatory notes for figure details should have a width equal to the text width. Continuous numbering should be used. The distance of an item from the text above it should be 12 pt. Remember to refer text to a given figure (Figure 1).

### 3.3. The total number of publications per journal

Out of 82 scientific journals, we identified three which are the most popular with researchers (Figure 4). The remaining 96% of journals occasionally publish articles about green universities.

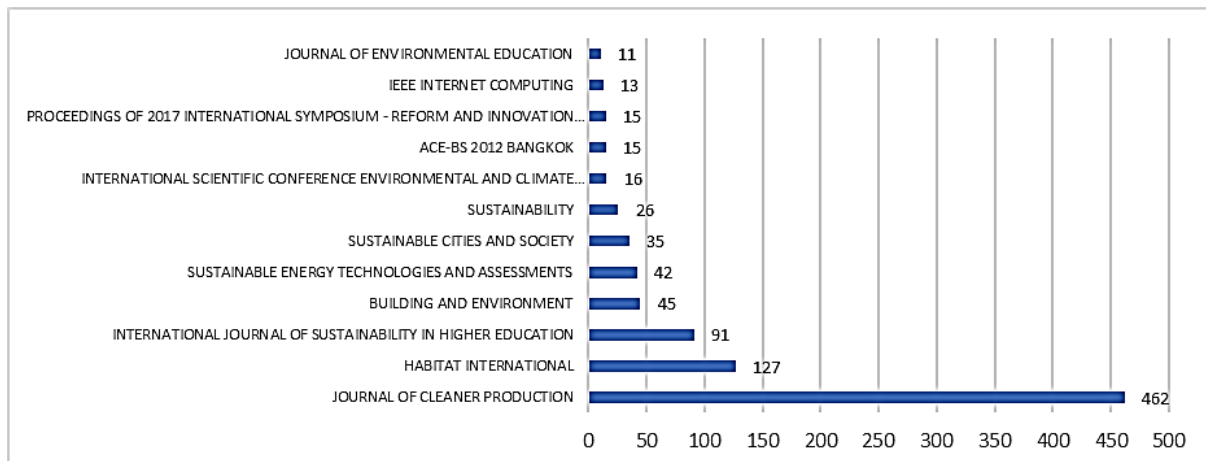


**Figure 4.** Number of papers per journal.

The most popular is published by Elsevier. The Journal of Cleaner Production is a leading international journal focusing on the field of green universities. The Journal of Cleaner Production is a transdisciplinary journal focusing on cleaner production, environmental, and sustainability research and practice. The purpose of this publication is to help societies become more sustainable. The Impact Factor of this journal is 11.072. The second most popular journal is the International Journal of Sustainability in Higher Education (Emerald Publishing) which aims to provide up-to-date information on new developments and trends in sustainability in a higher education context and to catalyze networking and information exchange on sustainable development as a whole, and on the SDGs in particular, on a global basis. The Impact Factor of this journal is 4.120. The third most popular journal is Sustainability (MDPI) an international, cross-disciplinary, scholarly, peer-reviewed, and open-access journal on the environmental, cultural, economic, and social sustainability of human beings. The Impact Factor of this journal is 3.889.

### 3.4. The total number of citations per journal

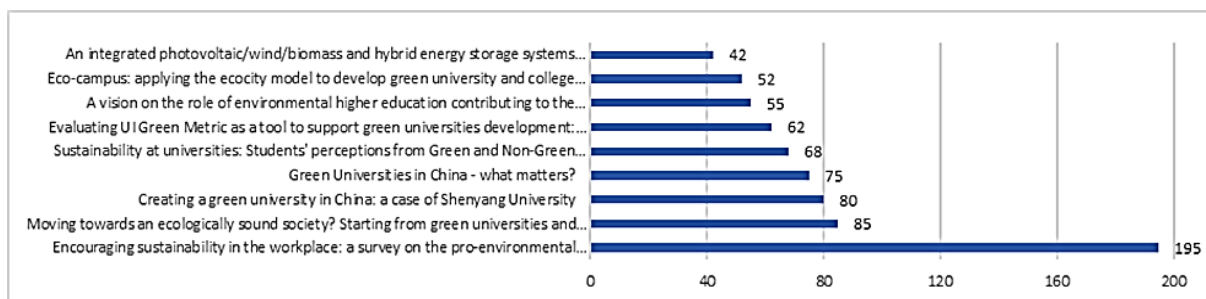
The journal that is most frequently cited is that published by Elsevier the Journal of Cleaner Production (Figure 5). It is a popular journal in which scientists are most likely to publish their articles. The others are: Habitat International (Elsevier), and the International Journal of Sustainability in Higher Education (Emerald Publishing) mentioned before.



**Figure 5.** Total number of citations per journal.

### 3.5. The total number of citations per paper

The most cited article has more than twice as many citations as other articles in the field (Figure 6).

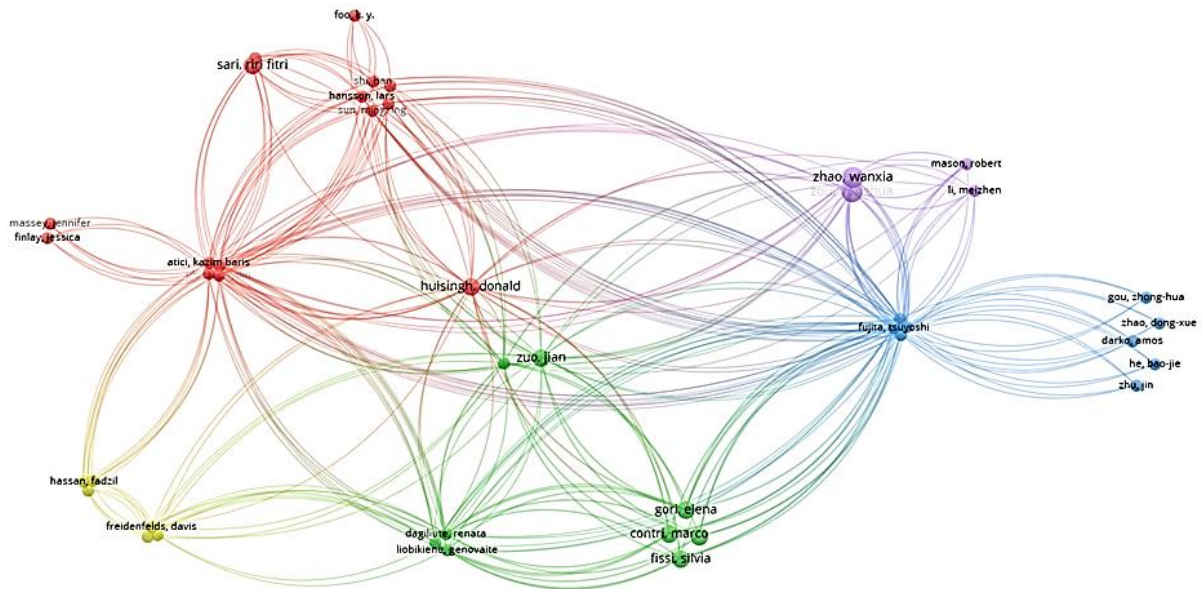


**Figure 6.** The total number of citations per paper.

The most cited article was published in the Journal of Cleaner Production in 2015 by researchers from the Netherlands. The title of the article is “Encouraging Sustainability in the Workplace: A Survey on the pro-environmental behaviour of university employees” (Blok et al., 2015). The research focuses on the identification of factors that have an impact on sustainable or pro-environmental behaviour. In second place is the article “Moving towards an ecologically sound society? Starting from green universities and environmental higher education” (Wang et al., 2013), published in 2013 by an international team from Asia, the USA, and Europe. The third one is “Creating and green university in China: case study of Shenyang University” (Geng et al., 2013) also published in 2013 by a team from China and Japan. The paper proposes an integrated model for the green university.

### 3.6. Scientific author cooperation

In Figure 7, we have tried to represent scientific collaboration between authors in the field of green universities. The authors with the greatest total link strength are presented in 4 clusters: the blue one represents researchers from Chinese universities, the green one represents researchers from Europe (Lithuania and Italy), the yellow one Malesia and Latvia, and the last one (red) represents international a team from Canada, Indonesia, Malesia, China, Turkey, United Kingdom.

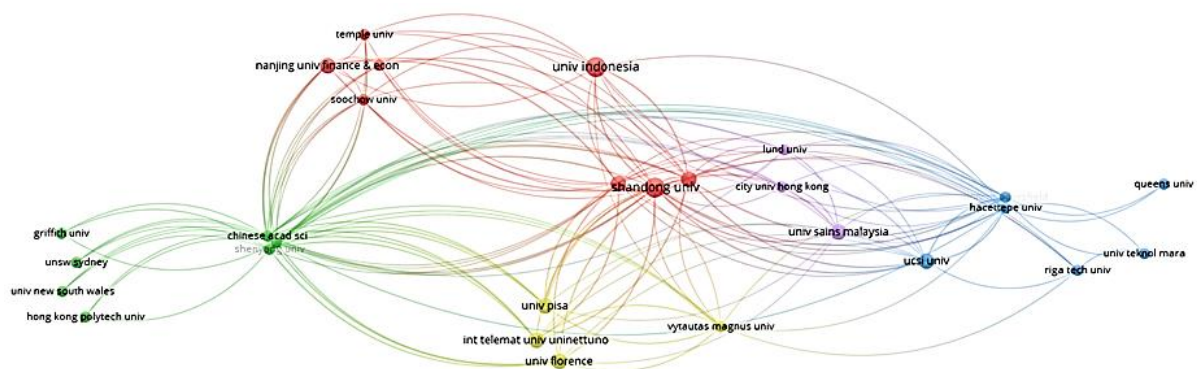


**Figure 7.** Scientific author cooperation.

The size of the dots in each cluster is similar, indicating that there is no world-leading centre for earth-based solutions at the university level.

### 3.7. Citations between universities

Another interesting issue is to consider the bibliographic connections between universities (Figure 8). For this analysis, a minimum of one document per university was chosen and a minimum of 10 citations per university. Finally, 44 universities were selected using VOSviewer.

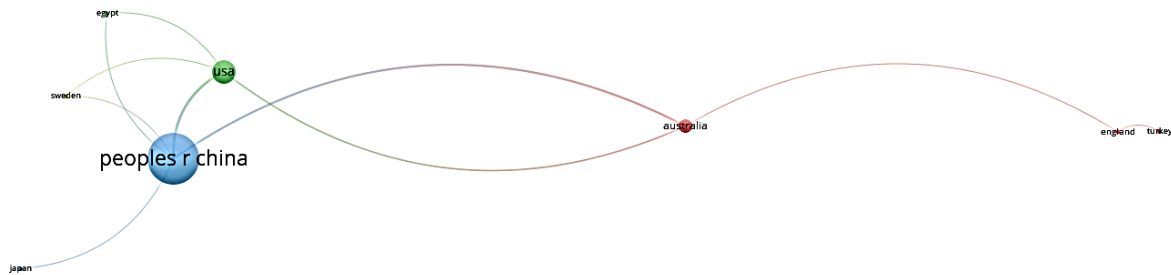


**Figure 8.** Citations between universities.

Asian universities represent the red cluster. Only a few universities from Europe appear in the yellow cluster (Italy). Universities from Australia and China are represented in the green cluster. The blue cluster represents international teams. We cannot say that some institutions from the same region and continent tend to connect more than institutions from other regions.

### 3.8. Co-authored documents by country

Do authors from individual countries share their experiences in the international field? The response is visualized in Figure 9.



**Figure 9.** Co-authored documents by country.

The lines of connection between individual universities are singular, which means that international cooperation has been singular. All these data are for the countries that the researchers are affiliated with. Here, we do not track their migration to research centres in other countries, which would undoubtedly be an interesting field of research.

## 4. Discussion and Conclusions

Universities are driving a creative and innovative approach to economic, social, and environmental change in line with the directions set by the SDGs. Green universities are higher education institutions that educate global citizens about the most important environmental challenges and shape their awareness, strive to minimize the environmental footprint of campus activities, and enable students and staff to understand and engage in ongoing research and development to work towards environmental sustainability and make it a priority.

This article aimed to conduct a bibliometric analysis of scientific publications on green universities from 2009-2022 (and early 2023) based on the WOSCC database. 82 articles were eligible for the final analysis, and their analysis and visualization were supported by Vosevier software. As a result of the bibliographic analysis, it was found that the concept of green universities is not popular - the number of publications in the period analyzed ranged from 0 in 2011 to 12 in 2013. It is also difficult to identify the leading research issues or changes in these issues over the years. The articles identified mainly concern approaches, methods, and tools for

the evaluation of green universities, case studies of the implementation of green universities and campuses, green curriculum content, or the adaptation of various concepts and frameworks in the process of creating green universities and campuses. As the research results show, there is a lack of leading research centres or research teams, and no significant international cooperation has been observed. It is also difficult to identify the leading journals, although it is worth emphasizing that those with the highest number of publications are characterized by a high IF. Unfortunately, this does not translate into high citability of publications in the area of green universities.

Although the results of the analysis are not optimistic, the current support of international institutions and the growing role of diversified and green behaviours of HEIs in rankings and accreditations make it worth supporting research processes in this area, and thus the process of green transformation of universities, which will be based on the results of sound scientific research results. In particular, our recommendations are the following:

1. Consideration of the subject of green universities in grant programs at the national and international levels. In particular, it is worth encouraging research in the field of existing practices in the area of green universities and the development of models, tools, and green measures of universities, which will allow for objective and systematic research on the advancement of HEIs transformation towards green and diversified universities.
2. Encouraging high-quality magazines and publications in the area of green transformation and sustainable development to prepare special editions devoted to the issues of green universities in general and in specific areas such as energy management, waste management, water management, and so on.
3. Organization of scientific conferences entirely or partially devoted to green universities.

The study presented in this research paper has certain limitations that are important to acknowledge. Firstly, the analysis primarily relied on data from a single database, the Web of Science Core Collection (WOSCC). While this database is comprehensive, it may not encompass all relevant publications on the topic of green universities. Future research could benefit from considering multiple databases to provide a more comprehensive view of the field.

Secondly, our analysis exclusively focused on English-language publications. While this was done to maintain consistency in the dataset, it may have excluded valuable research in other languages. To gain a more holistic understanding of the topic, it would be worthwhile to explore publications in other languages, allowing for a comparison of findings across different linguistic research streams. Furthermore, it's important to note that our analysis in this study is primarily quantitative. While quantitative analysis provides valuable insights into trends and patterns, future studies could greatly benefit from incorporating qualitative content analysis. Such an approach would enable researchers to delve deeper into the available definitions, models, tools, and measures related to green universities, providing a more nuanced understanding of the subject matter. Lastly, a promising avenue for future research would be to analyze publications in terms of their research methodologies and the identification of best



practices presented in selected publications. This qualitative aspect would offer valuable insights into the practical application of research findings within the context of green universities.

In conclusion, this study on green universities has yielded valuable insights into the evolving landscape of higher education institutions about sustainability and environmental responsibility. It is clear from this research that universities play a pivotal role in fostering global citizens with a deep understanding of environmental challenges and a commitment to sustainability. Furthermore, the findings of this bibliometric analysis shed light on the current state of research in this area. While the concept of green universities may not have gained widespread popularity, the support of international institutions and the increasing recognition of green practices in rankings and accreditations highlight the growing significance of this field. Moving forward, it is imperative to support research efforts in this domain to drive the green transformation of universities based on robust scientific foundations. Recommendations include the inclusion of green universities in grant programs, the promotion of specialized publications, and the organization of dedicated scientific conferences. These actions will not only enhance our knowledge of green universities but also facilitate their practical implementation, contributing to a sustainable and environmentally conscious future in higher education.

## References

1. Abdullah, S., Hamdan, H., Anuar, S. (2018, June). Supporting Sustainability and Healthy Learning Environment through Smart Green Management System (SGMS). *Journal of Physics: Conference Series*, Vol. 1019, No. 1, p. 012001. IOP Publishing.
2. Albrecht, P., Burandt S., Schaltegger S. (2007). Do sustainability projects stimulate organizational learning in universities? *International Journal of Sustainability in Higher Education*, Vol. 8, No. 4, pp. 403-15.
3. Al-Ghussain, L., Ahmad, A.D., Abubaker, A.M., Mohamed, M.A. (2021). An integrated photovoltaic/wind/biomass and hybrid energy storage systems towards 100% renewable energy microgrids in university campuses. *Sustainable Energy Technologies and Assessments*, Vol. 46, p. 101273.
4. Andargie, M.S., Azar, E. (2019). An applied framework to evaluate the impact of indoor office environmental factors on occupants' comfort and working conditions. *Sustainable Cities and Society*, Vol. 46, p. 101447.
5. Atici, K.B., Yasayacak, G., Yildiz, Y., Ulucan, A. (2021). Green University and academic performance: An empirical study on UI GreenMetric and World University Rankings. *Journal of Cleaner Production*, Vol. 291, p. 125289.

6. Bekessy, S.A., Samson, K., Clarkson, R.E. (2007). The Failure of Non-Binding Declarations to Achieve University Sustainability: A Need for Accountability. *International Journal of Sustainability in Higher Education*, Vol. 8, No. 3 pp. 301-316.
7. Beringer, A., Adomßent, M. (2008). Sustainable university research and development: inspecting sustainability in higher education research. *Environmental Education Research*, Vol. 14, No. 6, pp. 607-623.
8. Biasutti, M., Frate, S. (2017). A validity and reliability study of the Attitudes toward Sustainable Development scale. *Environmental Education Research*, Vol. 23, pp. 214-230.
9. Biggeri, M., Clark, D.A., Ferrannini, A., Mauro, V. (2019). Tracking the SDGs in an 'integrated' manner: A proposal for a new index to capture synergies and trade-offs between and within goals. *World Development*, Vol. 122, pp. 628-647.
10. Björk, B.C., Laakso, M., Welling, P., Paetau, P. (2014). Anatomy of green open access, *Journal of the Association for Information Science and Technology*, Vol. 65, No. 2, pp. 237-250.
11. Blok, V., Wesselink, R., Studynka, O., Kemp, R. (2015). Encouraging sustainability in the workplace: A survey on the pro-environmental behaviour of university employees. *Journal of Cleaner Production*, Vol. 106, pp.55-67.
12. Cai, Y.X., Ou, S.J., Chen, H.H., Chiu, C.C. (2019). Key strategies of sustainable and energy-saving development for green universities. In: IOP Conference Series: *Earth and Environmental Science*, Vol. 291, No. 1, p. 012018. IOP Publishing.
13. Chen, Y.L., Feng, X.P., Liu, Y.K. (2013). Research on Evaluation Index System and University's Green Degree Evaluation Model. *Applied Mechanics and Materials*, Vol. 357, pp. 2763-2767.
14. Chen, Y.L., Feng, X.P., Liu, Y.K., Tian, B. (2013). Green University Star Rating Evaluation Based on the Multi-Level Grey Approach. *Advanced Materials Research*, Vol. 807, pp. 312-315.
15. Claus, D. (2012). Integrating operations and research to demonstrate bioenergy heating at the university of Northern British Columbia. *Journal of Green Building*, Vol. 7, No. 1, pp. 3-16.
16. Collinge, W.O., DeBlois, J.C., Sweriduk, M.E., Landis, A.E., Jones, A.K., Schaefer, L.A., Bilec, M.M. (2012). Measuring Whole-Building Performance with Dynamic LCA: a Case Study of a Green University Building. *International Symposium on Life Cycle Assessment and Construction*, pp. 309-17.
17. Collinge, W., Landis, A.E., Jones, A.K., Schaefer, L.A., Bilec, M.M. (2013). Indoor environmental quality in a dynamic life cycle assessment framework for whole buildings: Focus on human health chemical impacts. *Building and Environment*, Vol. 62, pp. 182-190.
18. Corcoran, P.B., Wals, A.E. (2004). *Higher education and the challenge of sustainability*. Dordrecht: Kluwer Academic Publishers.

19. Cortese, A.D. (2003). The critical role of higher education in creating a sustainable future. *Planning for higher education*, Vol. 31, No. 3, pp. 15-22.
20. Dagiliūtė, R., Liobikienė, G., Minelgaitė, A. (2018). Sustainability at universities: Students' perceptions from Green and Non-Green universities. *Journal of Cleaner Production*, Vol. 181, pp. 473-482.
21. de Oliveira, R., Leitão, J., Alves, H. (2020). Corporate Governance and Sustainability in HEIs. In: *Introduction to Sustainable Development Leadership and Strategies in Higher Education*. Emerald Publishing Limited.
22. del Mar Alonso-Almeida, M., Marimon, F., Casani, F., Rodriguez-Pomeda, J. (2015). Diffusion of sustainability reporting in universities: current situation and future perspectives. *Journal of Cleaner Production*, Vol. 106, pp. 144-154.
23. Deloitte (2021). *Striving for balance, advocating for change*. Available online: <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/deloitte-2022-genz-millennial-survey.pdf>, 20 September 2022.
24. Dlimbetova, G.K., Bulatbayeva, K.N., Abenova, S.U., Fahrutdinova, G.Z., Khuziakhmetov, A.N. (2018). Management of ecologization of professional education. *Ekoloji*, Vol. 27, No. 106, pp. 1217-1225.
25. Dlimbetova, G., Abenova, S., Bulatbayeva, K., Fahrutdinova, G., Bakirova, K. (2019). Formation of Youth Readiness to the Development of Environmental Volunteering at University. *ARPHA Proceedings*, Vol. 1, p. 1193.
26. EC (2022). National expenditure on environmental protection, [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Environmental\\_protection\\_expenditure\\_accounts#](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Environmental_protection_expenditure_accounts#)).
27. El-Jardali, F., Ataya, N., Fadlallah, R. (2018). Changing roles of universities in the era of SDGs: rising up to the global challenge through institutionalising partnerships with governments and communities. *Health Research Policy and Systems*, Vol. 16, No. 1, pp. 1-5.
28. Finlay, J., Massey, J. (2012). Eco-campus: Applying the ecocity model to develop green university and college campuses. *International Journal of Sustainability in Higher Education*, Vol. 13, No. 2, pp. 150-165.
29. Fissi, S., Romolini, A., Gori, E., Contri, M. (2021). The path toward a sustainable green university: The case of the University of Florence. *Journal of Cleaner Production*, Vol. 279, p. 123655.
30. Foo, K.Y. (2013). A vision on the role of environmental higher education contributing to the sustainable development in Malaysia. *Journal of Cleaner Production*, Vol. 61, pp. 6-12.
31. Forbes (April 2021). *Gen Z Is Emerging As The Sustainability Generation*. Available online: <https://www.forbes.com/sites/gregpetro/2021/04/30/gen-z-is-emerging-as-the-sustainability-generation/>, 20 September 2022.

32. Freidenfelds, D., Kalnins, S.N., Gusca, J. (2018). What does environmentally sustainable higher education institution mean? *Energy Procedia*, Vol. 147, pp. 42-47.
33. Geng, Y., Liu, K., Xue, B., Fujita, T. (2013). Creating a “green university” in China: a case of Shenyang University. *Journal of Cleaner Production*, Vol. 61, pp. 13-19.
34. Gherheș, V., Cernicova-Buca, M., Fărcașiu, M.A., Palea, A. (2021). Romanian students’ environment-related routines during COVID-19 home confinement: water, plastic, and paper consumption. *International Journal of Environmental Research and Public Health*, Vol. 18, No. 15, p. 8209.
35. Gough, S., Scott, W. (2007). *Higher education and sustainable development: Paradox and possibilities*. London: Routledge.
36. Guo, J., Chen, Z.J., Tao, Z. (2013). To Build a Green University Library-Architectural Design of Hefei Institute Library. *Applied Mechanics and Materials*, Vol. 368, pp. 150-155.
37. He, B.J., Zhao, D.X., Zhu, J., Darko, A., Gou, Z.H. (2018). Promoting and implementing urban sustainability in China: An integration of sustainable initiatives at different urban scales. *Habitat International*, Vol. 82, pp. 83-93.
38. Heravi, G., Aryanpour, D., Rostami, M. (2021). Developing a green university framework using statistical techniques: Case study of the University of Tehran. *Journal of Building Engineering*, Vol. 42.
39. Heravi, G., Aryanpour, D., Rostami, M. (2021). Developing a green university framework using statistical techniques: Case study of the University of Tehran. *Journal of Building Engineering*, Vol. 42, p. 102798.
40. Hijazi, I. (2016). *Strategic Planning for the Transformation of a University Campus Towards Smart, Eco and Green Sustainable Built Environment: A Case Study from Palestine*. 10.3218/3774-6\_24.
41. Hindiyeh, M., Jaradat, M., Albatayneh, A., Alabdellat, B., Al-Mitwali, Y., Hammad, B. (2022). Sustainable Green University: Waste Auditing, German Jordanian University as a Case Study. *Front. Built Environ*, Vol. 8, p. 884656.
42. Holdsworth, S., Thomas, I.G. (2016). A sustainability education academic development framework (SEAD). *Environmental Education Research*, Vol. 22, pp. 1073-1097.
43. Hooi, K.K., Hassan, F., Mat, M.C. (2012). An exploratory study of readiness and development of green university framework in Malaysia. *Procedia-Social and Behavioral Sciences*, Vol. 50, pp. 525-536.
44. Huang, X.L. (2017). Green University: a new perspective on construction of heterogeneous competence of application-oriented Universities. *DEStech transactions on Social Science, Education and Human Science*.
45. Katiliūtė, E., Stankevičiūtė, Ž., Daunorienė, A. (2017). The role of non-academic staff in designing the green university campus. In: *Handbook of Theory and Practice of Sustainable Development in Higher Education* (pp. 49-61). Cham: Springer.

46. Kosiński, P., Skotnicka-Siepsiak, A. (2022). Possibilities of Adapting the University Lecture Room to the Green University Standard in Terms of Thermal Comfort and Ventilation Accuracy. *Energies*, Vol. 15, No. 10, pp. 3735.
47. Laengle, S., Lobos, V., Merigó, J.M., Herrera-Viedma, E., Cobo, M.J., De Baets, B. (2021). Forty years of Fuzzy Sets and Systems: A bibliometric analysis. *Fuzzy Sets and Systems*, Vol. 402, pp. 155-183.
48. Lewis, S.L., Maslin, M.A. (2015). Defining the Anthropocene. *Nature*, Vol. 519, No. 7542, pp. 171-180.
49. Li, H., Tao, M., Sun, Z. (2009, June). Research on the process evaluation of green university based on concordance analysis. In: *2009 Chinese Control and Decision Conference* (pp. 3599-3603). IEEE.
50. Li, H.W., Tao, M., Liao, X.L. (2010). Study on the Access Assessment on the Process of Building Green University. In: *2010 International Conference On Management Science And Safety Engineering (MSSE 2010)*. Vol. I and II. August 06-08, 2010, Yantai, China.
51. Li, Z., Chao, W. (2014). *Tentative Analysis on Fundamental Thinking and Realizing Approach of the Construction of Green University*. 11th International Conference on Innovation and Management (ICIM 2014). November 17-19, 2014, Univ Vaasa, Vaasa, Finland.
52. Liu, Y.K., Feng, X.P., Chen, Y.L. (2013). The Evaluation of Green University Based on Analysis Hierarchy Process. *Advanced Materials Research*, Vol. 726, pp. 1054-1058.
53. Liu, Y.K., Feng, X.P., Chen, Y.L. (2013). The Empirical Study on Evaluation of Green University. *Applied Mechanics and Materials*, Vol. 409, pp. 89-93.
54. Liyanage, S.I.H., Netswera, F.G. (2022). Greening Universities with Mode 3 and Quintuple Helix model of innovation–production of knowledge and innovation in a knowledge-based economy, Botswana. *Journal of the Knowledge Economy*, Vol. 13, No. 2, pp. 1126-1156.
55. Longo, M., Hossain, C.A., Roscia, M. (2013, December). *Smart mobility for a green university campus*. 2013 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), pp. 1-6.
56. Lukina, A., Skorobogatykh, I., Potravnyy, I., Kuznetsov, V. (2017). *The strategy of green university: Russian experience of implementation*. 2017 Tenth International Conference Management of Large-Scale System Development (MLSD), pp. 1-5.
57. Martek, I., Hosseini, M.R., Durdyev, S., Arashpour, M., Edwards, D.J. (2022). Are university “living labs” able to deliver sustainable outcomes? A case-based appraisal of Deakin University, Australia. *International Journal of Sustainability in Higher Education*.
58. Martínez, I., Zalba, B., Trillo-Lado, R., Blanco, T., Cambra, D., Casas, R. (2021). Internet of Things (IoT) as Sustainable Development Goals (SDG) Enabling Technology towards Smart Readiness Indicators (SRI) for University Buildings. *Sustainability*, 13(14), 7647.

59. Massimo, D.E., Fragomeni, C., Malerba, A., Musolino, M. (2016). Valuation supports green university: case action at Mediterranea campus in Reggio Calabrin. *Procedia-Social and Behavioral Sciences*, Vol. 223, pp. 17-24.
60. Mastercard (2021). Available online: <https://www.mastercard.com/news/europe/en-uk/newsroom/press-releases/en-gb/2021/april/mastercard-global-study-shows-that-post-pandemic-the-planet-comes-first/>, 20 September 2022.
61. McBeath, G.A., McBeath, J.H., Qing, T., Yu, H. (2014). *Environmental education in China's primary and middle schools*. In *Environmental Education in China*. Cheltenham, UK: Edward Elgar Publishing.
62. Meng, M.D., Trudel, R. (2017). Using emoticons to encourage students to recycle. *The Journal of Environmental Education*, Vol. 48, No. 3, pp. 196-204.
63. Menon, S., Suresh, M. (2022). Development of assessment framework for environmental sustainability in higher education institutions. *International Journal of Sustainability in Higher Education*.
64. Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Altman, D., Antes, G., ..., Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement (Chinese edition). *Journal of Chinese Integrative Medicine*, Vol. 7, No. 9, pp. 889-896.
65. Moore, T., Iyer-Raniga, U. (2018). Reflections of a green university building: from design to occupation. *Facilities*.
66. Mu, R., Liu, P., Song, Y., Cao, D., Zhan, L., Zuo, J., ..., Yuan, X. (2015, June). *Theory and Practice of Sustainability in Higher Education—From the Perspective of Green University*. 2015 Asia-Pacific Energy Equipment Engineering Research Conference, pp. 484-487.
67. National Union of Students of the United Kingdom (NUS-UK) (2018). Available online: <https://en.unesco.org/news/most-students-want-sustainable-development-part-all-university-courses-survey-reveals>, 20 September 2022.
68. Okanović, A., Ješić, J., Đaković, V., Vukadinović, S., Andrejević Panić, A. (2021). Increasing university competitiveness through assessment of green content in curriculum and eco-labeling in higher education. *Sustainability*, Vol. 13, No. 2, p. 712.
69. Ounsaneha, W., Chotklang, N., Laosee, O., Rattanapan, C. (2018). Predictors of behavior intention to develop a green university: a case of an undergraduate university in Thailand. *GEOMATE Journal*, Vol. 15, No. 49, pp. 162-168.
70. Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D. et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021.
71. Pandey, N., Diller, J.W., Miller, L.S. (2016). E-mailed prompts and feedback messages to reduce energy consumption: Testing mechanisms for behavior change by employees at a green university. *Journal of Organizational Behavior Management*, Vol. 36, No. 4, pp. 332-345.

72. Pedercini, M., Arquitt, S., Collste, D., Herren, H. (2019). Harvesting synergy from sustainable development goal interactions. *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 116, No. 46, pp. 23021-23028.
73. Pegus, P., Varghese, B., Guo, T., Irwin, D., Shenoy, P., Mahanti, A., ..., Hill, C. (2016, March). *Analyzing the efficiency of a green university data center*. Proceedings of the 7th ACM/SPEC on International Conference on Performance Engineering, pp. 63-73.
74. Pörtner, H.O., Roberts, D.C., Adams, H., Adler, C., Aldunce, P., Ali, E., ..., Fischlin, A. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. IPCC Sixth Assessment Report.
75. Pradhan, P., Costa, L., Rybski, D., Lucht, W., Kropp, J.P. (2017). A systematic study of sustainable development goal (SDG) interactions. *Earth's Future*, Vol. 5, No. 11, pp. 1169-1179.
76. Qdais, H.A., Saadeh, O., Al-Widyan, M., Al-tal, R., Abu-Dalo, M. (2019). Environmental sustainability features in large university campuses: Jordan University of Science and Technology (JUST) as a model of green university. *International Journal of Sustainability in Higher Education*.
77. QS (2021). Available online: [https://www.qs.com/portfolio-items/sustainability-in-higher-education-what-more-can-universities-do/?utm\\_source=website&utm\\_medium=blog](https://www.qs.com/portfolio-items/sustainability-in-higher-education-what-more-can-universities-do/?utm_source=website&utm_medium=blog), 20 September 2022.
78. Quacquarelli Symonds (2022). Available online: <https://www.qs.com/>, 20 September 2022.
79. Rajan, J., Fredeen, A.L., Booth, A.L., Watson, M. (2018). Measuring food waste and creating diversion opportunities at Canada's Green University TM. *Journal of Hunger & Environmental Nutrition*, Vol. 13, No. 4, pp. 573-586.
80. Rey-Martí, A., Ribeiro-Soriano, D., Palacios-Marqués, D. (2016). A bibliometric analysis of social entrepreneurship. *Journal of business research*, Vol. 69, No. 5, pp. 1651-1655.
81. Rochim, A.F., Sari, R.F. (2015, October). *Study on the correlation of web repository ranking to the green campus ranking of Indonesian Universities*. 2015 2nd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE), pp. 148-152.
82. Rome Communique. Available online: <https://erasmusplus.org.ua/novyny/3131-bologna-conference-in-rome-19-nov-2020.html>, 13 April 2022.
83. Shanghai Ranking (2022). Available online: <https://www.shanghairanking.com/>, 20 September 2022.
84. Sharma, P., Pegus II, P., Irwin, D., Shenoy, P., Goodhue, J., Culbert, J. (2017). Design and operational analysis of a green data center. *IEEE Internet Computing*, 21(4). pp. 16-24.
85. Sippel, M., Meyer, D., Scholliers, N. (2018). What about greenhouse gas emissions from students? An analysis of lifestyle and carbon footprints at the University of Applied Science in Konstanz, Germany. *Carbon Management*, Vol. 9, No. 2, pp. 201-211.

86. Siregar, S.V., Tenoyo, B. (2019). *Understanding Undergraduate Students' Perceptions on Green University*. 34th International-Business-Information-Management-Association (IBIMA) Conference; November 13-14, 2019; Madrid, Spain.
87. Sisriany, S., Fatimah, I.S. (2017, October). Green campus study by using 10 UNEP's Green university toolkit criteria in IPB dramaga campus. *IOP Conference Series: Earth and Environmental Science*, Vol. 91, No. 1, p. 012037. IOP Publishing.
88. Statista statistics/239158 (2022). Available online: <https://www.statista.com/statistics/239158/number-of-researchers-in-the-r-d-sector-per-million-inhabitants-in-china/>, 20 September 2022.
89. Steffen, W., Grinevald, J., Crutzen, P., McNeill, J. (2011). The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, Vol. 369, No. 1938, pp. 842-867.
90. Stevens, N., Bond, W., Feurdean, A., Lehmann, C.E. (2022). Grassy Ecosystems in the Anthropocene. *Annual Review of Environment and Resources*, Vol. 47.
91. Suwartha, N., Sari, R.F. (2013). Evaluating UI GreenMetric as a tool to support green universities development: assessment of the year 2011 ranking. *Journal of Cleaner Production*, Vol. 61, pp. 46-53.
92. Suwondo, D., Yunus, M. (2017, November). Integrating between Malay culture and conservation in Green campus program: Best practices from Universitas Riau, Indonesia. *AIP Conference Proceedings*, Vol. 1908, No. 1, p. 030014.
93. Tao, M., Li, H., Song, P. (2009). *Study on the Statistical Indicators System of the Process to Building Green University*. 2nd Conference of the International-Institute-of-Applied-Statistics-Studies, July 24-29, 2009, Qingdao, China.
94. Thongplew, N., Kotlakome, R. (2019). Getting a drink: An experiment for enabling a sustainable practice in Thai university settings. *Journal of Cleaner Production*, Vol. 218, pp. 294-303.
95. Thongplew, N., Duangput, N., Khodkham, S. (2021). Addressing plate waste and consumption practice at university canteens: realizing green university through citizen-consumers. *International Journal of Sustainability in Higher Education*.
96. Times Higher Education (2022). Available online: <https://www.timeshighereducation.com/>, 20 September 2022.
97. Tong, S., Bambrick, H., Beggs, P.J., Chen, L., Hu, Y., Ma, W., Steffen, W., Tan, J., (2022). Current and future threats to human health in the Anthropocene. *Environment international*, Vol. 158, p. 106892
98. Tsai, W.T. (2019). Environmental education policy for pursuing sustainable campus: experience from Taiwan higher education. *Environmental Engineering & Management Journal (EEMJ)*, Vol. 18, No. 3.



99. Tu, J., Hu, M.L. (2017, November). *Building on management model of modern green university. 2nd International Conference on Humanities Science and Society Development (ICHSSD 2017)*, pp. 391-396.
100. UI GreenMetrics (2022). Available online: <https://greenmetric.ui.ac.id/>, 20 September 2022.
101. UNEP (1972). *Declaration of the United Nations conference on the human environment*. Available online: <http://www.unep.org/Documents.Multilingual/Default.asp>, 20 September 2022.
102. Vaisi, S., Alizadeh, H., Lotfi, W., Mohammadi, S. (2021). Developing the Ecological Footprint Assessment for a University Campus, the Component-Based Method. *Sustainability, Vol. 13, No. 17*, p. 9928.
103. Valentukeviciene, M., Rynkun, G. (2016). Water reuse possibilities at students dormitories. *Rocznik Ochrona Środowiska, Vol. 18*.
104. Wang, J., Yi, F., Zhong, Z., Qiu, Z., Yu, B. (2021). Diversity and causality of university students' energy-conservation behavior: Evidence in hot summer and warm winter area of China. *Journal of Cleaner Production, Vol. 326*, p. 129352.
105. Wang, Q., Feng, X.P., Tian, B., Chen, Y.L. (2014). Green Campus Culture Construction of Green University. *Advanced Materials Research, Vol. 869*, pp. 980-985.
106. Wang, Y., Shi, H., Sun, M., Huisingh, D., Hansson, L., Wang, R. (2013). Moving towards an ecologically sound society? Starting from green universities and environmental higher education. *Journal of Cleaner Production, Vol. 61, No. 1-5*.
107. Wilkening, K. (2016). The University of Northern British Columbia's Green Fund: Crafting a Tool for Sustainability Transformation. In: *Challenges in Higher Education for Sustainability*. Cham: Springer, pp. 265-282.
108. World Commission on Environment and Development (WCED) (1987). *Our Common Future*. Oxford/New York: Oxford University Press.
109. Wu, C.H. (2021). An empirical study on discussion and evaluation of green university. *Ecological Chemistry and Engineering, 28(1)*, 75-85.
110. Wu, Chia-Huei (2021). An Empirical Study on Discussion and Evaluation of Green University. *Ecological Chemistry and Engineering, vol. 28, no. 1*, pp. 75-85. <https://doi.org/10.2478/eces-2021-0007>
111. Xiong, L. (2017, March). *The Application of green construction in the Universities in South China*. 4th International Conference on Renewable Energy and Environmental Technology (ICREET 2016), pp. 478-482.
112. Xue, F., Yan, G., Zhou, X., Xu, S. (2019, December). *Evolutionary Game Analysis of Green Building Promotion Mechanism Based on SD*. 2019 International Conference on Economic Management and Model Engineering (ICEMME), pp. 356-359.

113. Xue, Z., Liu, H., Zhang, Q., Wang, J., Fan, J., Zhou, X. (2019). The impact assessment of campus buildings based on a life cycle assessment–life cycle cost integrated model. *Sustainability*, Vol. 12, No. 1, p. 294.
114. Yadegaridehkordi, E., Nilashi, M. (2022). Moving towards green university: a method of analysis based on multi-criteria decision-making approach to assess sustainability indicators. *International Journal of Environmental Science and Technology*, pp. 1-24.
115. Yuan, X., Zuo, J., Huisingh, D. (2013). Green universities in China–what matters? *Journal of Cleaner Production*, Vol. 61, pp. 36-45.
116. Zalewski, J., Sybramanian, N. (2015, April). *Developing a green computer science program*. 2015 Seventh Annual IEEE Green Technologies Conference, pp. 95-102.
117. Zeng, Z.P., Zeng, X. (2017). *Research on the Advantages of Local Universities to Establish Green University Taking Linyi University as an Example*. International Symposium on Reform and Innovation of Higher Engineering Education; OCT 15-16, 2017; Chengdu City, China.
118. Zhao, K., Zhao, H. (2017, July). *Research on green university operation mode based on "Mercedes-Benz models"*. 2017 3rd International Conference on Economics, Social Science, Arts, Education and Management Engineering (ESSAEME 2017). Atlantis Press.
119. Zhao, W., Zou, Y. (2015). Green university initiatives in China: a case of Tsinghua University. *International Journal of Sustainability in Higher Education*.
120. Zhao, W., Zou, Y. (2018). Variation of greenness across China's universities: motivations and resources. *International Journal of Sustainability in Higher Education*.
121. Zou, Y., Zhao, W., Mason, R., Li, M. (2015). Comparing sustainable universities between the United States and China: Cases of Indiana university and Tsinghua university. *Sustainability*, Vol. 7, No. 9, pp. 11799-11817.