

IMPACT OF GREEN OPEN SPACES (GOS) ON SUSTAINABLE CAMPUS AND FUTURE ENVIRONMENTAL PRESERVATION IN A LITERATURE REVIEW

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Abstract

This article presents a system literature review that aims to analyze the impact of environmental damage caused by the lack of campus Green Open Space (GOS) that meets sustainable standards on environmental quality and the welfare of the campus community. Furthermore, this article discusses the impact of the lack of campus green spaces that do not meet sustainable standards on the future of the campus environment. Finally, this article explains how official policies in developing sustainable campus green spaces can influence environmental conservation efforts in the campus environment and its surroundings. The results of this study found that the impact of the lack of GOS on the campus environment includes a decrease in air quality, an increase in air temperature, and the risk of flooding, which can be detrimental to the campus environment. In addition, the negative impacts extend to people's well-being by affecting mental, emotional, and physical aspects, increasing the risk of disease, and lowering the overall quality of life. Sustainable practice initiatives, campus assessments, and policy implementation can positively impact students and create an environment that supports well-being.

Keywords: Sustainability, Green Open Spaces, Impact, Future, Campus.

1. INTRODUCTION

Important questions about GOS arise with the increasing trend of urbanization (Byrne & Sipe, 2010). The approach to green spaces and sustainable campuses involves a shift towards recognizing the role of nature in promoting environmental sustainability and well-being. The physical transformation of concrete-dominated landscapes into green havens has become a top priority for environmental sustainability in cities (Trencher et al., 2014). The increasing prevalence of climate change and its impacts on the environment and human health. These issues are further exacerbated by the impact of environmental degradation on overall well-being, academic performance, and retention rates, requiring immediate action to create an enabling environment.

This suggests that green spaces play a role in protecting urban schools from flooding and making the environment safer for future generations. Green spaces are thought to address the issue of awareness about the importance of maintaining environmental sustainability among students so that they can become agents of change who bring positive impacts to the environment and people (Wurianturi et al., 2022). Universities, as microcosms of big cities, recognize the importance of green spaces to improve environmental literacy and sustainable practices among students, helping them build a more environmentally friendly and sustainable future.

Green spaces not only address environmental concerns but also serve as strategic investments in the health and well-being of campus communities and the world as a whole (La Fua et al., 2022). Green spaces can also raise students' awareness about the importance of maintaining environmental sustainability so that they can become agents of change who have a positive impact on the environment and people around

them (Inggriani & Amrifo, 2020). Not only a short-term solution but also a step towards sustainable progress with long-term impact.

Previous studies on the impact of GOS on sustainable campus and future environmental preservation reveal that it has been recognized that existing studies have identified that GOS plays a crucial role in creating a sustainable campus environment and supporting student well-being (Anggraini et al., 2022; Mayona, 2019). The green campus concept, which integrates environmental development and campus development, has been adopted by several universities as an effort to realize sustainable development, with green spaces being one of its key indicators (Fatriansyah, et al., 2021).

Research at the National Institute of Technology (Itenas) Bandung shows that the presence of green spaces can increase the awareness and concern of the academic community for the environment, which is expected to be an example for other institutions in good environmental management (Mayona, 2019). However, there is still a lack of understanding of how green spaces can be integrated with existing campus infrastructure, as well as how they can be properly maintained to ensure long-term sustainability. Several studies have shown that community participation in green space management can improve the effectiveness and sustainability of green space management programs (Bonatti et al., 2022; Fatriansyah et al., 2021; Wicki, et al., 2021). Therefore, further research is needed to deepen the understanding of how green spaces can be integrated with existing campus infrastructure, as well as how community participation can be integrated into green space management to achieve sustainable campus and environmental preservation in the future.

Based on the analysis of the presence of green spaces and their impact on campus sustainability and environmental preservation in the future, the hypothesis is that the integration of green spaces in the concept of campus sustainability will have a positive impact on the environment and campus sustainability. Based on existing studies, green spaces have been shown to have positive effects on air quality by providing space for photosynthesis and pollutant absorption (Pagnini et al., 2023). Firstly, by exploring the future forms of sustainable campus green spaces, it is hoped that models that are effective in supporting environmental sustainability can be found.

Green space not only functions as the lungs of the campus that improve air quality and reduce pollution but also as a social space that enriches the life of the campus community. Second, the analysis of models for integrating campus greenspace with the concept of sustainability in the future is expected to provide insight into how greenspace can be an integral part of campus sustainability efforts. By integrating green spaces into campus infrastructure and policies, educational institutions can play an important role in reducing carbon footprints, improving air quality, and creating healthy ecosystems for campus communities.

Third, by identifying challenges or barriers in integrating green spaces in the context of a sustainable campus, it is hoped that solutions can be found that can overcome these barriers and strengthen the role of green spaces in supporting campus sustainability and environmental preservation in the future. Thus, this paper is expected to contribute to strengthening the understanding of the importance of green spaces in the context of campus sustainability and environmental preservation.

This paper aims specifically to analyze the impact of green spaces on campus sustainability and environmental preservation in the future. First, this paper will explore the forms of sustainable campus green spaces in the future. Second, this paper analyzes the model of integrating campus green spaces with the concept of sustainability in the future.

Third, this paper aims to identify what are the challenges or obstacles in integrating green spaces in the context of a sustainable campus. Fourth, it analyzes the positive impact of the future allocation of GOS on the Universitas Negeri Padang (UNP) campus. Thus, this paper will provide an in-depth understanding of the positive impacts of sustainable campus green space allocation with environmental preservation in the future, as well as provide insights related to the challenges that may be faced in implementing this concept. The novelty of this research is

- 1) **Holistic or Multifunctional Approach to Sustainable Campus at UNP:** This research not only focuses on the ecological aspects of green spaces but also incorporates social and aesthetic aspects. This creates a vision of the campus as a space that not only contributes to environmental sustainability but also provides added value for its inhabitants in various aspects of life; and
- 2) **Innovations in Green Space Management at UNP Campus:** By presenting findings related to the new renewable energy park on campus, this research opens up insights into innovation in green space management. This concept not only fills empty spaces but also contributes to education and inspiration towards sustainability practices among the campus community. By bringing these aspects together, this research contributes to a more holistic understanding of the role of green spaces in the context of a sustainable campus at UNP and enriches the literature with findings that can be applied in various global contexts.

2. LITERATURE REVIEWS

2.1 Green Open Space (GOS)

GOS is a concept that refers to open areas covered by vegetation, whether in the form of parks, gardens, urban forests, or agricultural land (Anggraini et al., 2022). According to the Department of Public Works and Public Housing, GOS has an important role in maintaining environmental quality and public health (Albaroza et al., 2021). One of the main benefits of green spaces is their effect on air quality, pollution reduction, and water absorption around the campus. Conditions show that green spaces on campus can help reduce air pollution and improve air quality around campus (Hadinoto et al., 2020). GOS is defined as an area dominated by vegetation, whether in the form of parks, urban forests, or agricultural land, which can contribute to carbon dioxide absorption and improved air quality (Anggraini et al., 2022).

According to experts, green spaces play an important role in mitigating the impacts of climate change by providing ecosystem services such as climate regulation, greenhouse gas sequestration, and biodiversity enhancement (Mayona, 2019). In addition, it also contributes to adaptation to climate change by providing areas that can reduce the risk of natural disasters such as floods and droughts, and increase the resilience of ecosystems and human communities to changing climatic conditions. GOS can be categorized into several forms, such as urban parks, green belts, urban forests, and urban farmlands.

Each type of green space has specific characteristics; for example, urban parks are often designed for recreation and aesthetics, while urban forests focus on biodiversity conservation and carbon sequestration (Anggraini et al., 2022).

Green belts, which usually surround urban areas, serve as buffers to prevent uncontrolled urban expansion and maintain environmental balance (Mayona, 2019). Urban agricultural land not only provides green space but also supports food security by producing food near its consumers. Each of these forms of green space has a role to play in mitigating the impacts of climate change in different ways, but all are important for improving adaptation to ongoing climate change (Mushtaha et al., 2022).

2.2 Sustainable Campus

The conceptualization of a sustainable campus can be interpreted as an effort to integrate environmental development and campus development, which aims to create an educational environment that supports the sustainability of natural resources and environmental quality. This definition includes campus management policies that are oriented towards environmental management, including activities to save water, paper, and electrical energy, provision of green spaces, and waste management by applying the 3R principle (reduce, reuse, recycle) (Anggraini et al., 2022).

The Sustainable Campus concept also includes social and economic aspects, such as community participation, industry involvement, and sustainable economic development (Mayona, 2019; Suciyani, 2018b). In this case, a Sustainable Campus can be interpreted as an effort to create a campus that is environmentally friendly, efficient, and economically and socially sustainable. Sustainable campuses are also expected to be an example of sustainable development in the surrounding environment, with the academic community acting as agents of change (Mohammed et al., 2022; Rinaldi et al., 2022).

The categorization of sustainable campuses can be seen through several indicators that are referenced in the UI GreenMetric World University Rankings, which include Arrangement and Infrastructure, Energy and Climate Change, Waste, Water, Transportation, and Education and Research (Mayona, 2019). Forms of Sustainable Campus can include campuses that use renewable energy, campuses that have efficient water and waste management systems, and campuses that have sustainable transportation. The type of Sustainable Campus also varies, ranging from campuses that focus on reducing carbon emissions to campuses that focus on sustainable economic development (Fatriansyah et al., 2021; Tudorie et al., 2020).

The characteristics of a Sustainable Campus that play a role in creating a sustainable campus include the use of green technology, community participation, and the development of sustainable policies and strategies (Sugiarto et al., 2022). In the context of green spaces, the Arrangement and Infrastructure category is important because it includes the need for GOS that function to support the sustainability of the campus environment.

Green spaces on campus play a role in water absorption, reducing air pollution, and providing habitat for biodiversity. In addition, the involvement of the academic community in maintaining green spaces shows an active role in good environmental management (Anggraini et al., 2022).

2.3 Environmental Preservation

The conceptualization of environmental conservation in the context of a sustainable campus can be interpreted as a systematic and planned effort made by higher education institutions to integrate sustainability principles in all aspects of campus management. According to experts, the Green Campus concept is an approach that prioritizes sustainable and sustainable campus management by taking into account environmental aspects to minimize and anticipate various environmental problems (Safarkhani & Örnek, 2022). Indicators of the creation of the green campus concept include the existence of campus management policies oriented towards environmental management, maintaining environmental cleanliness and comfort, and the concern and involvement of all elements of the academic community in a culture of environmental care (Tudorie et al., 2020). The categorization of environmental preservation in a sustainable campus can be seen in various forms, types, and characteristics. Forms of environmental conservation include the use of renewable energy, efficient water and waste management systems, and sustainable transportation. The types of sustainable campuses vary, from those that focus on reducing carbon emissions to those that focus on sustainable economic development. The characteristics of a sustainable campus that play a role in creating a sustainable campus include the use of green technology, community participation, and the development of sustainable policies and strategies (Mohammed et al., 2022). This also includes the provision and utilization of ideal green spaces, tailored to the campus population, as well as the use of environmentally friendly transportation systems (Cortese, 1997).

3. METHODS

This article uses a systematic literature review method. The purpose of this systematic literature review is to provide mapping, and identify gaps in understanding the topic to be studied, deepen knowledge about the field or topic under study, find out the research results of previous studies related to the topic of study, clarify research problems, and find out the methods proposed by other researchers to solve research problems (Al-Saleh & Arefin, 2023; Sugianto et al., 2022). Two key phrases in searching for this article are: first is the relationship between campus GOS and sustainability and second is the relationship between sustainable campus GOS and future trends and directions.

The four base data selected to compile this article were collected from various journal articles, book reviews, conference proceedings, and reports. The search process fogoser filtered relevant articles. Specifically, the databases focused on keywords based on the phrases specified in the abstracts. The databases that were screened were SAGE Journal, Science Direct, Springer, and Taylor & Francis. Fogoser search restrictions were made based on open access, environmental and sustainability disciplines, and text relevance. The chronology of this research was limited to 2019 to 2023. A careful inclusion and exclusion process was carried out on titles, abstracts, and full texts. First, it was filtered based on the title and its relevance to the search phrase and then filtered based on the abstract. Finally, the full text was screened for relevance to the research problem (Table 1). This article was collected from 47 articles based on 4 databases that were selected based on inclusion and exclusion criteria and added 3 additional articles from Google Scholar manually to determine their relevance to the specified phrase. The following Table 1 was found.

Table 1: Number of Research Articles obtained from databases; SAGE Journals, Science Direct, Springer Link, and Taylor & Francis

Database	Exclusion and Inclusion Criteria	Keyword Phrase	
		The relationship between campus GOS and sustainability	Sustainable campus GOS relations and the future
SAGE Journal	Search result	9,436	3,303
	Includes Open Access	698	338
	Includes Environmental Science Disciplines	36	57
	Included based on the full text	4	5
Science Direct	Search result	5,423	15,422
	Includes Open Access	1,365	2,512
	Includes Environmental Science Disciplines	97	434
	Included based on the full text	3	9
Taylor & Francis	Search result	5,873	7,260
	Includes Open Access	510	508
	Includes Environmental Science Disciplines	75	56
	Included based on the full text	11	6
Springer Link	Search result	20,051	7,260
	Includes Open Access	75	508
	Includes Environmental Science Disciplines	24	22
	Included based on the full text	6	3

Based on Table 1 above, it can be seen that the number of phrases that show the relationship between GOS and sustainability has a lot of relevant research and sustainable campus green space and the future shows a variety of search numbers. Based on the search results above, it can be seen that it includes several important aspects including;

- 1) This table contains search results from several different journal sources, such as SAGE Journals, Science Direct, Taylor & Francis, and Springer Link;
- 2) Each search result has the number of documents related to a particular keyword or phrase;
- 3) Some search results include information about open access and environmental science disciplines;
- 4) There is variation in the number of documents associated with a keyword or phrase in each journal source; and
- 5) This table provides information on the number of documents included in full text, the number of documents included by open access, and the number of documents included by environmental discipline.

Thus this table provides information about sustainable GOS access and environmental disciplines.

This paper not only uses references from SAGE Journals, Science Direct, Taylor & Francis, and Springer Link as international journals but also from national journals sourced from Google Scholar. The total number of search sources for this article is 50 pieces. consisting of 47 sources obtained from international sources and 3 from national sources. In addition, based on the searches from international and national journals from Fig 1, a flow chart can be prepared that illustrates the form of study literature sources used as references for writing this article. This aims to make it easier

for readers to understand the sources of literature obtained in writing this article. The following is a flowchart of the literature sources of this study based on Fig 1 below.

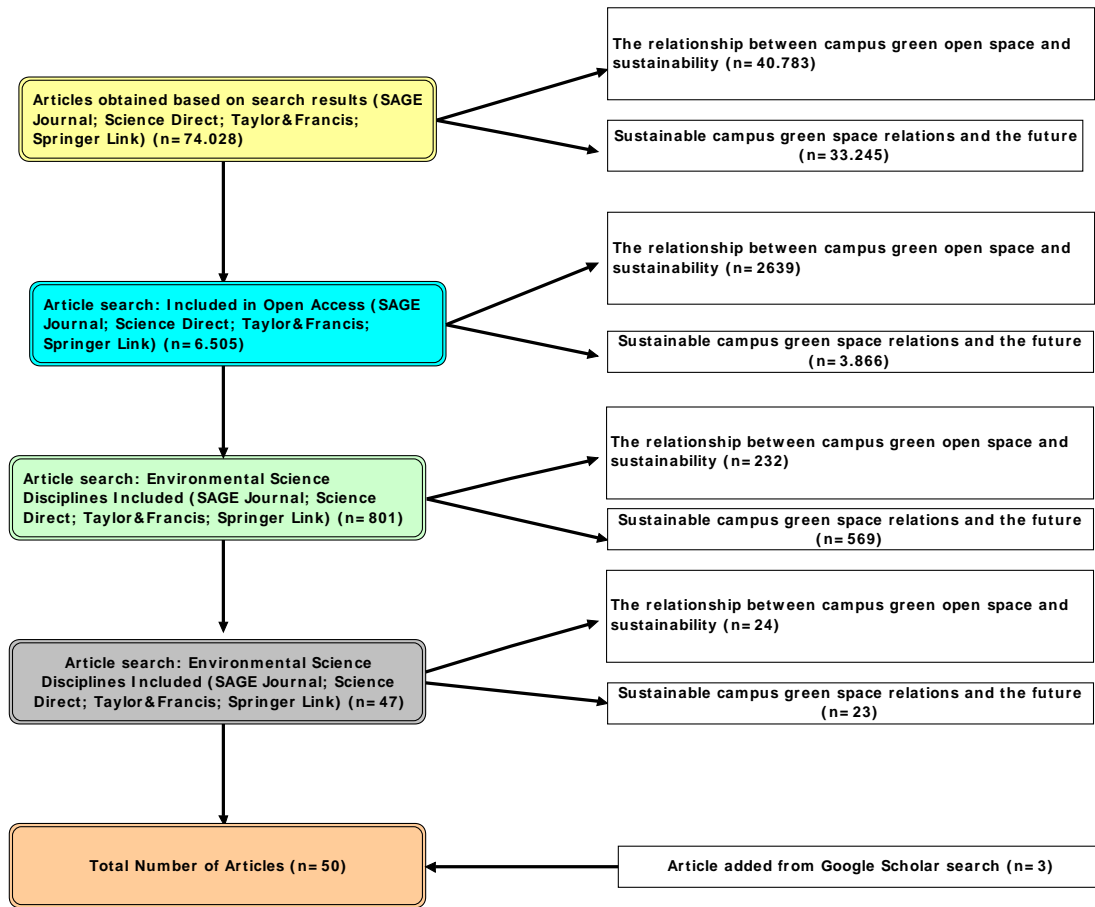


Figure 1: Flow Chart of Inclusion and Exclusion Criteria in Article Selection, n, Number of Articles

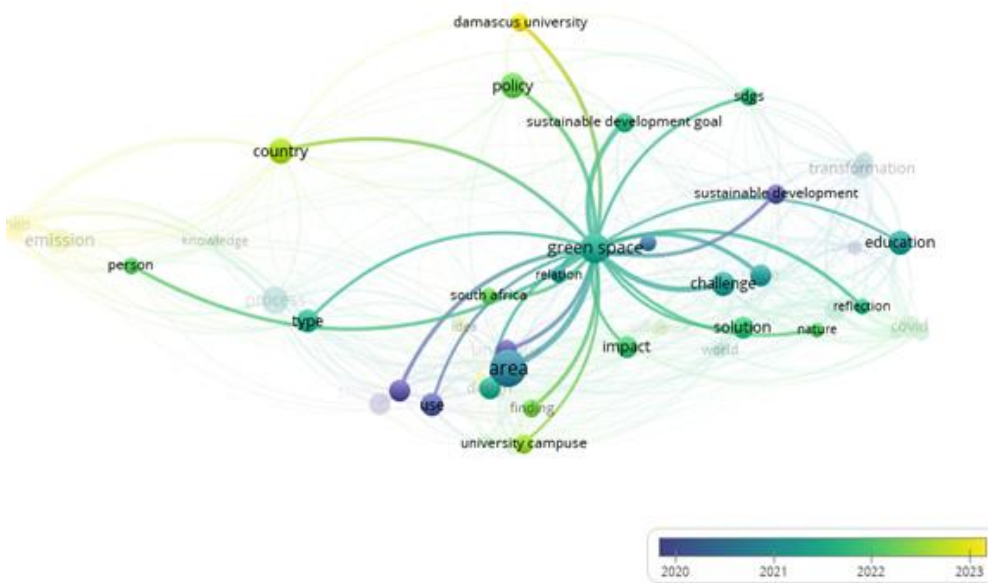


Figure 2: VOSviewer on Green Space, Sustainability, and Campus from 47 Sources Collected

Based on the Fig 1 and Fig 2 above the year limit is from 2023-2019. The yellow image shows the themes that are still recent and limited to be discussed. Based on the figure above, the most recently discussed theme is about campus in the 2023 distribution. The studies that have a large number of discussions are topics related to the area, sustainability, green space, policy, country, obstacles, challenges, and solutions. The analysis of the concept of sustainability of campus green space in the future is integrated into the allocation of green space on the UNP campus to provide solutions to the UNP campus green space problem based on the study literature. Four articles are used as references in understanding the UNP campus green space in the preparation of this paper.

4. FINDINGS

4.1 Future Forms of Sustainable Campus Green Spaces

Experts in the available literature emphasize the importance of developing sustainable campus green spaces by considering aspects of green technology, water management, and the use of environmentally friendly building materials (Pratama, 2019; Roosandriantini & Putra, 2021). In line with that, the concept of multifunctional green spaces is key (Ba et al., 2023; Wicki et al., 2021), where parks are not only used as places for recreation and sports but also play a role in the rainwater absorption system, which supports the sustainability of the campus environment. For example, at the Polytechnic of Jakarta State, research shows that existing green spaces should be maintained and enhanced to create a balance between development and the environment (Pratama, 2019).

Meanwhile, at the Polytechnic of Bandung State, the potential of GOS as a public space and open learning space is expected to be optimized by adding supporting facilities such as tables, chairs, and internet access (Suciyani, 2018b). This approach reflects a holistic vision in campus green space planning that not only pays attention to aesthetic and ecological aspects but also social and educational.

Based on these existing data sources, forms of GOS on campus can be categorized by considering various factors. Firstly, based on population, GOS should be designed to accommodate the high density of campus users, as presented in the form of the vertical campus forest at UKDC, which is a response to limited land and increasing campus users (Roosandriantini & Putra, 2021).

Secondly, in terms of function, GOS at Polban Campus is identified as having potential for additional functions such as socio-cultural, which includes public spaces and open learning spaces, demonstrating the importance of GOS as a means of supporting education and community activities. Thirdly, based on the area of public space, the existing green spaces at UKDC in the West and South have different areas, with the West only 8m² while the South is larger, reaching 180.75m², which shows variations in scale and potential utilization (Roosandriantini & Putra, 2021).

The strategic location of GOS on the Polban Campus, such as behind the MKU Canteen and around the Computer Engineering Building, shows the potential to be used as a public space equipped with supporting facilities such as tables, chairs, and internet access. Finally, the types of potential green spaces on campus also include aesthetic and economic aspects, which contribute to the creation of a comfortable, clean, and healthy campus environment (Suciyani, 2018; Wurianturi et al., 2022^b).

Based on the analysis of existing data, there is a tendency pattern that shows that future forms of sustainable campus green spaces tend to lead to the integration of ecological, social, and educational functions.

Some studies show that the development of green spaces does not only focus on aesthetic and environmental aspects but also on creating multifunctional spaces, which can support social and learning activities on campus. For example, at the Jakarta State Polytechnic Campus, the high Green Area Coefficient (GAC) value shows a commitment to the preservation of green spaces, which must be maintained to create a balance between development and the environment (Pratama, 2019).

Meanwhile, at Polytechnic of Bandung State, the campus green space was identified as having the potential to be used as a public space and open learning space, with the addition of supporting facilities such as tables, chairs, and internet access that would increase the utilization of green space as a place of interaction and learning (Suciyani, 2018b). In addition, the concept of vertical campus forests has also emerged as an innovation in the formation of sustainable green spaces, which allow vertical greening amidst the limitations of horizontal land (Pratama, 2019).

All of these data indicate a strong trend towards sustainable campus green spaces, which are designed to support a greener, more productive, and harmonious campus life with the environment. Based on Table 2 above description, it can be categorized as follows.

Table 2: Forms of Sustainable Campus GOS in the Future

No	Form of green space	Aspects of concern	Example of implementation	Challenges and solutions
1	Vertical Campus Forest	Campus user density,	UKDC land limitation	response to land limitation Challenge: Land limitation, Solution: Vertical innovation
2	Multifunctional green space	Additional functions such as social culture, public space and open learning	Additional functions such as socio-cultural, public space and open learning	Challenges: Lack of facilities, Solution: Addition of supporting facilities
3	Wide Variation of Public Spaces	Wide variation of green spaces	Potential utilization of UKDC, wide variation in the West and South	Challenges: Adequate arrangement, Solution: Utilization of strategic locations

4.2 Models for Integrating Campus Green Spaces with Future Sustainability Concepts

Data collected from various studies show that the model of integrating campus green spaces with the concept of sustainability in the future involves various innovative and multifunctional strategies. The table designed in the study by Pagnini et al (2023) highlights the use of green technologies such as green roofs and green walls that have proven effective in reducing the campus carbon footprint.

Images taken from the campus showing how smartly designed green areas can serve as social and educational spaces, while facilitating stormwater management. The matrix developed by Bezerra et al (2022) evaluates the performance of green spaces in terms of sustainability, biodiversity, and community engagement, showing that well-integrated green spaces can improve the overall quality of the campus environment.

Excerpts from interviews with campus managers conducted by Sanlloriente et al (2023) reveal that there is a growing awareness of the importance of green spaces as part of the educational infrastructure that supports sustainable learning.

Text excerpts from interviews with campus managers reveal that there is a strong desire to create green spaces that function not only as recreational areas but also as centers of community and educational activities that support environmental and social sustainability (Sanlloriente et al., 2023; Sugiarto et al., 2022). These models show that integrating green spaces with the concept of sustainability requires a holistic approach involving aspects of design, management, and campus community participation.

Integrating GOS on campus with the concept of sustainability in the future is the focus of research conducted at Polytechnic of Bandung State (Polban) and Polytechnic of Jakarta State (PNJ). At Polban, the potential utilization of green spaces is not optimal, with a lack of facilities that support socio-cultural, economic, and aesthetic functions (Suciyani, 2018a).

However, GOS at Polban has the potential as an open public and learning space that can accommodate various activities of campus residents, as well as support aesthetic and economic functions through planting cultivated plants (Suciyani, 2018a). Meanwhile, PNJ has managed to maintain a GAC value of 39.61%, which exceeds the minimum requirement of 20% determined by the Depok City Regional Regulation, showing a balance between development and the environment (Pratama, 2019). Both institutions demonstrate the importance of GOS in creating a sustainable campus environment (Jiang & Kurnitski, 2023), with Polban focusing on developing existing GOS potential and PNJ maintaining the standards already achieved.

There is a pattern of tendency indicating that integrating campus green spaces with the concept of sustainability in the future leads to the importance of improved facilities and more inclusive utilization of green spaces (Mohammed et al., 2022). Research conducted at Polytechnic of Bandung State revealed that the campus green space has not been optimally utilized, mainly due to the lack of facilities that support socio-cultural, economic, and aesthetic functions (Suciyani, 2018b).

This shows a tendency that the development of green spaces should involve the addition of infrastructure such as tables, chairs, weather protection, electricity networks, and internet to create public spaces conducive to the activities of campus residents (Amores et al., 2023). In addition, the study also suggested planting cultivated plants in the green space to support the economic function, which can produce products that can be consumed or sold.

The proposed model of integrating green spaces includes using green spaces as open learning spaces and improving campus aesthetics, which can become a campus icon while supporting environmental sustainability. Based on the description Table 3 above, it can be categorized as follows.

Table 2: Campus green space integration model with the concept of future sustainability

No	Study/Model	Findings/Imphasis
1	Pagnini et al. (2023)	<ul style="list-style-type: none"> - The use of green technologies such as green roofs and green walls is effective in reducing the campus carbon footprint. - Green areas are intelligently designed to serve as social and educational spaces. - Rainwater management is facilitated.
2	Bezerra et al. (2022)	<ul style="list-style-type: none"> - Green space performance evaluation matrix highlights sustainability, biodiversity, and community engagement. - Well-integrated green spaces can improve the quality of the campus environment
3	Sanllorente et al. (2023)	<ul style="list-style-type: none"> - Awareness is increasing about the role of green spaces as part of sustainable education infrastructure. - Desire to create green spaces as centers for community and educational activities.
4	Polytechnic of Bandung State (Polban)	<ul style="list-style-type: none"> - The potential utilization of green spaces is not optimal. - GOS has potential as an open public and learning space. - Focus on developing the potential of GOS.
5	Polytechnic of Jakarta State (PNJ)	<ul style="list-style-type: none"> - Has a KDH value of 39.61%. - Maintain a balance between development and the environment. - Plays a role in creating a sustainable campus environment.
6	Future Integration	<ul style="list-style-type: none"> - Trend towards improved facilities and inclusive utilization of GOS. - Need for additional infrastructure such as tables, chairs, weather protection, and internet. - Suggestions for planting cultivated plants in green spaces. - The integration model involves GOS as an open learning space and campus aesthetic enhancement.

4.3 Challenges or Barriers in Integrating Green Spaces in the Context of a Sustainable Campus

Based on existing articles, there are various challenges and barriers to developing sustainable campus green spaces. One of the main challenges is the limited land available on campus for the development of green spaces such as desert natural resources in Saudi Arabia (Mushtaha et al., 2022), and located in dense and limited urban areas (Wurianturi et al., 2022b), limited financial and professional knowledge of bio-based materials in green space construction (Dams et al., 2023), limited understanding of the benefits of green spaces and lack of support from campus management, limited understanding of the benefits of green spaces and lack of support from campus management in the green space planning and development process (Mohammed et al., 2022; Valks, Arkesteijn et al., 2020), and lack of participation from students and campus staff (Deleye, 2023; Gomez & Derr, 2021).

This can be seen from the indicators of the arrangement and infrastructure category in the UI GreenMetric World University Rankings 2018, where the percentage of campus areas that are forests and parks is still relatively low (Mayona, 2019). In addition, the lack of understanding and awareness of the importance of green spaces in the context of a sustainable campus is also an obstacle to the development of green spaces on campus (Anggraini et al., 2022). Based on the challenges faced by the t Polytechnic of Bandung State, an analysis of the potential utilization of GOS shows that the existing conditions have not been optimally utilized, mainly due to the lack of facilities that support socio-cultural, economic, and aesthetic functions (Suciyani, 2018a). Langmeyer found limitations on not only the provision of ecosystem services,

but also economic, structural, and institutional barriers to integrating GOS in the campus environment (Langemeyer et al., 2020). In addition, based on an interview with the Head of Assets and Housekeeping, the timing of GOS utilization is limited to campus operational hours, unless there is special approval for activities outside these hours (Suciyani, 2018a).

These challenges point to the need for improved infrastructure and policies that support more flexible and inclusive use of GOS, which can facilitate various activities of campus residents and strengthen the function of GOS as an open public and learning space. Individual awareness and participation in maintaining and caring for GOS is also an important factor in integrating GOS effectively, as positive perceptions of GOS can encourage behaviors that support environmental sustainability (Pratama, 2019).

Based on the data content, challenges or obstacles in integrating green spaces in the context of sustainable campuses, in general, have challenges in the form of the need for adequate spatial arrangements to create a balance between the natural and built environment, which is important to control rapid development (Byrne & Sipe, 2010; Pratama, 2019). While specifically caused by several aspects; first, caused by natural resources or nature (Fatriansyah et al., 2021; Mushtaha et al., 2022), second, limited finances and professional knowledge about environmental preservation (Sugiarto et al., 2022), third, lack of support from the local government, (Cortese, 2023; Price et al., 2021), fourth, lack of student and campus staff participation (Gomez & Derr, 2021), fifth, limited flexible and inclusive utilization of GOS (Mushtaha et al., 2022; Sandratama & Siswanto, 2018) Sandratama et al., 2018).

Sixth, the a lack of use of the latest technology and innovations in its management such as angi energy, electricity with renewable energy, and others (Puspa Artiani, 2019; Shandiz, Rismanchi, Foliente, & Aye, 2023). Seventh, there is still a lack of facilities and rules related to the application of green transportation on campus in the form of waste management, water management, and electrical energy management as obstacles in implementing the concept of an environmentally friendly campus.

The trend of data related to challenges or obstacles in integrating green spaces in the context of a sustainable campus shows that one of the main challenges is the non-optimal utilization of green spaces, such as what happened at the Polytechnic of Bandung State, where green spaces have not fully supported socio-cultural, economic, and aesthetic functions (Suciyani, 2018a). In addition, there is a time restriction on the utilization of green spaces that is only during campus operational hours, which limits the accessibility and flexibility of using green spaces as public spaces and open learning spaces (Suciyani, 2018b).

Adequate spatial planning is also a challenge, given the importance of creating a balance between the natural and built environment to control rapid development. Although there are institutions that have managed to maintain a GAC value above the minimum requirement, such as Polytechnic of Jakarta State with a GAC value of 39.61% (M. I. S. M. Pratama, 2019), there is still a need to improve comfort, beauty, and environmental sustainability through the establishment of effective green spaces (Roosandriantini & Putra, 2021).

These overall patterns suggest that concerted efforts are needed to overcome barriers to effectively integrating green spaces in campus environments. Based on the description Table 3 above, it can be grouped as follows.

Table 3: Challenges or Barriers to Integrating GOS in the Context of a Sustainable Campus

No	Source of Main Challenges	Challenges or barriers in integrating
1	Mushtaha et al. (2022)	Limited land on campus, especially in areas such as the desert SDA in Saudi Arabia.
2	Wurianturi et al. (2022b)	Location in dense and limited urban areas, causing limited land for green spaces.
3	Dams et al. (2023)	Limited financial and professional knowledge of bio-based materials in green space construction
4	Mohammed et al. (2022), Valks et al. (2020)	Lack of understanding of green space benefits and campus management support in planning and development..
5	Deleye (2023), Gomez & Derr (2021)	Lack of student and campus staff participation.
6	UI GreenMetric World University Rankings 2018	World University Rankings 2018 The percentage of campus area in the form of forests and parks is still relatively low.
7	Anggraini et al. (2022)	Lack of understanding and awareness of the importance of green spaces in the context of a sustainable campus.
8	Suciyani (2018)	The lack of facilities that support socio-cultural, economic, and aesthetic functions at Polban.
9	Langemeyer et al. (2020)	Economic, structural, and institutional barriers to integrating green spaces in campus environments.
12	Roosandriantini & Putra (2021)	It is necessary to increase comfort, beauty, and environmental sustainability through the establishment of green spaces.

4.4 GOS Condition of UNP Campus

Based on the article provided, the current condition of the GOS of the UNP campus can be explained that the UNP campus is located in Air Tawar Barat Village, Padang City, with alluvial rainfall because of its position less, because of its position less than 1 km from the coast. The UNP campus in Air Tawar before 1966 was community land that was gradually purchased by the campus. The land area of 26.9 ha was purchased in 27 plots along with land certificates (Aliman et al., 2017). The condition of the green space of the UNP campus still needs to be improved to maintain the sustainability of the campus environment in the future. According to the UNP Faculty of Social Sciences RENSTRA (2014-2018), environmental problems still found on the UNP campus include energy use, waste management, water management, and transportation management. In addition, research conducted by Puspa (Artiani, 2019) showed that obstacles in implementing the green campus concept on the UNP campus include a lack of awareness and participation from students and lecturers and a lack of support from the university. Therefore, there needs to be a more serious and integrated effort in developing the UNP campus green space to contribute significantly to the sustainability of the campus environment in the future.

Some areas are divided into certain clusters, the details of which can be seen in the UNP location cluster table based on the color of all 12 faculties in UNP (Aliman et al., 2017). Based on Artisna et al (2018); Yuzandi & Anhar (2022), it can be seen based on the main elements of the concept of an environmentally friendly campus owned by UNP. Some of the main elements are evaluated based on: 1) Land utilization: UNP has implemented the concept of an environmentally friendly campus by utilizing land for greening, arranging parks, and planting protective trees; 2) Energy management: There are problems related to energy use in the Faculty of Social Sciences UNP which has not used renewable energy; 3) Waste management: Waste management at UNP

is carried out by making reservoirs and providing trash bins in rooms and yards; 4) Transportation: The concept of green transportation has not been implemented due to the absence of facilities and regulations (Artisna et al., 2018).

Based on all the articles in this folder, there is a tendency pattern that shows that UNP faces challenges in managing GOS on its campus. Data shows that UNP has the potential to become one of the GOS in Padang City (Aliman et al., 2017). In addition, the results of the study also show that UNP has a green space area of 23%, which does not meet the ideal requirement of having 30% green space in each city (Artisna et al., 2018). This condition shows that UNP is experiencing problems related to the lack of green space, which can affect the balance of the ecosystem and the welfare of the campus environment which only has 1384 vegetation in 2022 (Yuzandi & Anhar, 2022). This indicates that the management and development of green spaces at UNP need to be improved to achieve better campus sustainability. In addition, there is a tendency to discuss the condition of GOS on the Universitas Negeri Padang (UNP) campus by arranging parks, increasing park areas, and increasing the number of shade trees in each faculty (Artisna et al., 2018). The articles highlighted the land area of GOS on the UNP campus, as mentioned in the Buana Journal "the land area for GOS is 40% of the total land area(Artisna et al., 2018)." In addition, the article also highlights the efforts made to increase greening and preserve the environment on the UNP campus (Artisna et al., 2018). Based on the description above, it can be grouped as follows.

Table 4: Condition of Green Spaces on the UNP Campus

No	Source of Information	Aspects Discussed
1	Aliman et al. (2017)	Cluster location of UNP based on the color of all faculties.
2	Artisna et al. (2018)	The main elements of UNP's environmentally friendly campus concept.
3	Puspadi et al. (2016)	Obstacles in implementing the green campus concept at UNP.
4	RENSTRA Faculty of Social Sciences (2014-2018)	Environmental issues at UNP: energy use, waste management, water management, transportation management.
5	Yuzandi & Anhar (2022)	The amount of vegetation at UNP in 2022 (1384).

5. DISCUSSION

5.1 Impact of Lack of GOS on Campus Environmental Quality

The lack of GOS in urban areas such as campus areas has a significant impact on environmental quality degradation, which is reflected in reduced air quality, increased microclimate temperatures, and disruptions to urban hydrological systems (Albaroza et al., 2021). Green spaces play an important role in absorbing pollutants and reducing air pollution, so a deficit of green areas can worsen public health conditions. The urban heat island phenomenon caused by the lack of green spaces causes a rise in temperature in urban areas, which not only reduces living comfort but also increases energy use for cooling (Pratama et al, 2021b). In addition, green spaces have a vital function in stormwater management, the lack of which can lead to increased surface runoff and a higher risk of flooding. Suboptimal implementation of green space policies, such as the one in Dumai City, shows that factors such as non-comprehensive planning, limited fund allocation, and lack of skilled human resources can hinder efforts to improve environmental quality through the provision of green spaces (Darlis et al., 2022). Therefore, local governments need to optimize the

planning and management of green spaces with a sustainable approach to ensure environmental and social well-being for city residents (Albaroza et al., 2021; Pratama et al., 2021^b).

The lack of GOS in the campus environment causes an increase in temperature and a decrease in comfort, which hurts academic activities and the welfare of the academic community. As a first impact, the lack of GOS can result in an increase in micro temperature on campus, as without adequate green areas, heat absorption by concrete and asphalt surfaces is higher, leading to higher air temperatures (Hadinoto et al., 2020; Iswanto et al., 2022; Suciyani, 2018a). As a result, the campus becomes vulnerable to the effects of heat and less comfortable for its occupants. In addition, the lack of green spaces can also affect the air quality around the campus, as green plants have an important role in filtering air pollutants and producing oxygen (Roosandriantini & Putra, 2021; Yuzandi & Anhar, 2022). With a lack of vegetation, air quality can decline, increasing the risk of respiratory-related health problems for students, staff, and visitors to campus. Therefore, efforts to increase and maintain GOS on campus are a must to support optimal environmental quality and the well-being of the campus community. Thus, the presence and management of adequate green spaces in the campus environment is important to maintain the balance of the built environment and ensure good environmental quality for all campus residents (Roosandriantini & Putra, 2021).

5.2 Planning the Integration of GOS in the Future Sustainable Campus

Planning for the integration of GOS in a future sustainable campus has significant multifunctional implications, covering social, ecological, and aesthetic aspects. Its real-world relevance can be seen in the case of the Polytechnic of Bandung State, where research has identified the potential of green spaces as public and learning spaces that support student activities, showing direct relevance to improving the quality of the academic environment (Suciyani, 2018a). In addition, the potential of campus green spaces is developed to support socio-cultural, economic, and aesthetic functions, so that green spaces can become campus icons and have the potential to produce products that can be sold and have implications for the welfare of its users and make a positive contribution to the surrounding environment (Suciyani, 2018a). This research provides a basis for more advanced change, as in the case of the development of a new renewable energy park, which not only utilizes vacant land but also contributes to the education and inspiration of the campus community regarding sustainability practices (Artiani, 2019; Quitzow & Rohde, 2022). The potential of the research is to guide recommendations for cross-sector partnerships, which can facilitate collaboration between universities and local or regional governments in promoting urban sustainability (Trencher et al., 2014). Finally, the research can serve as a basis for understanding larger issues, such as the role of universities in urban sustainability transformation, which includes challenging existing academic norms and incentive structures and promoting regional sustainability initiatives that can be adapted across different global contexts (Baker-Shelley et al., 2020; Trencher et al., 2014). This suggests that good sustainable Campus Green Spaces not only support the balance between the natural and built environment but also reinforce the Green Campus concept by providing conducive outdoor learning spaces supporting the reduction of global warming and addressing broader sustainability challenges at an urban and global level.

Planning for the integration of GOS for a future sustainable campus can be put forward through several steps; the first is to conduct a thorough analysis of the total land area and existing GOS area and calculate the GAC value to ensure compliance with applicable local regulations (Pagnini et al., 2023). This is important because rapid development on campus, such as what happened at the Polytechnic of Jakarta State (Pratama, 2019), can reduce the area of green space and affect the balance between the natural and built environment. Second, identifying GOS areas that have the potential to be developed into public spaces and outdoor learning spaces, as proposed at the Polytechnic of Bandung State (Suciyani, 2018b), can improve the socio-cultural, economic, and aesthetic functions of the campus. The third and final step is to equip the green space with supporting facilities such as tables, chairs, electricity networks, internet networks, weather protection, and garden lights to support social and academic activities and meet the ideal criteria for utilizing green spaces as public spaces and open learning spaces (Deleye, 2023; La Fua et al., 2022). The implementation of these steps will result in green spaces that not only fulfill regulatory aspects but also provide added value to the campus community and the surrounding environment.

5.3 Barriers and Challenges to Sustainable UNP Green Space Planning

GOS planning at UNP faces several obstacles and challenges that need to be overcome. One of them is First, the lack of well-integrated facilities and infrastructure, such as maintenance support facilities that are still the responsibility of each faculty. Secondly, the lack of vacant land that can be utilized for GOS development is also an obstacle, especially in meeting the GOS requirement criteria of 30% of the total campus area. The third challenge is the lack of specific planning for campus greening programs. The focus is the lack of support from all elements of UNP, including lecturers, students, and employees, in supporting UNP's GOS planning and development (Aliman et al., 2017; Artisna et al., 2018). The implication of these obstacles and challenges is the need for sustainable implementation of institutional policies and full support from the entire UNP academic community to achieve integrated and sustainable GOS development. This means that there is a lack of integration of facilities and infrastructure required for the maintenance of campus green spaces in the form of institutional policies. The implication of this obstacle is the potential disruption of the function and condition of UNP's green spaces as a whole. With the lack of integration of facilities, the maintenance of green spaces may not be optimized (Suciyani, 2018a). This condition can reduce the environmental and social benefits that can be obtained from the GOS. Therefore, it is important to improve coordination between various related parties in the management and maintenance of UNP green spaces to ensure that the functions and benefits of green spaces can be maximized by the entire campus community and the surrounding environment.

A sustainable UNP GOS development model can be developed with a holistic approach that involves aspects of design, management, and campus community participation. Data from various studies show that integrating UNP campus green spaces with the concept of sustainability in the future involves innovative and multifunctional strategies. The cause of the lack of integrated facilities and infrastructure required for the maintenance of UNP green spaces is the lack of awareness and active participation of the entire campus community in efforts to maintain and develop green spaces. The result is a lack of optimization in the maintenance of UNP green spaces. This can disrupt the overall function and condition

of the UNP GOS. In addition, the lack of awareness and active participation of the entire campus community can hinder the process of sustainable development of UNP GOS, resulting in the potential disruption of the UNP GOS ecosystem and reduced environmental benefits that can be obtained from the GOS.

5.4 Future Allocation Plan for Green Spaces in UNP

The implications of a concrete future allocation plan for green spaces at UNP can be seen in the case of the planning and development of green spaces on the UNP campus. The planning and development of green spaces at UNP can have significant positive impacts on the campus environment, such as improved air quality, reduced air temperature, and improved health and comfort for all campus residents (Artisna et al., 2018; Yuzandi & Anhar, 2022). In addition, these studies also show that active participation from the entire campus community, including students, staff, and administration, is essential in achieving campus environmental sustainability goals. Another implication is the importance of developing policies and regulations that support sustainable green space management, as expressed in Permen of ESDM No. 13/2012 on Environmentally Friendly Building (Muryati et al., 2022). Thus, the future GOS allocation plan at UNP has concrete implications in planning a sustainable and environmentally friendly campus environment, in line with implications from the literature that highlight the importance of sustainable GOS development and active participation from the entire campus community.

The allocation of GOS within the UNP campus must be carefully planned to ensure sustainability, diversity, and maximum benefit for the entire campus community. The UNP campus GOS allocation steps include; the identification of potential areas is an important first step, by conducting a thorough mapping to identify areas that can be used as GOS and prioritizing areas that can provide maximum impact. Diversification of GOS forms is also required, by determining various forms of GOS and ensuring compatibility between plant species, open space functions, and campus user needs. Integration of GOS with buildings is also a focus, by developing a spatial plan that integrates GOS with campus buildings and infrastructure and ensuring that each building has easy access to GOS. Community participation, sustainable maintenance and development, environmental education and awareness, utilization of green technology, and sustainable allocation of funds are also important steps in the GOS allocation plan within the UNP Campus (Aliman et al., 2017; Putra et al., 2021). These steps will ensure that the allocation of GOS at UNP not only provides optimal environmental benefits but also involves the entire campus community in the process of planning and developing sustainable GOS. With a well-thought-out allocation plan that involves the entire campus community, UNP Campus can create a green environment that is not only beautiful but also supports sustainability and environmental conservation.

6. CONCLUSIONS

The conclusions of the impact of GOS on the UNP campus in the context of sustainability and environmental preservation in the future can be found; 1) Understanding and emphasizing sustainable forms of GOS in the future opens up opportunities to create a greener and environmentally friendly campus environment; 2) Analysis of the model of integrating sustainable green spaces with holistic and multifunctional concepts can reveal the active involvement of the entire campus

community is key in realizing a sustainable campus; 3) Identification of challenges or obstacles in integrating green spaces shows that the allocation of increased awareness of the campus community, and optimal maintenance of green space areas are important focuses; and 4) Analysis of the positive impact of the allocation of GOS in UNP Campus can be found that investment in GOS can make a real contribution to the sustainability of the campus. Considering the findings from "Holistic Approach or Multifunctionality of Sustainable Campus at Universitas Negeri Padang Campus" and "Innovation in Green Space Management at Universitas Negeri Padang Campus," this conclusion confirms that holistic approach, innovation, and active community participation are key elements in designing a sustainable and environmentally friendly campus future. As for the recommendations given to increase the positive impact of green spaces on the UNP campus, it is necessary to make continuous efforts to increase environmental awareness, promote active participation from all stakeholders, and find sustainable funding sources. The use of green technology and innovation can be fuGOSer integrated to improve the efficiency and effectiveness of UNP's GOS management. Small steps such as tree planting, environmental cleaning activities, and educational programs can strengthen community involvement in maintaining the sustainability of UNP's green spaces. The ability of the UNP campus to overcome these challenges will set an example for other educational institutions in creating a sustainable campus environment and contributing to future environmental conservation.

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