Journal of Sustainability Perspectives

journal homepage: https://ejournal2.undip.ac.id/index.php/jsp/

Managing Green Space to Achieve Sustainability of Infrastructure at IPB University

Heriansyah Putra[*1,2], Febrian R Hidayat[2], Sutoyo[2], Ibnul Qayim[1], Anisa D Utami [1,3], Alim S Slamet[3]*

[1]*Office of Sustainable Campus Development, IPB University, Bogor, 16680 Indonesia*
[2]*Department of Civil and Environmental Engineering, IPB University, Bogor, 16680 Indonesia*
[3]*Faculty of Economics and Management, IPB University, Bogor, 16680 Indonesia*
*corresponding author: heriansyahptr@apps.ipb.ac.id

Article Info

Received:
05 June 2024
Accepted:
19 June 2024
Published:
28 June 2024

DOI:
10.14710/jsp.2024.24790

Presented at the 10th[th] International Workshop on UI GreenMetric World University Rankings (IWGM 2024)

Abstract. IPB University, Indonesia, has 18 campuses and is designed as a sustainable university. With a total area of 1669 Ha, IPB University has been beneficial in managing the massive area of campus site infrastructure. Managing the infrastructure development that considers the open space, including the forests, planted vegetation, and the ground surface for water absorption, is essential to achieve the sustainability of the infrastructure at IPB University. This paper presents the lessons learned from IPB University's campus setting in managing infrastructure development, focusing on developing open space, forests, and planted vegetation. Managing infrastructure development on campus to support the increasing number of students and the development of education, research, and campus activities faces various challenges. For this, IPB University provides a master plan as a policy and control system to ensure that all developed infrastructure has the goal of supporting campus activities and is highly considered for the sustainability of open spaces on campus.

Keywords:
Campus, forest, green space, infrastructure development, planted vegetation, sustainability

1. Introduction

IPB University has 18 campus locations spread across West Java, Banten, and Jakarta, with a total area of 1,669 hectares [1]. As a campus that embraces the concept of a living laboratory, IPB University develops various types of supporting infrastructure such as forests, farmlands, wetlands, teaching factories, and business units that provide students, staff, and lecturers with hands-on experience to make a more significant impact on society [2].

Since 2015, IPB University has also developed a green campus program [3]. This program is a form of IPB University's commitment to a sustainable campus that adopts environmental concepts with technology, personality, community, and programs that form an environmentally friendly lifestyle for all involved [3].

Various policies have been issued to control the development of campus infrastructure, starting with the preparation of the Campus Master Plan, which conceptually designs the green campus program of IPB University, the issuance of the declaration of IPB Dramaga Campus as a biodiversity campus [4,5] the carbon balance commitment toward 2030 [6], and the construction of several parks and the SDGs Lake [2]. In addition, infrastructure that carries the concept of green building has also been developed in various new building constructions, such as the AM Satari Building and BRI Work Building at the IPB University Dramaga Campus [7]. Educational institutions have two methods to implement the concept of sustainability on campus: campus greening and education on sustainability principles [8]. Campus greening is emphasized through the availability of green spaces on campus and restrictions on building areas. The development of green spaces on campus can positively impact the quality of teaching and learning activities [9,10]. In addition, *green space* is essential in improving groundwater quality, preventing floods, reducing air pollution, supporting macroclimate regulation, and creating microthermal comfort [11–13].

Population growth, massive scientific development, and increasing awareness of the importance of education are the main challenges for campuses in managing infrastructure and green space needs. Based on the Annual Performance Report of IPB University [7], IPB University experienced a 4.3% increase in the number of students in 2022, with a total of 32,768 students, most of whom were at the Dramaga Campus as the main campus of IPB University. The increase in the number of students will encourage the growth of infrastructure such as classrooms, laboratories, and other supporting facilities to maintain the effectiveness of the learning process. In addition, the increase in the number of students will require additional staff, including lecturers and education personnel. Therefore, the infrastructure development must consider the principle of sustainability that IPB University has adopted. Infrastructure planning and development on the IPB University campus must consider the availability of green space and be environmentally sound. Green spaces serve as a means to reflect the regional identity, as a place for research, education, and counseling, and as an area for active and passive recreation [14].

As a biodiversity campus, Dramaga Campus, the main campus of IPB University, makes green spaces a natural habitat for various plant and animal species. These green open spaces create ideal conditions for migration, breeding, and maintenance of populations of different species. By providing sufficient habitat, the campus can support the sustainability of local ecosystems and preserve biodiversity. Green spaces also play an important role as water catchment areas. It is one of the measures to prevent waterlogging, influenced by infiltration capacity. Efficient and proper management of green spaces can maintain the harmony of environmental ecosystems [15]. Therefore, maintaining and expanding green spaces at IPB University Dramaga Campus are crucial to preserving biodiversity and supporting a healthy ecosystem [16]. This study outlines IPB University's policy through the preparation of a Campus Development Master Plan. This plan aims to manage land use, monitor changes in green space, and forecast future requirements and alterations in green space at IPB University Dramaga Campus, in alignment with IPB University's Strategic Plan 2023 - 2028.

2. Methodology

This study was conducted to analyze the changes in open and green spaces on the IPB University Dramaga Campus, which is the main campus of IPB University and has an area of 267 ha [2]. This study used a variety of data, ranging from changes in land use of IPB University Dramaga Campus from 2019 to 2023, obtained from satellite imagery and drone mapping, IPB University Dramaga Campus Master Plan Map, to the number of IPB University civitas, consisting of students, lecturers, and educational staff.

The procedure for processing the study data included collecting data of satellite images of IPB University Dramaga Campus and the number of IPB's Civitas consisting of students, lecturers, and staff of IPB University Dramaga Campus in the last five years in the period of 2019-2023. The digitization process was performed to obtain the land use based on UI Green Metric criteria [17]. The green space ratio is fixed and compared to the requirement, which refers to the ideal green space by WHO, 50m^2 per person, by knowing the number of university civitas and the total area [18].

2.1. Satellite image collection

The satellite image collection procedure began with the Google Earth Pro application being opened and the location of the IPB Dramaga Campus being searched by utilizing the search feature. Once the area was found, the "historical imagery" feature was activated. Then, the time "slider" was moved to display imagery from various years, and the best quality imagery for each year from 2019 to 2023 was selected. When the imagery for each year was found, the area of IPB Dramaga Campus was zoomed in to get more details. The imagery was saved using the "save as" feature on the toolbar for each year with the maximum resolution (8192x4902) and all elements in the "map option" left blank. Each file was then saved with a clear and specific name, including the year of capture, to facilitate identification and further analysis.

2.2. Georeferencing

The procedure for georeferencing satellite images starts with preparing satellite image data for the IPB Dramaga Campus. Thus, control points were identified on the imagery to be referenced. Control points that were clear and easy to identify were selected using the placemark feature on the toolbar of the Google Earth Pro application. The control points were grouped in a folder and saved in *kml format. Once the control points were identified and their coordinates collected, the georeferencing process was carried out using ArcMap 10.8 software. Then, the *kml files of the control points were converted into layers using the conversion tools in ArcToolbox in the ArcGIS application. After that, the satellite imagery was loaded into ArcGIS, and the georeferencing process was carried out by adjusting the points on the satellite imagery with the converted control points in the form of layers. When all points were georeferenced, the georeferencing process ended with an update. The georeferenced imagery will become the digitized imagery in the following process.

2.3. Digitization

Digitization begins with the satellite image data resulting from the georeferencing process. After that, "Catalog" in the toolbox is opened, and the location of the file to be saved is selected. Then, "New" and "Shape File" are selected. The available toolbox is filled with the appropriate name, and choose Polygon as the "Feature Type." Next, change the coordinate system to a projected coordinate system: UTM WGS 1984 Zone 48S. After completing these steps, the "Editor" tool is selected, and "Start Editing" is performed. The "Editing Windows" tool was opened, and "Create Feature" was selected. Next, an area was created using

the "Polygon" type.

Digitize the areas of the IPB Dramaga Campus was performed according to land cover classification refers to the UI GreenMetric guidelines [17] and additional specific classifications, including:

1) Buildings: ground floor areas of university buildings on campus
2) Forest: areas covered by large trees and their natural and planted biodiversity for conservation purposes.
3) Plants: lawns, gardens, green roofs, and vertical gardens.
4) Ground Surface: soil, grass, concrete blocks, and synthetic fields.
5) Lake: a relatively large body of standing water.
6) Parking area: areas specifically designed for vehicle parking.

2.4. Green Space Change Analysis

The green space change analysis procedure begins with digitized satellite imagery data from various years of 2019 - 2023. These images are then processed according to the land cover area, resulting in a digitation process. The green space ratio value can be calculated using Equation (1), where GS is green space ratio (%), F for forest area (m^2), P for planted vegetation area (m^2), L for Lake area (m^2), and A is total campus area (m^2). Then, the change in green space is analyzed annually to evaluate evolution in green space areas over time, identify trends of increase or decrease, and the factors that influence them.

$$\mathrm{GS} = \frac{\mathrm{F+P+L}}{\mathrm{A}} \times 100\% \quad (1)$$

In calculating changes in green space in 2028, it is essential to pay attention to the value of the Green Base Coefficient (GBC) in the construction of new buildings, given that in the IPB master plan, the new building construction area is still in the form of a site. The minimum GBC value is seen from the Bogor Regency Regent Regulation Number 92 of 2018 concerning Technical Guidelines for General Provisions of Zoning Regulations for Space Utilization in Bogor Regency [19]. In addition, analyzing green space needs begins with collecting IPB community data as the basis for calculation. IPB community data for 2028 was obtained from projections based on the IPB Strategic Plan 2024-2028 [20]. Furthermore, the number of Civitas is multiplied by the ideal green space recommended by WHO, which is 50 m^2 per person. This value is then divided by the total area of IPB Dramaga Campus to get the percentage of ideal green space required. This process ensures that the ideal green space requirement is calculated accurately following the projected growth of the IPB community. The Equation (2) used in the calculation of campus green space requirements is based on the ideal value of green space according to WHO in Russo and Cirella [18,21–23].

$$\mathrm{IGS} = \frac{\mathrm{C \times R}}{\mathrm{A}} \times 100\% \quad (2)$$

where:

IGS : Ideal green space (%)
C : Civitas IPB (people)
R : WHO ideal green space /person: (50 m^2/ person)
A : Area of IPB Dramaga Campus (m^2)

3. Results and Discussion

3.1. IPB University Sites

IPB University manages various lands scattered in West Java, Banten, and Jakarta. IPB University manages land in 18 locations with ownership status by IPB University (The Ministry of Education, Culture, Research, and Technology), the provincial government, and the Ministry of Environment and Forestry. These lands cover various uses, including land for education, research, and conservation activities. Land use in each location differs from the Dramaga campus, the center of academic activities, to Tinjil Island, a conservation area. The location of IPB University and its area details are depicted in Figure 1 and Table 1, respectively.

IPB Dramaga Campus is the main site of IPB University's activities. This campus is the fourth largest area, with a total area of 267 Hectares. The map demonstrates the area's role as a conservation area that must be maintained and preserved. However, there are significant differences in land distribution and function among the sites managed by IPB University, as seen from the IPB Ancol Marine Science Lab, which has a minimal total area of only 0.44 Hectares. Of this area, the green space owned only reaches 0.08 Hectares.

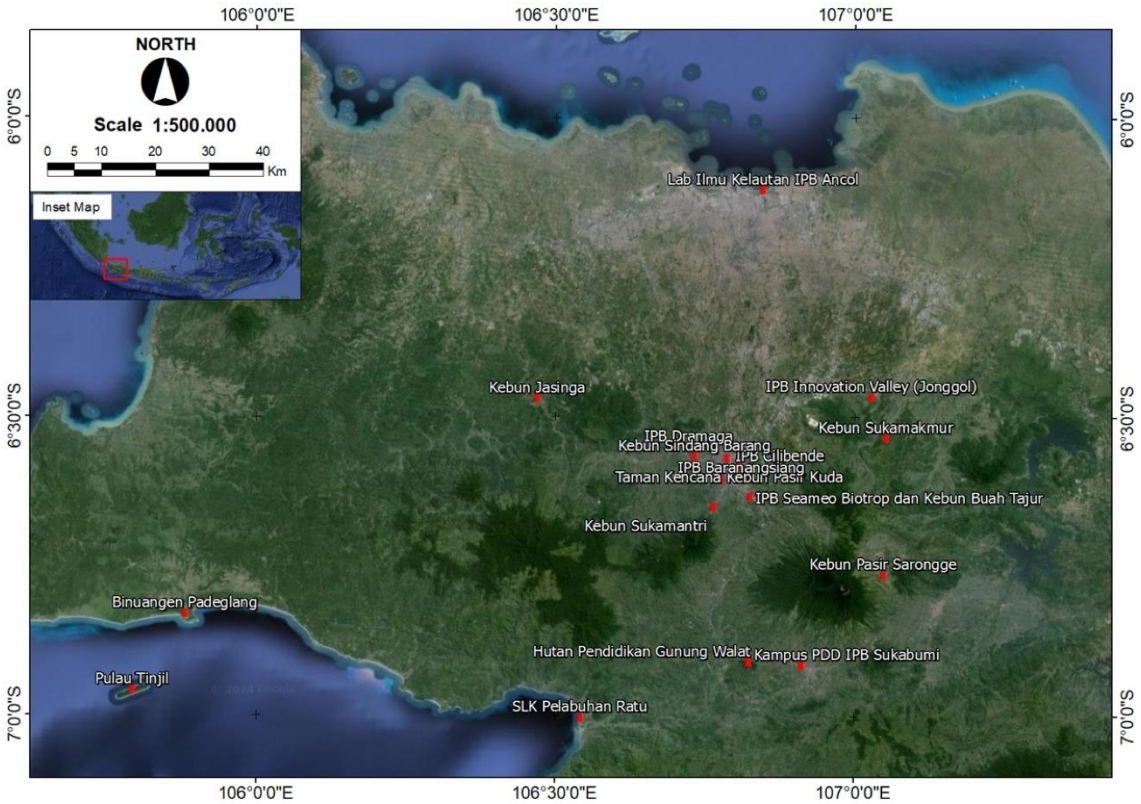

Figure 1. Distribution of IPB Dramaga Campus land location

In contrast, the Tinjil Island, where the entire land area of 590 hectares, can be classified as green space. A comparison of the open space and green space on IPB University lands shows that almost all locations have a high proportion of green space, which follows the principles of sustainability and environmental conservation held by IPB University. For example, the IPB Innovation Valley in Jonggol has a total area of 268.66 Hectares, with 257.54 Hectares of green space. Other locations, such as Gunung Walat University Forest, also show the same proportion; almost all of the land is dedicated to green space, which is 358.18

Hectares out of a total area of 359 Hectares. IPB University's land management shows varied differences depending on the needs and characteristics of the location but overall indicates a strong commitment to environmental preservation and green space conservation. The total land area of IPB University reaches 1,668.73 Hectares, of which the majority, 1,608.17 Hectares (96.37%), is open space, and 1,560.93 Hectares (93.54%) is green space. These facts reflect IPB's strong commitment to providing green space that is important to support the local ecosystem and the welfare of the IPB community.

Tabel 1. Area of IPB University Campus

Sites	Area (Ha)		
	Total	*Open Space*	*Green Space*
IPB Dramaga, Bogor Regency	267	231.09	208.61
IPB Baranangsiang, Bogor City	11.42	6.66	3.43
IPB Cilibende, Bogor City	14.75	10.93	8.29
Taman Kencana, Bogor City	3.46	2.48	1.49
SLK Pelabuhanratu, Sukabumi Regency	5.23	3.47	2.36
Binuangen Padeglang, Banten	0.30	0.20	0.14
Gunung Walat Eduacation Forest, Sukabumi	359	358.37	358.18
Pasir Sarongge Farm, Cianjur	7.16	6.76	6.28
Sukamantri Farm, Bogor Regency	39.21	33.73	32.63
Sindang Barang Farm, Bogor City	10.91	9.55	8.63
IPB *Innovation Valley*, Bogor Regency	268.66	266.80	257.54
IPB Seameo Biotrop and Tajur Farm, Bogor Regency	20.42	17.64	15.52
Pasir Kuda Farm, Bogor Regency	1.86	1.83	1.78
IPB Sukabumi Campus, Sukabumi	20.40	19.91	18.41
Sukamakmur Farm, Bogor Regency	17.77	17.76	17.69
Lab Ilmu Kelautan IPB Ancol, Jakarta	0.44	0.29	0.08
Jasinga Farm, Bogor Regency	30.74	30.69	29.86
Tinjil Island, Banten	590	590	590
Area (ha)	**1668.73**	**1608.17**	**1560.93**
Area (%)	**100**	**96.37**	**93.54**

3.2. Land Use of IPB Dramaga Campus

IPB University stated that by 2023, 96% of its area would be *open space*, consisting of 52% forest and 41% vegetation [1]. The total number of the IPB University community was 36,163, most located on the main Dramaga Campus. The land use in Dramaga Campus, the main campus of IPB University, is shown in Figure 2. In 2023, IPB University Dramaga Campus was recorded to have 86.55% *open space* and 78.13% *green space*. Open space consisted of forests, vegetation, lakes, roads, parking lots, and ground surfaces. Green space is a part of open space that consists of forests and vegetation. IPB University Dramaga Campus offers a natural environment of 34.12% forests, 44.67% plants, and 0.69% lakes for research that can benefit various fields of study. For example, ecology researchers can conduct experiments in the university's forests, while researchers studying wastewater treatment can use the university's wetlands as a research site [2].

In addition, IPB Dramaga Campus provided infrastructure in the form of parking lots with an area of 1.46% and roads with an area of 4.53% to facilitate mobility and accessibility

for all campus civitas. A ground surface of 1.78% was part of the open space, not included in the classification of forests, vegetation, lakes, roads, and parking lots. The existing buildings on the IPB University Dramaga Campus amounted to 12.75% of the total 267 ha because buildings on campus play a vital role in supporting various academic and non-academic activities. The buildings serve as a place for learning and teaching and as centers for student activities, research, and educational community development.

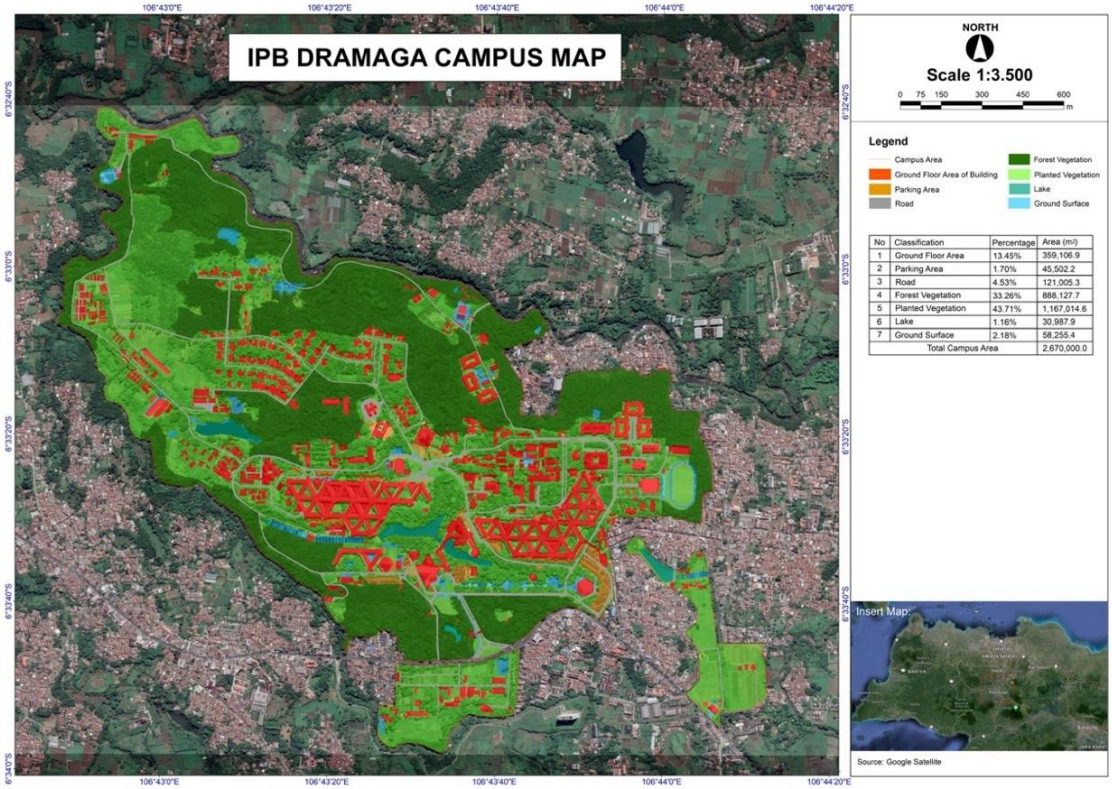

Figure 2. Land use map of IPB University Dramaga Campus

3.3. Changes on the Civitas and its impact on green space

The large number of students at IPB University means that many facilities need to be built, which affects the area of green space on the Dramaga Campus of IPB University. The changes in the amount of IPB's Civitas and the green space area on the Dramaga Campus in 2019 - 2023 are shown in Figure 3. Figure 3 shows that the number of students tends to be relatively stable each year. However, there was a decrease in 2023, so the total number of students, lecturers, and staff was 24,190. This decrease in the number of students occurred during the COVID-19 pandemic. Based on the strategic plan of IPB University for 2028, there should be an increase in the number of students, lecturers, and staff to reach 33,129, so efforts must be made to maintain the academic performance of IPB University [7,24,25].

Reputation is essential in educational institutions, as a good reputation brings various benefits to the institution, including a positive view from the public. Along with the diversity of universities nationwide, many higher education institutions have become known as campuses with the most significant number of students in Indonesia [26]. According to the QS Ranking [27], IPB is ranked 22nd out of 40 universities in the category of the most significant number of students. Meanwhile, Universitas Brawijaya (UB) ranks first with a total of 48,546 students, followed by Universitas Gadjah Mada (UGM) with 39,209 students and Universitas Muhammadiyah Malang (UMM) with 38,629 students.

The presence of students in an institution has a positive impact on supporting academic achievement. The campus can increase revenue from tuition fees and other resources with many students. The additional revenue can be reinvested to improve academic facilities and programs, thus improving student achievement. According to Arthon et al. [26], the quality of an educational institution's output, represented by students, is one of the main factors in building the institution's good reputation. Therefore, maintaining the quality of education and student learning experience is crucial to maintaining a good university reputation.

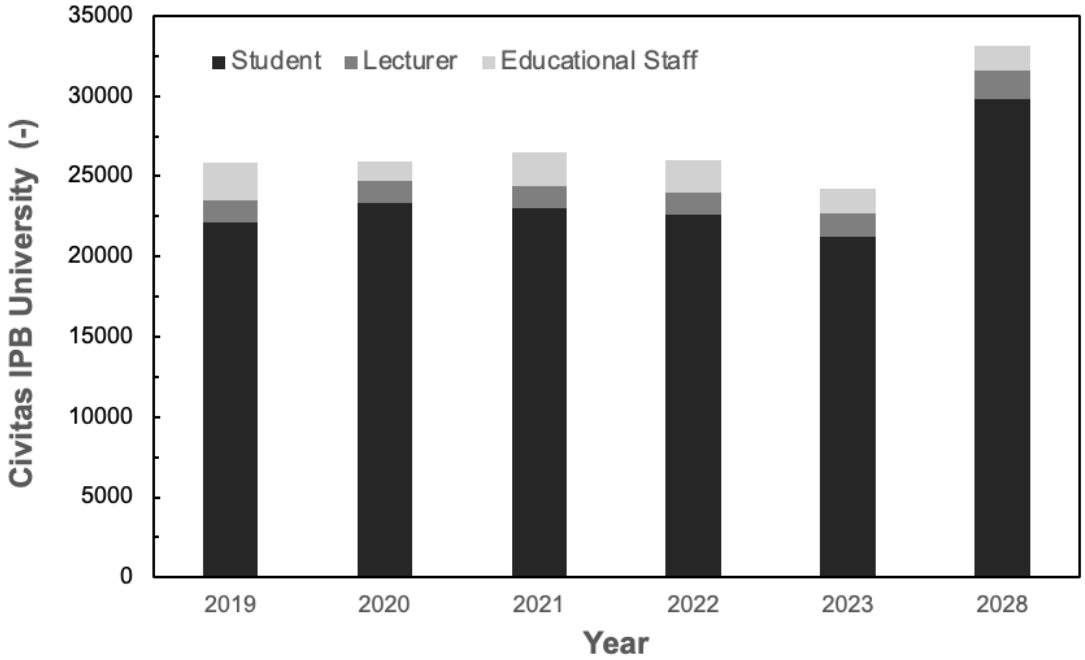

Figure 3. Changes in the Civitas of IPB University *on* the Dramaga Campus of IPB University

Tabel 2. The landuse changes at IPB Dramaga Campus 2019 - 2023

Landuse	**Area (%)**				
	2019	**2020**	**2021**	**2022**	**2023**
Building	12.75	12.84	13.20	13.37	13.45
Road	4.53	4.53	4.53	4.53	4.53
Parking area	1.46	1.52	1.61	1.61	1.70
Ground surface	1.78	1.90	2.08	2.17	2.18
Forest vegetation	34.12	34.08	33.46	33.29	33.26
Planted vegetation	44.67	44.47	44.39	43.93	43.71
Lake	0.69	0.65	0.74	1.11	1.16
Total	100	100	100	100	100

The increasing number of students at IPB Dramaga Campus proposed increasing facilities to support education, research, and other campus activities. Thus, new construction is required. Hence, this phenomenon affects the IPB Dramaga Campus's land area. The results of the detailed analysis of changes in the land use area at IPB Dramaga Campus from 2019 to 2023 are detailed in Table 2.

Figure 3 shows a downward trend in green space area each year. However, the green space area at IPB University's Dramaga Campus was still above the ideal minimum green space area requirement for the last five years, as shown by the dotted line in Figure 4. Data on changes in green space at IPB Dramaga Campus from 2019 to 2023 shows a downward trend that is important to note. The area of forests and plants experienced a significant decrease during this period. The reduction in forest area amounted to 2.28 Hectares (0.85%), and plant area to 2.58 Hectares (0.92%). The construction of new infrastructure facilities, such as the construction of the new FEM building, AM Satari building, swimming pool facilities, and other facilities caused this. Meanwhile, the lake area has almost doubled, from 1.84 hectares (0.69%) to 3.10 hectares (1.16%), one of the causes of which is the construction of the SDGs lake. Although the green space area decreased by 3.60 hectares (1.35%), the value is still above the ideal requirement shown by the gray dot in Figure 4.

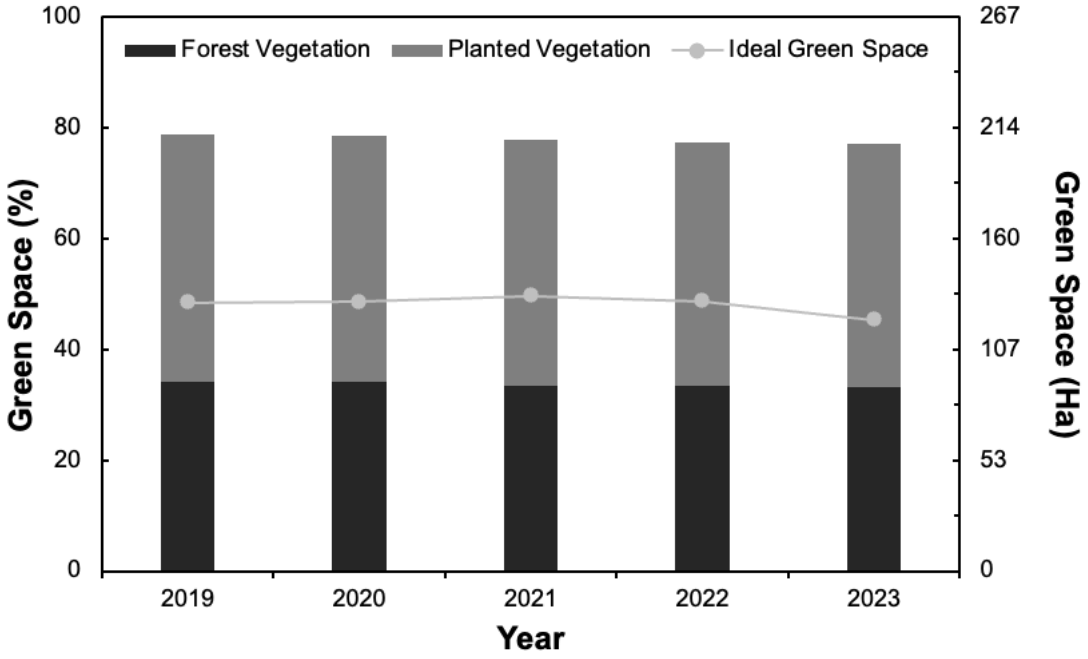

Figure 4. Changes in *green space* area *on* the Dramaga Campus of IPB University

IPB University has established living laboratories outside the main campus to reduce development pressure. IPB University provides living laboratory infrastructure on many campuses, including Dramaga, Sukabumi, Jonggol, Taman Kencana, and Baranangsiang. The Gunung Walat University Forest in Sukabumi and the Jonggol Teaching Farm are the main facilities for learning, research, and business in forestry, the site for the study of Sorinfer (fermented feed product for ruminants made from Sorghum and Indigofera) and a mini palm oil mill, and provide the Agribusiness Technology Park and Serambi Botani Outlets as marketing points for IPB University's innovative products [2]. Through these living laboratories, IPB University creates opportunities for research and innovation and mitigates the negative impacts of overdevelopment on the main campus. By allocating research and development activities off-campus, IPB University can maintain the sustainability of the environment around the main campus while still providing opportunities for the continued development of science and technology. Although living laboratories have been established outside the main campus, development continues on the main campus. Infrastructure development on the Dramaga Campus of IPB University requires special attention, especially concerning

changes in existing green spaces, to ensure the campus's sustainability and support the vision of IPB University as a sustainable university. Policies in the form of Standard Operating Procedures (SOPs) and Master Plans are needed to guide the development to be sustainable.

3.4. Masterplan of IPB University Dramaga Campus

The green space projection of IPB University Dramaga Campus is an essential milestone in managing the green space in the campus area for the future. To manage the increase in student body and its impact on the increasing education infrastructures and human resources, IPB University developed the master plan for IPB University Dramaga Campus, as is presented in Figure 5. In this plan, the new infrastructures are plotted in an area of 26.94 ha. Development based on the master plan of IPB Dramaga Campus includes various initiatives to improve facilities and infrastructure to meet the needs of the IPB community. These initiatives involve constructing academic buildings, laboratories, and supporting facilities. Some of the buildings to be built include Parking Lots & Bus Shelters, IPB International Hospital, Faculty of Human Medicine and Pharmacy, Tani Center, Innovation and Enterprenuership Center Building, Research & Resort, IPB University Gas Station, Housing Zone, Apartment, Office House, International Student Dormitory, Postgraduate CCR Building, Guesthouse & Resto, Greenhouse, and Collection Garden FMIPA, Laboratory of Poultry Health Research Center (FKH), Rehabilitation and Reproduction Unit (FKH), Faculty of Engineering, Fateta Technology Gallery, ATC (Korea Cooperation), Fahutan Field Laboratory, Biology Field Laboratory, Broiler Teaching Industry Fapet, Broiler Research Station Fapet, Sheep Teaching Industry and Wisma Fahutan.

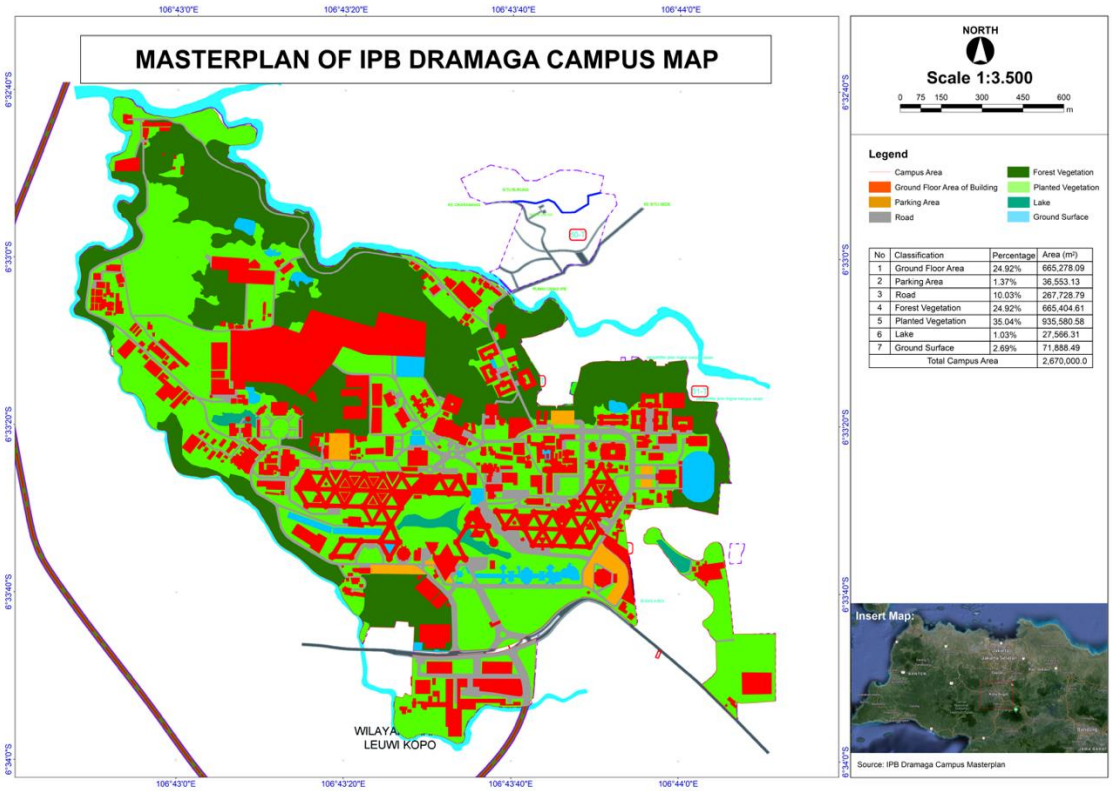

Figure 5. Digitized map of the IPB Dramaga Campus Master Plan

As a result of planning to construct new buildings, there was a land conversion of 26.94 Hectares (10.09%) into building areas. This transformation shows the significant impact of

planning policies on land use, where areas previously used for vegetation, forests, or open land are now built-up areas. The green space projection of IPB Dramaga Campus is an essential milestone in maintaining the campus green space area in the future. This step was taken in response to the need to preserve and increase green space on campus. This projection uses the IPB Dramaga campus master plan as the primary foundation. Green space based on the analysis of the IPB Dramaga Campus masterplan is 162.86 hectares (60.99%), consisting of 66.54 hectares (24.92%) of forest and 93.56 hectares (35.04%) of plants. This value is 17.14% smaller than green space in 2023 due to infrastructure growth, such as buildings and roads. Land use based on the IPB master plan is shown in Figure 5.

There are 26.94 hectares (10.09%) of planned new building construction in the master plan. In addition, IPB Dramaga Campus in 2028 is projected, based on IPB Strategic Plan 2024-2028, to experience an increase in the number of IPB community members to 33,129 people. According to WHO, both factors impacted the required green space area to fulfill the ideal green space [21,22]. The minimum green base coefficient (GBC) value refers to the Regent Regulation of Bogor Regency Number 92 of 2018 concerning Technical Guidelines for General Provisions of Zoning Regulations for Space Utilization in Bogor Regency [19], a minimum GBC value of 20% to new buildings are applied and result in the additional green space of 5.39 Hectares (2.02%). Using the civitas projection in 2028, the ideal value of green space required by IPB Dramaga Campus in 2028 is 165.65 hectares (62.04%). This result is lower than the green space obtained from Masterplan 2028, including the additional green space from GBC, resulting in a green space of 63.01%. Hence, the IPB Dramaga Campus in 2028 will fulfill the ideal green space requirements.

4. Summary and Future Perspectives

Managing the development of infrastructure to accommodate the increase in IPB's Civitas is the main challenge at the university. IPB University has developed a master plan to control land use, especially in constructing new facilities to support academic activity. In the master plan of IPB University, the new infrastructures are projected in an area of 26.94 Ha, or about 10% of the total campus area. According to the increase of IPB's Civitas on the Dramaga campus of 33,129 in 2028, the green space projection in the master plan fulfills the ideal green space of 50 m^2/person with a green space of 62.04%. Hence, the master plan of the IPB Dramaga campus is an excellent way to manage the development of infrastructure in the IPB Campus to ensure the campus's sustainability and support the vision of IPB University as a sustainable university.

References

1. Mardiana R, Putra H, Qayim I, Helmi A, Anggraini E, Jayanegara A, et al. Magazine Sustainability [Internet]. Bogor: Badan Pengembangan Kampus Berkelanjutan. 2023. https://bpkb.ipb.ac.id

2. Satria A, Slamet AS, Kosasih A, Purwito A, Siregar IZ, Putra H. Campus Setting as Living Labs: Lessons from IPB University, Bogor, Indonesia. Journal of Sustainability Perspectives. 2023 Nov;3(Special Issue):257–262.

3. IPB. SK Rektor IPB No 205-IT3-LK-2015 tentang Pelaksanaan Gerakan Green Campus 2020. IPB, 205-IT3-LK-2015 Indonesia; Aug 18, 2015.

4. Mustari AH. Biodiversitas di kampus IPB University : mamalia, burung, amfibi, reptil, kupu-kupu, dan tumbuhan. Bogor: IPB Press; 2020. 477 p.

5. IPB. Deklarasi IPB sebagai Kampus Biodiversitas. 2016.

6. IPB. SK Rektor IPB No 298-IT3-LK-2020 tentang Komitmen Institut Pertanian Bogor dalam Mencapai Netral Karbon Tahun 2030. 298-IT3-LK-2020 Indonesia; Dec 18, 2020.

7. IPB. Laporan Kinerja INSTITUT PERTANIAN BOGOR Tahun 2021. 2022.

8. Simangunsong TL. Pengelolaan Sampah Kampus untuk Mewujudkan Kampus Berkelanjutan (Sustainability Campus). PROZIMA (Productivity, Optimization and Manufacturing System Engineering). 2017 June;1(1):59–63.

9. Ren Y, Qu Z, Du Y, Xu R, Ma D, Yang G, et al. Air quality and health effects of biogenic volatile organic compounds emissions from urban green spaces and the mitigation strategies. Environmental Pollution. 2017 Nov;230:849–61.

10. Imas Gandasari, Hotimah O, Miarsyah M. Pemanfaatan Ruang Terbuka Kampus sebagai Potensi menjaga Lingkungan. Jurnal Green Growth dan Manajemen Lingkungan. 2021 Jan;9(2):71–85.

11. A'yun Q, Wati PC, Khafidz MC. Eksplorasi Disain Ventilasi Ruang Kuliah Untuk Mencapai Kenyamanan Termal. EMARA Indonesian Journal of Architecture. 2019 Feb;4(2):119–25.

12. Chen L, Young MH. Green-Ampt infiltration model for sloping surfaces. Water Resour Res. 2006;42(7):1–9.

13. Tian Y, Jim CY, Wang H. Assessing the landscape and ecological quality of urban green spaces in a compact city. Landsc Urban Plan. 2014 Jan;121:97–108.

14. Kementrian Dalam Negeri. Peraturan Menteri Dalam Negeri No 1 Tahun 2007 tentang Penataan Ruang Terbuka Hijau Kawasan Perkotaan. No 1 Tahun 2007 Indonesia; Jan 11, 2007.

15. Kusumastuti AL, Yudana G, Rini EF. Kemampuan Ruang Terbuka Hijau Publik dalam Berkontribusi Meresapkan Genangan Air Hujan di Surakarta. *UNIPLAN: Journal of* Urban and Regional Planning. 2020 Nov;1(1):20.

16. Robinson JM, Breed AC, Camargo A, Redvers N, Breed MF. Biodiversity and human health: A scoping review and examples of underrepresented linkages. Environ Res. 2024 Apr;246.

17. UI Green Metric. Guideline UI GreenMetric World University Rankings 2023. Depok: Universitas Indonesia; 2023.

18. Russo A, Cirella GT. Modern compact cities: How much greenery do we need? Int J Environ Res Public Health. 2018 Oct;15(10).

19. Perbup. Peraturan Bupati Kabupaten Bogor tentang Petunjuk Teknis Ketentuan Umum Peraturan Zonasi Pemanfaatan Ruang Di Kabupaten Bogor. Nomor 92 Tahun 2018 2018.

20. Cuthbert MO, Riley MS, Handley-Sidhu S, Renshaw JC, Tobler DJ, Phoenix VR, et al. Controls on the rate of ureolysis and the morphology of carbonate precipitated by S. Pasteurii biofilms and limits due to bacterial encapsulation. Ecol Eng. 2012;41:32–40.

21. WHO. Sustainable cities Health at the heart of urban development [Internet]. www.breathelife2030.org

22. WHO. Health Indicators of sustainable cities [Internet]. OECD; 2012. (OECD Environmental Outlook). https://www.oecd-ilibrary.org/environment/oecd-environmental-outlook-to-2050_9789264122246-en

23. Russo A, Escobedo FJ, Cirella GT, Zerbe S. Edible green infrastructure: An approach and review of provisioning ecosystem services and disservices in urban environments. Agric Ecosyst Environ. 2017 May;242:53–66.

24. IPB. Rencana Strategis IPB University 2024-2028. Bogor: Institut Pertanian Bogor; 2024.

25. IPB. Laporan Kinerja INSTITUT PERTANIAN BOGOR Tahun 2020. 2021.

26. Arthon S, Imanudin A, Semuel H. Pengaruh Faktor Mahasiswa dan Faktor Universitas Terhadap Prestasi Akdemik dan dampaknya terhadap Reputasi Universitas Kristen Petra. Petra Business & Management Review. 2016;2.

27. QS Ranking. https://www.topuniversities.com/world-university-rankings/2023. 2024.