Original Article

Low-Carbon Campus Planning Through the RMU Green Concrete Matrix: A Sustainable Infrastructure Framework

Azhar Mehmood[1], Tayab Ahmed Ali[2], Sarah Rafi[3], Sadia Ahmed[2]

Abstract

Rapid urbanization and expansion of higher education institutions have significantly altered land-use patterns, often at the cost of environmental sustainability. Universities, as centers of innovation and public leadership, have a responsibility to adopt eco-friendly campus planning models. This study presents a comprehensive assessment of the covered and uncovered area matrix of Rawalpindi Medical University (RMU), Pakistan. Using systematic spatial measurement and categorization, the campus land was divided into built-up areas, open concrete spaces, and green zones including grassy lawns and tree-covered areas. Results demonstrate that approximately 62.5% of the campus is under concrete coverage, while nearly 35% is reserved for green and ecological purposes. The findings highlight RMU's progress toward a green campus model while identifying opportunities for further optimization in line with international sustainability benchmarks.

Keywords: covered area, uncovered area, ecofriendly, green campus model

Introduction

Rapid urbanization and expansion of higher education institutions have resulted in increased land sealing, loss of green spaces, and heightened environmental stress in urban centers[1]. Universities are increasingly recognized as key stakeholders in promoting sustainable development and climate-resilient infrastructure due to their educational, research, and societal roles[2]. Integration of green infrastructure within campus planning aligns with global sustainability frameworks, particularly the United Nations Sustainable Development Goals (SDGs), including SDG-11 (Sustainable Cities and Communities) and SDG-13 (Climate Action)[3],[4]. Concrete-dominated environments contribute to urban heat island effects, impaired stormwater drainage, reduced biodiversity, and adverse physical and mental health outcomes[5–7]. Conversely, green spaces—particularly tree-covered areas—play a critical role in carbon sequestration, microclimate regulation, air purification, and psychological well-being[8–10]. International green campus initiatives emphasize achieving a balanced ratio between built and natural environments to ensure long-term sustainability[11].

Rawalpindi Medical University (RMU), a major public-sector medical institution in Pakistan, has initiated the Green Campus Project to assess and optimize land utilization patterns. The present study documents the covered and uncovered area matrix of RMU, providing quantitative evidence of green versus concrete coverage and offering a model for environmentally responsible campus planning in Pakistan and comparable low- and middle-income settings[12],[13].

Materials & Methods

This descriptive, cross-sectional land-use assessment was conducted at Rawalpindi Medical University, Pakistan. The total campus area comprises 120 Kanal (approximately 60,703 m²).Primary data were obtained from official RMU campus planning records, engineering layouts, and on-ground measurements documented in the RMU Green Concrete Matrix report . Areas were measured in square meters and converted into Kanal using standardized local land measurement units. Covered Area: Roofed and built-up structures including academic buildings, hostels, mosque, auditorium, laboratories, and residential units. Concrete Area: Non-green hard surfaces such as roads, pedestrian pathways, parking spaces, and sports courts. Uncovered Green Area: Open spaces comprising grassy lawns and tree-covered zones. Tree-Covered Area: Green spaces with permanent plantation, including Miyawaki forest patches and landscaped areas. Descriptive statistics were used to calculate proportions, percentages, and area ratios. Area distribution ratios were computed to compare covered vs. uncovered areas, green vs. concrete spaces, and tree vs. non-tree zones. Graphical interpretations (pie and bar charts) were generated for visual representation.

RESULTS

Overall Land Utilization: Of the total 120 Kanal campus area, 78 Kanal (62.5%) is occupied by concrete-covered surfaces, while approximately 42 Kanal (35%) is dedicated to green and ecological zones. **Covered Area**: The total building-covered area accounts for 12,646.43 m² (25 Kanal; 20.83%) of the campus. This includes: Main academic building, Hostels, Mosque, Latif Auditorium, Research and simulation laboratories, Lecture theater complex and Residential units for staff.

Concrete Open Area: Open concrete spaces occupy 16,966.44 m² (33.54 Kanal; ~28%), comprising: Roads and pedestrian walkways, Parking areas and Basketball court. Concrete Area with Plantation: Semi-concrete zones with plantation cover 9,286.76 m² (19.46 Kanal; 13.72%), accommodating approximately 328 planted trees.

Uncovered Green Areas: Green grassy lawns: 13,860.48 m² (27.4 Kanal; 22.83%) and Tree-covered green zones: 18,969.64 m² (37.5 Kanal; 31.25%), including the Miyawaki forest area. Area Ratios included Covered : Uncovered = 13 : 7, Green : Concrete = 7 : 9 and Tree : Non-tree green area = 25 : 3.

These ratios indicate a substantial concrete footprint but also demonstrate meaningful institutional commitment to plantation and green coverage. The RMU campus consist of open concrete area completely comprised of concrete and constitutes an area of ~16,966.44m2 (33.54 Kanals). The concrete area comprises of open area for general walking and road area, parking areas and the basketball court. It is around 28% of the total university area. The details are given in Table 1.

Un-Covered Area: The uncovered area includes tree planted green area and the grassy area such as lawns and the open concrete area. Approximately, 42 Kanal (21,246 m2) is covered by green grass and plants, ~35% of the total university area has been specifically reserved for green and ecological purposes, in line with RMU's commitment to environmental sustainability and campus beautification. The total uncovered area including tree planted green area and the grassy area such as lawns and the open concrete area constitutes

Green Grassy Area: The green grassy area is the uncovered area that is open and covered by grass without plants such as main ground, two front lawns of the main building and boys hostel lawns areas as listed in the above table. it constitutes an area of 13860.48 m2 (27.4 Kanal), which is approximately 22.83% of the total 120 Kanal university area and 42.31% of the total ~65 Kanal of uncovered green area.

Tree covered Green Area: The green area covered by trees in which different plant species are cultivated constitutes an area of approximately 18969.64 m2 (37.5 Kanals) which is 31.25% of the total area of the university. Open Concrete Area: The open concrete area is the uncovered area of RMU, completely comprised of concrete without any plant or grass area and constitutes an area of ~16,966.44m2 (33.54 Kanals). The open concrete area comprises of open area for general walking and road area, parking areas and the basketball court. It is around ~33.54% of the total university area. The details are given in Table 2.

Table 1: Total uncovered area distribution of RMU

S.NO	Location	Sub-Location	Area (m²)	Area in Kanal
1	**Green Grassy Area**	• grass covered area • no plants • main ground, • two front lawns • boys hostel lawns	12120.34	23.96
2	**Tree covered Green Area**	328 plants on semi concrete area in 2×2 area=4feet	18969.64	37.5

Table 1: Total uncovered area distribution of RMU

3	Open Concrete Area	• Pedestrians walking area	~16,966.44	33.54
		• road area		
		• parking areas		
		• basketball court		
Total Uncovered Area			**48056.42**	**95.0**

Table 2: Distribution of Un-Covered green grassy and Tree covered green Area of RMU measurements.

S.No	Location	Sub-Location	Area (m²)	Area in Kanal
1	**Simulation Lab Lawn**	Front Lawn	708.20	1 Kanal 8 Ma rla
2	**Student Section**	Student Section (Back lawn)	758.80	1 Kanal 10 Marla
		Down stair toward ground	126.46	5 Marla
		Upstairs left to R&D	50.59	2 Marla
		Toward gate	37.94	1.5 Marla
		Back side student section	68.29	2.7 Marla
3	**Front Lawn**	1st Front Lawn (in front of R&D)	885.25	1 Kanal 15 Marla
		2nd Front Lawn (in front of VC office)	910.54	1 Kanal 16 Marla
4	**Front semi-concrete**	Exam Back (with wall)	50.59	2 Marla
		Exam Back with Stair	12.65	0.5 Marla
		Gate side	37.94	1.5 Marla
5	**Main Ground**	Including sides	10117.16	20 Kanal
6	**Auditorium**	Front side	50.59	2 Marla
		Side + Front	113.82	4.5Marla
		Total	164.40	6.5 Marla
7	**Boys Hostel**	1st front lawn + gate side	177.05	7Marla

Table 2: Distribution of Un-Covered green grassy and Tree covered green Area of RMU measurements.

	Gate side toward Miyawaki	151.76	6 Marla
	1st front lawn toward ground	75.88	3 Marla
	2nd front lawn toward ground	75.88	3 Marla
	Total	480.57	19 marla
8	**Miyawaki forest**	63.24	2.5 kanal
Total Un-Covered Green area		**21,246**	**42 kanal**

Area wise Distributions of RMU: The overall spatial distribution of land utilization patterns of the green and concrete matrix of the university is given below in Table 5. The ratio of Covered to Uncovered area is calculated as 78:42, which simplifies to 13:7, indicating that the built-up or roofed structures constitute a relatively greater proportion compared to open spaces as shown in Figure 1. The ratio of Covered to Concrete area (78:54), simplified to 13:9, shows a moderately higher prevalence of structural coverage building area compared to open concrete area as shown in Figure 2. Similarly, the Green to Concrete area ratio is 42:54, simplifying to 7:9, reflecting that concrete area slightly exceed the green areas within the campus as shown in Figure 3. Additionally, the Tree to Non-tree area ratio (37.5:4.5), simplified to 25:3, highlights a substantial dominance of tree-covered regions relative to open non-tree green spaces, underscoring significant vegetative density in the assessed area. The results are shown in Figure 4.
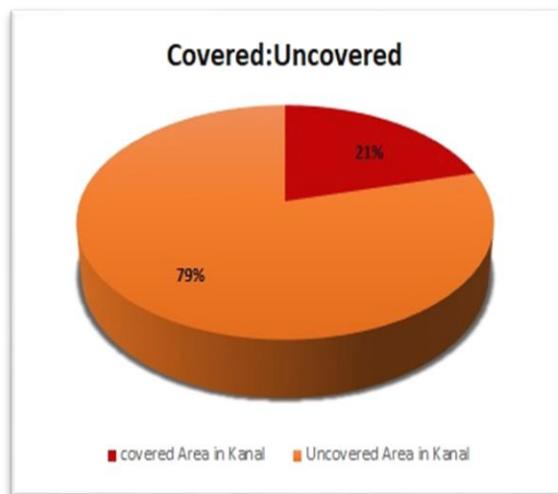

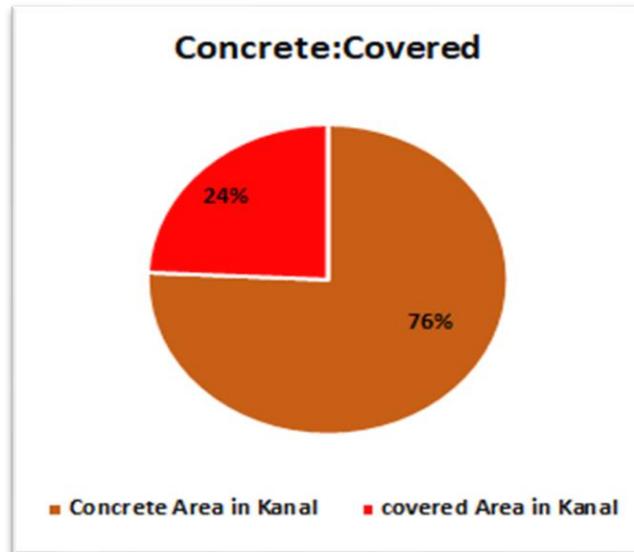**Figure 1: Graphical representation of the covered and uncovered area of RMU**

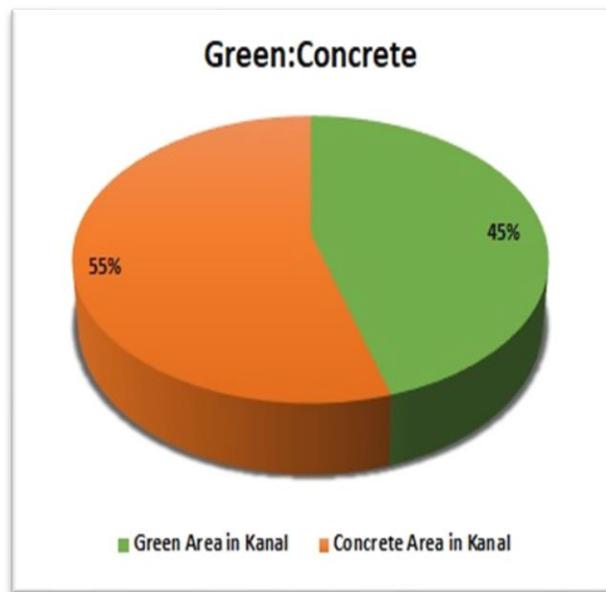**Figure 2: Graphical representation of the covered and concrete area of RMU**

.

Figure 3: Graphical representation of the Green and concrete area of RMU.
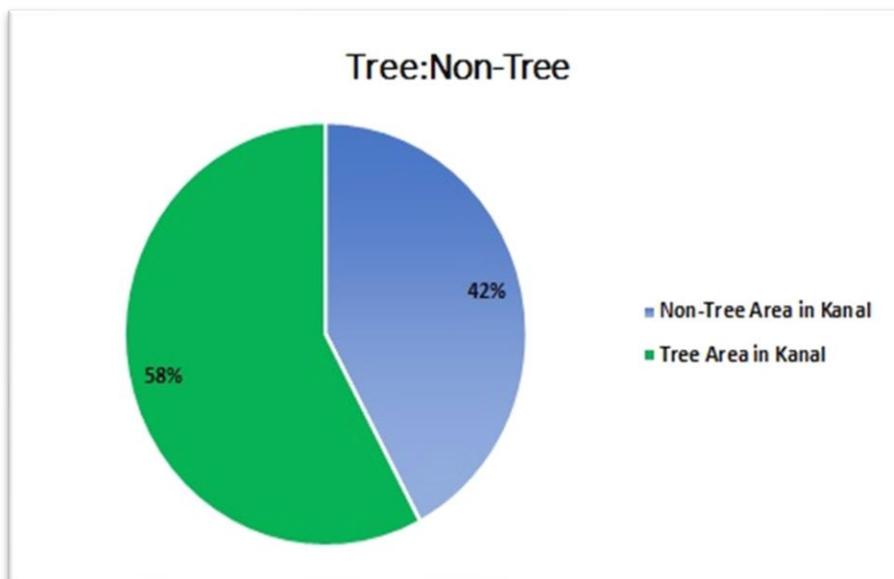
Figure 4: Graphical representation of the Green Tree area and non-Tree area of RMU.

Table 3: Distributions of RMU Geen-Concrete Matrix

S.No	Area Distribution	Area (Kanal)	Ratio
1.	**Covered : Uncovered**	25 : 95	1 : 3.8
2.	**Green : Concrete**	42 : 78	1 : 1.85
3.	**Covered : Concrete**	25 : 78	1 : 3.12
4.	**Non-Tree area : Tree area**	27.4 : 37.5	1:1.37

DISCUSSION

The RMU campus demonstrates a transitional land-use pattern typical of expanding public-sector universities in South Asia, where infrastructure development often precedes environmental considerations[17]. Despite a relatively high concrete footprint, RMU has allocated a substantial proportion of land to green and tree-covered areas, aligning with international recommendations for sustainable institutional planning[18]. Tree-dominated green spaces significantly contribute to climate adaptation by mitigating heat stress, improving air quality, and enhancing stormwater management[19]–[21]. The presence of a Miyawaki forest is particularly notable, as such micro-forests have been shown to accelerate biomass growth, enhance urban biodiversity, and improve ecosystem resilience[22],[23]. From a public health perspective, access to green spaces within medical education environments is associated with reduced stress, improved cognitive function, and enhanced physical activity among students and healthcare workers[24]. These findings reinforce the importance of integrating environmental health considerations into campus design. However, the high proportion of open concrete areas suggests potential for improvement through green retrofitting strategies such as permeable pavements, shaded walkways, and green roofs[25]. Such interventions could further reduce environmental impact without compromising functional infrastructure.

CONCLUSION

The Project for Covered and Uncovered Area Matrix of Rawalpindi Medical University provides a comprehensive and evidence-based overview of campus land utilization. While concrete infrastructure occupies a dominant proportion of the campus, RMU has demonstrated a substantial commitment to green space preservation and plantation. The current green-to-concrete ratio, along with extensive tree coverage, positions RMU as a promising model for sustainable campus planning in Pakistan. Strategic planning focused on reducing open concrete surfaces and enhancing green infrastructure can further align RMU with international green campus standards and climate resilience goals.

Author Information

[1] Assistant Professor, Research & Development (R&D) Department, Rawalpindi Medical University, Rawalpindi
[2] Department of Gastroenterology, Holy Family Hospital, Rawalpindi
[3] Department of Pathology, Rawalpindi Medical University, Rawalpindi
* Corresponding author: Azhar Mehmood (azhar.mehmood@rmur.edu.pk)

References

1. United Nations. Sustainable Development Goals Report 2024.
2. World Health Organization. Urban green spaces and health. 2023.
3. IPCC. Climate Change 2023: Mitigation of Climate Change.
4. WHO. Urban heat islands and public health. 2022.
5. UNEP. Global Environment Outlook 6. 2023.
6. Sharifi A. Urban sustainability and resilience. Sustain Cities Soc. 2024.
7. Norton BA, et al. Green infrastructure and ecosystem services. Environ Res. 2023.
8. Kabisch N, et al. Nature-based solutions in cities. Environ Sci Policy. 2022.
9. World Bank. Greening public sector institutions. 2023.
10. Gómez-Baggethun E, et al. Urban ecosystem services. Ecol Econ. 2024.
11. Gill SE, et al. Green roofs and urban cooling. Build Environ. 2022.
12. Li D, Bou-Zeid E. Synergistic cooling of trees. Environ Res Lett. 2023.
13. Tzoulas K, et al. Green spaces and health. Int J Environ Res Public Health. 2022.
14. Hartig T, et al. Nature and mental health. Annu Rev Public Health. 2023.
15. Oke TR. Urban climatology principles. Prog Phys Geogr. 2022.
16. Meerow S, Newell JP. Urban resilience frameworks. Landsc Urban Plan. 2023.
17. Akbari H. Urban heat mitigation strategies. Energy Build. 2024.
18. Pak EPA. National Climate Change Policy Update. 2023.
19. Higher Education Commission Pakistan. Green Campus Guidelines. 2024.
20. Khan M, et al. Urban greenery in Pakistan. Environ Dev Sustain. 2023.
21. Ali S, et al. Tree plantation and air quality. Atmos Pollut Res. 2022.
22. Ahmad K, et al. Land use planning in public universities. J Urban Plan Dev. 2024.
23. OECD. Universities and sustainability transitions. 2023.
24. Beatley T. Green urbanism. Island Press. 2022.
25. RMU. Green Campus Project Technical Report. 2025.