

Sustainable Nature-Based Landscaping and Environmental Conservation: A Case Study of Faculty of Engineering, Imo State University, Owerri

Happiness Ebere Emeribe, Ihuomachuchukwu Ucheoma,
Ephraim Uwakwe, Favour Ahamefule, Ephraim Ibe
Imo State University, Owerri, Nigeria
nestorhappiness@gmail.com

Article Info:

Submitted:	Revised:	Accepted:	Published:
Mar 20, 2026	Apr 17, 2026	Apr 29, 2026	May 4, 2026

Abstract

Although urban landscape studies have largely emphasized large-scale parks and green infrastructure, limited attention has been given to small-scale but high-impact spaces such as building entrances, particularly within educational institutions. This study aims to redesign the entrances of the Agricultural Engineering (AGE) and Civil Engineering (CVE) Departments, Faculty of Engineering, Imo State University, Owerri, using sustainable landscape practices and Nature-Based Solutions (NBS). A site assessment was conducted to develop a sustainable landscape plan that integrates ecological functionality with existing soil conditions, topography, vegetation, biodiversity, and ecosystem services. The redesign incorporated grasses and native plants to enhance site aesthetics, support rainwater absorption, and reduce flooding risk. Clearly defined walkways bordered by kerbs were introduced to guide pedestrian movement while improving functionality and visual quality, and a designated car entrance was created to ensure smooth vehicular access without disrupting the natural layout. The findings show that NBS-based entrance design can enhance aesthetics, functionality, institutional identity, ecological performance, and

interdisciplinary relevance across the humanities, engineering, and arts. The study concludes that university entrance spaces can function beyond ornamental purposes by becoming dynamic ecological systems that provide environmental, educational, and psychological benefits. Its contribution lies in demonstrating that the integration of Nature-Based Solutions in institutional landscapes can strengthen climate resilience, improve visual appeal, support Sustainable Development Goals, particularly SDG 11 and SDG 15, and position entrance spaces as critical ecological nodes that shape first impressions, influence microclimatic conditions, and guide future landscape research and design.

Keywords: Sustainable Landscape Design; Nature-Based Solutions; University Campus Landscape; Ecological Functionality; Urban Green Infrastructure.

INTRODUCTION

Green spaces are considered vital components of modern urban environments due to their positive impact on the quality of life and individual health. They contribute to improving the local climate, reducing pollution levels, and promoting environmental sustainability (Al-Azhar et al 2025). Green Infrastructure is a network of natural and semi-natural systems that provide ecological functions within urban areas. A landscape is where we all make our homes, do our work, live our lives, dream our dreams" (Lowenthal, 2007). Yu (1997) mentions "Landscape is a kind of objective existence. A scene, whether natural or human, shall not be taken as a landscape if it cannot be or will not be understood by people". Pierre Donadieu also believes landscape is a common asset for all people and encompasses both geographical aspect and human inhabitants.

The scope of landscape meaning and the complexity of its concept on the one hand, and the interaction of the human with the environment in this vast area, on the other hand, have led the researchers to use different approaches in their researches. In fact, the concept of "landscape" has various meanings, depending on the person who views or discusses it (Swaffield, 1991). Opdam et al. (2018) defined landscape as a "geographical unit characterized by a specific pattern of ecosystem types, formed by the interaction of geographical, ecological and human-induced forces." Or "Landscape refers to a common perceivable part of the Earth's surface" (Keshtkaran, 2019). The European Landscape Convention (ELC) defines landscape as "an area, as perceived by People, which character is the result of the action and interaction of natural and/or Human Factors" (Council of

Europe, 2000). Simpson et al. (2001) points out that landscapes are cultural assets for all of the people or "Landscape is shaped by mental attitudes and that a proper understanding of landscapes must rest upon the historical recovery of ideologies" (Baker and Biger, 2006). Hokema (2015) in his research to investigating common understanding of landscape explains which major image of people from the landscape is related to some terms which included nature, beauty, country, city and garden. He also adds "The outcomes indicate a positive connotation of landscape and its high relevance for individuals".

Concept of sustainable landscape design

Sustainable landscape design refers to the integration of ecological principles into landscape planning to create environmentally responsible, socially beneficial, and economically viable outdoor spaces. Sustainable Landscape is designed and managed to be environmentally responsible, resource-efficient, and supportive of biodiversity. It emphasizes the conservation of resources, promotion of biodiversity, and adaptation to changing environmental conditions. According to Makhzoumi and Pungetti (2006), sustainable landscaping combines natural processes with design practices to restore and maintain ecological balance. Key strategies include the use of native plants, efficient irrigation systems, soil conservation techniques, and environmentally friendly construction materials. These designs also support ecosystem services such as air purification, storm water management, and thermal regulation, which are essential in urban and institutional settings.

Nature-Based Solutions (NBS): definition and principles

Nature-Based Solutions (NBS) are defined as actions that harness the power of nature to address societal challenges, including climate change, disaster risk, and biodiversity loss (Cohen-Shacham et al 2016). Furthermore, these actions are inspired by, supported by, or copied from nature that address societal challenges while providing environmental, social, and economic benefits. The International Union for Conservation of Nature (IUCN, 2020) describes NBS as cost-effective, scalable interventions that protect, sustainably manage, and restore ecosystems while simultaneously providing human well-being and biodiversity benefits. Core principles of NBS include multi-functionality, inclusiveness, resilience, and context-specific application. These solutions range from the restoration of wetlands to the creation of green roofs, and they are increasingly being incorporated into institutional landscape designs to promote sustainability.

Ecosystem services and their enhancement through NBS

Ecosystem services refer to the benefits humans derive from nature, typically categorized into provisioning, regulating, cultural, and supporting services. Over the years' humans have derived several benefits from ecosystems, such as air and water purification, carbon sequestration, soil fertility, and recreation. NBS play a crucial role in enhancing these services by mimicking or reinforcing natural processes. For instance, green spaces can help manage stormwater (regulating), improve air quality (supporting), provide aesthetic value and recreational spaces (cultural), and foster biodiversity (supporting). Kabisch et al. (2017) assert that integrating NBS into urban design can significantly improve environmental quality and human health. In institutional environments, these services create conducive learning and working environments while contributing to ecological sustainability.

Institutions such as universities and government buildings have a unique opportunity to model sustainability through their landscapes. Sustainable landscaping in institutional settings serves functional, aesthetic, and educational purposes. It provides microclimate control, enhances campus image, and supports student well-being. Felson, et al (2013) argue that institutional landscapes can act as "living laboratories" where sustainable practices are visibly demonstrated and researched. Moreover, such spaces foster a sense of environmental responsibility among students and staff while reducing maintenance costs and environmental impact over time.

Case studies of NBS in public or institutional spaces

Several institutions globally have successfully integrated NBS into their landscapes. For example, the University of British Columbia incorporates bioswales and rain gardens to manage stormwater and support native biodiversity. Similarly, the National University of Singapore features green roofs and vertical gardens as part of its Green Campus Initiative. Locally, efforts such as the University of Lagos campus greening project illustrate a growing awareness of NBS in Nigerian institutions. These case studies demonstrate that sustainable landscapes are not only feasible but also beneficial in institutional environments, improving ecological performance and user satisfaction.

Entrance spaces as ecological nodes: importance and potentials

Entrance spaces are more than transitional zones - they serve as ecological nodes with significant potential for environmental and social impact. These areas are typically high-traffic and visually prominent, making them ideal for demonstrating sustainable landscape

practices. Redlich et al. (2022) suggest that entrance landscapes can be designed to provide shading, reduce heat island effects, and support pollinators through the use of native vegetation. Additionally, well-designed entrances can enhance campus identity and promote environmental awareness among users. By acting as ecological buffers, these spaces contribute to the overall resilience and aesthetics of institutional landscapes.

Surveying

Surveying delivers valuable data for engineers dealing with geotechnical or rock mechanical problems. With quite different techniques surveyors determine or monitor ground movements and deduce related values like subsidence, heave, inclinations, tilting, strains etc. as shown in Figure 1. They also deliver digital elevation models (DEM) useful for the setup of numerical models for more detailed rock mechanical stability and deformation analysis. Surveying can vary from micro-scale to macro-scale, depending on the task and the used technique, resolution and size of the considered objects. Surveying data are important for Geo-engineers in several directions. Plane surveys are performed on an assumed plane to compute horizontal positions (earth is approximated by a flat plane; curvature can be corrected).

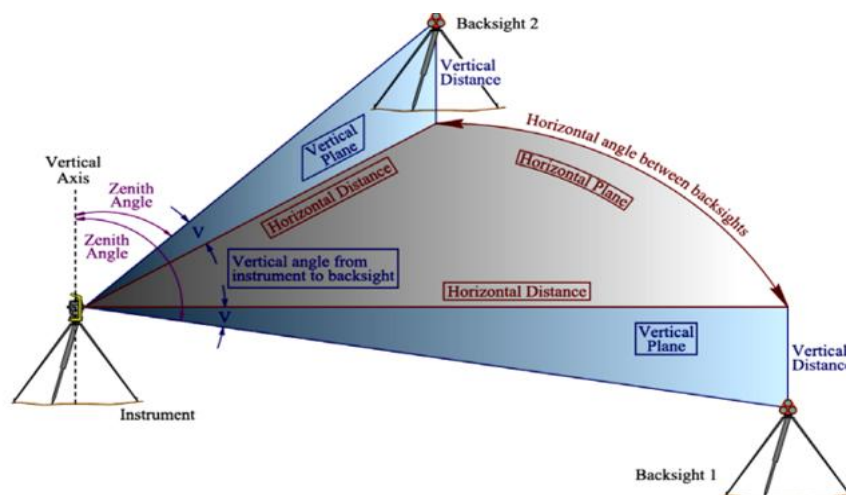


Figure 1: Common types of survey measurements; horizontal distances and angles, vertical distances and angles, slope distances (Wyoming, 2013)

The concept of cut and fill

Profile levelling is a method used to determine the elevation of points along a fixed line, such as the centre line of a road, railway, canal, or pipeline in order to understand the vertical profile (longitudinal section) of the ground. Cut and fill is a common process where

the movement of the earth is handled in a logical manner. Cut and fill excavation, also known as excavation and embankment, involves removing (cutting) soil from higher areas and using it to fill lower areas, creating a level surface. This process balances earth movement, reduces the need for imported material, and is essential for preparing sites for construction. The two terms are defined as follows. **Cut:** Earth that is removed from an area is considered “cut” or excavated earth. **Fill:** Earth that is brought into an area is considered “fill” or embankment earth.

The goal of cut and fill is ultimately to conserve energy and maximize the use of existing materials to avoid bringing in or shipping out dirt mass. While common, it can be an exhaustive process — moving earth takes a great deal of labor, and mistakes can lead to costly rework. To avoid such problems, project planners use detailed and intelligent cut and fill maps, providing exhaustive plans to help guide excavation teams to the most efficient use of mass and labor. These diagrams illustrate all the areas where cut or fill are required. Such maps are generated by taking highly precise measurements of the existing topography and elevation, then overlaying a map of the desired topography. Cut and fill maps contain many of the same terrain features as traditional maps, though they often also include elevations for the purpose of calculation. Some of the common terrain features included in cut and fill maps are: **Hill:** a hill is defined as an area of elevated ground where the ground rises at a slope. Hills are shown on maps using contour lines that form concentric circles. The closed circle that’s smallest represents the hilltop. **Saddle:** A saddle is a low point between two points of high ground. It may appear as low ground between two hills or a break or dip along a ridge crest. This feature is typically represented on the map with an hourglass shape. **Valley:** A valley appears as a long groove in the land and usually contains a stream or river flowing through it. On a map, valleys are usually represented by contour lines in a U or V shape with the closed end pointing upstream. Draws are less prominent versions of valleys and are notated in the same way. **Ridge:** A ridge is an area with steep slope and high ground on one side. Usually, ridges will be shown with contour lines forming in a U or V shape with the closed end pointing away from the higher ground. Sometimes, spurs form from ridges, appearing as continuous lines of higher ground jutting out from the ridge. They’re noted similarly, though they may affect the shape of the ridge.

Depression: Depressions are low points or sinkholes in the ground. Maps usually show depressions only if they are significant enough in size, and these features are notated by closed contour lines with tick marks pointing to lower areas. **Cliff:** A cliff is a sudden

drop-off, appearing as a vertical or near-vertical change in elevation. Cliffs usually appear as contour lines being drawn extremely close together or on top of one another. From the complete map, cut and fill can be planned around existing topographical features. Commonly, a map with these features may be used as a base, with the final project laid over it to determine areas of potential cut and fill. Once initial plans are made, cut and fill plans are added based on the topographical features.

Grass Propagation: It is the process of growing new grass plants from existing ones, primarily through seed sowing or vegetative methods like division, stem cuttings, or runners (stolons). The appropriate method and timing depend on the type of grass. There are two methods of grass propagation. Seed Propagation and Vegetative Propagation. In seed propagation, seeds are harvested from mature plants and later sown on the surface of a well-draining seed-raising mix in trays or pots. Once seedlings develop several true leaves, transplant them into individual pots. In Vegetative Propagation, this method uses parts of a parent plant and is particularly effective for many ornamental and creeping grasses. The stem sections with nodes (cuttings) or short pieces of sod (slips) from a healthy plant are sown in a well-draining potting mix, keeping the soil moist until new growth appears.

Despite the growing body of knowledge on sustainable landscape practices and NBS, significant gaps remain. Many studies focus on large-scale urban parks and green infrastructure, with limited attention given to small-scale, high-impact areas like building entrances (ASLAN 2020). The increasing rate of urbanization and infrastructural development has led to significant environmental challenges, including habitat loss, soil degradation, poor air quality, biodiversity decline, and the disruption of ecosystem services. Educational institutions, which serve as centers for learning and innovation, are not exempt from these challenges. Their built environments often prioritize functionality over ecological balance, resulting in poorly planned open spaces, heat-island effects, and reduced ecological benefits.

Moreover, there is a scarcity of data on the application of NBS in African institutional contexts, particularly in engineering faculties where hardscapes often dominate. Integration between landscape design and civil engineering is often overlooked, leading to missed opportunities for multifunctional design. Addressing these gaps is essential to develop context-specific, innovative solutions that combine technical functionality with ecological performance.

The current entrance spaces of the Agricultural and Biosystems Engineering (AGE) and Civil Engineering (CVE) departments of Imo State University Owerri, lack adequate landscape planning and ecological integration. Observations reveal issues such as Minimal vegetation cover, leading to low biodiversity and poor ecological functionality; Soil compaction and surface runoff, contributing to erosion and reduced groundwater recharge; Lack of functional green infrastructure, which limits air purification, carbon sequestration, and cooling effects and Aesthetic inadequacy, failing to reflect the engineering departments' commitment to sustainable development as shown in Figures 2 and 3, respectively.



Figure 2 (a) and (b): The Proposed Site for landscaping – AGE Entrance



Figure 3(a) and (b): The Proposed Site for landscaping – CVE Entrance

Without appropriate intervention, these spaces will continue to provide limited ecological and social value, contrary to global calls for sustainable development and climate resilience. Therefore, there is a need for a landscape redesign that integrates NBS to enhance ecosystem functions and create a sustainable, visually appealing, and functional environment of the CVE and AGE entrances.

METHODS

This study adopts a qualitative and quantitative research design to effectively assess and integrate sustainable landscape planning strategies. The qualitative aspect focuses on the in-depth understanding of social, environmental, and perceptual aspects of the landscape, while the quantitative component provides measurable data on physical site conditions. The approach involves a combination of field surveys, which help in gathering on-site data related to vegetation, land use, and user interaction; ecosystem assessments, which evaluate the health, structure, and function of the ecological systems within the site; spatial analysis, which examines spatial patterns, landform relationships, and infrastructure layout using tools such as GPS and GIS; and participatory design methods, which actively involve stakeholders such as students, staff (supervisors) in the planning and decision making. The following design concepts were used in this study to develop a sustainable landscape design using nature-based solutions to enhance the ecosystem services of the entrance space of AGE and CVE.

- i. Assessment of the existing environmental and ecological conditions of the AGE and CVE entrance spaces.
- ii. Identification of appropriate nature-based solutions suitable for enhancing ecosystem services in the study area.
- iii. Development of a sustainable landscape design plan that integrates selected NBS for improved ecological and aesthetic performance.

Evaluation of the potential ecosystem benefits (e.g., biodiversity, stormwater management, carbon sequestration) of the proposed landscape plan.

Study area description (AGE and CVE entrance space)

The research focuses on the entrance space of the AGE and CVE departments, which serves as a transitional zone for students and staff. This strategically located area is not only a passageway but also a potential communal space that could enhance the daily experience of users within the academic environment. However, the space currently faces several environmental and functional challenges that hinder its optimal use. Among these are poor drainage systems, which result in waterlogging during rainy periods and create accessibility issues; limited vegetation cover, which contributes to a lack of shade, undesirable vegetation, increased surface temperatures, and reduced aesthetic value.

Data collection methods

Data were gathered through direct observation, field measurements, conversations with our supervisors about the project and secondary sources. The main aim was to gather information about the landscape by looking at both what we can see and what people think or feel about the place. This means studying the physical parts of the area, like the land, plants, buildings, and pathways, as well as understanding how people experience the space. We looked at how the land is shaped, how water moves through it, and what types of vegetation grow there. This helped us understand not just the structure of the landscape, but also how it affects people's thoughts, and daily activities. The Site analysis focused on identifying key biophysical elements of the study area such as the Soil: Texture, composition, fertility, and erosion status. The Vegetation: Existing plant types, canopy cover, and invasive species. The Drainage: Water flow patterns, areas of waterlogging, and erosion. The Topography: Elevation changes and slope orientation.

Ecosystem service assessment

The ecosystem services were assessed based on four main categories: provisioning, regulating, cultural, and supporting services.

- i. Provisioning services: include things that the environment provides directly, such as shade from trees and food from plants.
- ii. Regulating services: refer to natural processes that help control the environment, like how plants help filter water and prevent soil erosion.
- iii. Cultural services: are the non-material benefits people get from nature, such as the beauty of the landscape (aesthetics).
- iv. Supporting services: are the basic natural functions that help keep the ecosystem healthy over time, such as the formation of soil and the presence of different plants.

These services were carried out by field observations, getting opinions from professionals, and listening to the views and experiences of people who use the space.

Tools and Materials for Landscape Planning

The study employed various tools such as:

- i. GPS (Global Positioning System) is a satellite-based navigation system that provides precise location.
- ii. GIS (Geographic Information System) is a software for spatial mapping (the visual representation of geographical information on maps) and analysis.
- iii. Soil type.
- iv. Survey equipment (e.g; level, tripod, levelling staff, measuring tapes, GPS)
- v. Sketching tools (e.g; sketch book, AutoCAD).
- vi. Sustainable materials (e.g., permeable pavers such as; interlocking, oversight concrete, Asphalt) kerbs, native plants)
- vii. Farm tools (e.g; shovel, wheel barrow, rake, hammer, digger).

Design Process for Sustainable Landscaping

The design process involved the following steps:

- i. Site inventory and analysis: to determine elements and conditions that will impact the ultimate use and design of the landscaping.
- ii. Problem identification: it involves recognizing and defining a problem that needs to be addressed.
- iii. Concept development: the process of refining an initial idea into a well-defined and actionable plan.
- iv. Preliminary design: It involves establishing the main parameters, like size, total area of land to be covered.
- v. Review and feedback.
- vi. Final design implementation with sustainability elements (e.g., native planting, kerbs etc).

The study site was designed as shown in Figure 4.



Figure 5: (a) Cut and fill process; (b) Sand filling and levelling of CVE Area

Edging of Walkways (Kerb Stone Installation)

Kerb stones are concrete blocks used for edging, outlining of pathways and as retaining walls. It is a long narrow stone or concrete block, laid end to end with others to form a kerb (Figure 6a). The kerb dimensions vary significantly by type and region. The standard size of kerb stone selected for the perimeter edging of walkways are given as: 250 × 100 (Chamfered) × 400 mm for height, width and length respectively. From the scaled drawing, a total of 325 kerb stones were installed as shown in Figure 6b. Figures 7 and 8 show the laying of kerbs and sandfilling

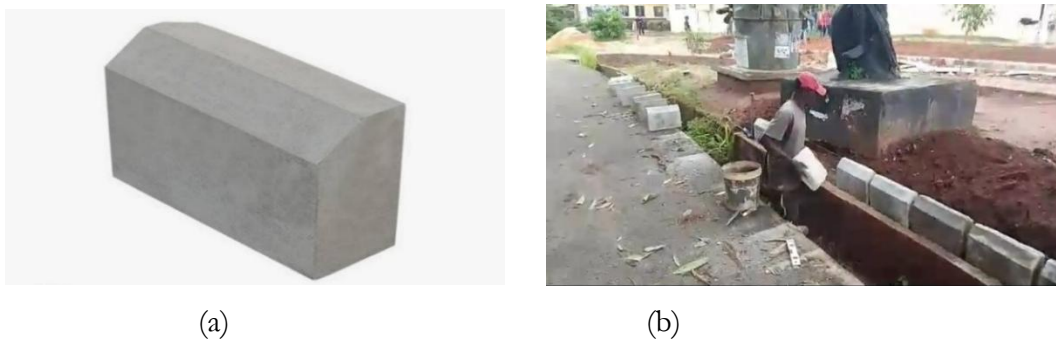


Figure 6: (a) Kerb Stone; (b) Laying of Kerbs



Figure 7: Laying of Kerbs - FENG Area



Figure 8: Sand filling and Levelling of Adjacent Area

The driveway of AGE and CVE was paved with fresh concrete in its plastic workable state immediately after mixing, before it hardens (Figures 9 and 10). Concrete flooring design involves calculating the required material volume, by determining the Length (L) Width (W) and Height (H) of the concrete floor using the formula (ScienceDirect.com):

$$V = L \times W \times T \text{ (m)} \quad (2)$$



Figure 9: Levelling of driveway area



Figure 10: Concrete flooring of AGE/CVE drive way

Grassing of AGE and CVE Entrances

To ensure the health and spread of carpet-grass after propagation, it is necessary to maintain a routine of regular watering, especially during dry periods. Fertilize the plant with

a balanced, slow-release fertilizer according to package directions, usually at the beginning of the growing season. Mow the grass at the recommended height for carpet-grass to encourage dense growth and discourage weeds. Monitor for pests and diseases, addressing any issues promptly. Periodically aerating the soil can also promote healthy root systems and allow for better water and nutrient absorption (Narsimha, 2006).. These processes were followed judiciously as illustrated in Figures 11 and 12.



Figure 11: Grass propagation of the area



Figure 12: Grassing of the AGE department area

RESULTS

The study area, situated at the entrance space of the AGE and CVE departments within the university campus, comprises a combination of open space, footpaths, undesirable plants, and built infrastructure. The existing site conditions before the implementation of the sustained natured based solution and design reflected challenges such as limited vegetation coverage, water logging etc.

The entrance of CVE and AGE department is now wearing a new look as shown in Figures 14 and 15. Notably, the integration of Bill of Engineering Measurement and Evaluation (BEME) as shown Table 1, enhanced the project cost management and timeliness.



Figure 14: Sustainable effects of nature based landscaping



Figure 15: The aesthetic appeal of the nature based landscaping of CVE and AGE entrances

Table 1: Materials and Labour Costing for the Landscaping Project

S/N	Description of Materials/Labour Requirements	Quantity	Rate	Amount (Naira)	Remarks
1	Wheel barrow hiring/repair	1 unit	4000	N4000	Paid
2	Sharp Sand	1 trip	80,000	N90,000	Paid and Supplied
3	Kerb	325 units	1000	N325,000	Paid and Supplied
4	Peg	2 bundles	2000	N4,000	Paid and Supplied
5	Rope line	3 Units	500	N1500	Paid and Supplied
6	Shovel	2 Units	5000	N10,000	Paid and Supplied

7	Cement	16 Bags	10,000	N160,000	Paid and Supplied
8	Transportation of material	6 trips	2000	N12,000	Paid
9	Labour for casting the walkways	8 bags	3500	N28,000	Paid
10	Labour for breaking of big lumps	-	-	N37,000	Paid
11	Labour for breaking of small lumps	-	-	N17,000	Paid
12	Labour for kerb work	325 kerbs	-	N100,000	Paid
13	Labour for grassing	900m ²	220/ m ²	N200,000	Paid
14	Labour for levelling & Sand filling	3 trips	10,000/trip	N30,000	Paid
15	Oil paint	10 litres	3000	N30,000	Paid
16	Fuel/Thinner/brush	3 litres	1000	N3000	Paid
17	Labour for painting	300 m ²	100	N30,000	Paid
18	Refreshment	-	-	N20,000	Paid
Grand Total				N1,101,500	

DISCUSSION

Prior to the development of Sustainable Landscaping Design of AGE and CVE entrances, the soil was predominantly loamy, with moderate drainage capabilities, but signs of erosion and surface runoff were noticeable. The terrain was relatively flat with minor undulations, creating opportunities for water stagnation in certain parts. There were only a few decorative plants and some undesirable plants on the site. There are very few trees. There were very few natural plants on the site. Regulating services, such as water filtration and erosion control, are insufficient. The place also lacked aesthetic and didn't offer much cultural or visual value.

Sustainable Landscape Plan

Based on the findings from site assessment, a sustainable landscape plan was developed to integrate ecological functionality with the existing soil, topography, vegetation, biodiversity and ecosystem services. In this connection, a variety of grasses and native plants were used to improve the appearance of the site. These are used to help absorb rainwater and prevent flooding (Cohen-Shacham et al 2013). Clearly defined walkways were included to guide pedestrian movement. These paths were bordered by kerbs and grass, offering both functionality and beauty while encouraging people to enjoy the space. A designated car entrance was planned to ensure smooth vehicle access without disturbing the natural layout.

The area was landscaped with low-maintenance plants and permeable materials to control water runoff. The overall layout was designed to be visually attractive, using a balance of greenery, open space, and well-placed features to create a welcoming and relaxing environment.

Application of Nature-Based Solutions in The Design

The new plan integrated several Nature-Based Solutions (NBS) to address environmental and social challenges. Remarkably, the Bioretention Systems such as the rain gardens serve as biofilters to treat stormwater and reduce surface runoff. The permeable pathways and materials allow infiltration, preventing flooding and soil erosion (LASEPA 2020). The vertical greening and living walls improve air quality, reduce heat, and enhance building aesthetics. The tree canopy network was needed for temperature regulation, carbon sequestration, and habitat provision.

Nature-based solutions were selected based on their adaptability to local conditions and their multi-functionality in delivering ecosystem services. The implementation of the new plan yielded the following benefits:

- i. Enhanced Regulating Services: Improved water management, reduced erosion, and better microclimatic control.
- ii. Increased Biodiversity: Through habitat creation and native plant integration.
- iii. Improved Aesthetic and Recreational Value: A more attractive and welcoming space for students and staff.
- iv. Climate Resilience: Greater resilience to seasonal changes, flooding, and drought stress.

In summary, these enhancements contribute to environmental sustainability and user well-being. The findings from this study align with previous research indicating that integrated landscape planning and NBS significantly improve ecosystem performance in urban institutional environments (Benedict & McMahon, 2006). Similar interventions in other university campuses have demonstrated positive outcomes in managing runoff, enhancing biodiversity, and improving user satisfaction. However, this study contributes uniquely by focusing on a specific, underutilized department entrance and combining ecological design with participatory site analysis.

REFERENCES

- American Society of Landscape Architects. (2017). *Designing our future: Sustainable landscapes*. <https://www.asla.org/sustainablelandscapes>
- Baker, A. R. H., & Biger, G. (Eds.). (2006). *Ideology and landscape in historical perspective: Essays on the meanings of some places in the past*. Cambridge University Press.
- Benedict, M. A., & McMahon, E. T. (2006). *Green infrastructure: Linking landscapes and communities*. Island Press.
- Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (Eds.). (2016). *Nature-based solutions to address global societal challenges*. IUCN. <https://doi.org/10.2305/IUCN.CH.2016.13.en>
- Council of Europe. (2000). *European Landscape Convention* (European Treaty Series No. 176). <https://www.coe.int/en/web/landscape/the-european-landscape-convention>
- Felson, A. J., Pavao-Zuckerman, M., Carter, T., Montalto, F., Shuster, B., Springer, N., Stander, E. K., & Starry, O. (2013). Mapping the design process for urban ecology researchers. *BioScience*, 63(11), 854–865. <https://doi.org/10.1525/bio.2013.63.11.4>
- Harnisch, B., & Hopkins, T. (2013). *Wyoming drivers survey, 2013* (WYSAC Technical Report No. SRC-1310). Wyoming Survey & Analysis Center, University of Wyoming. https://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Highway_Safety/Behavioral%20Grants/Drivers%20Survey/Wyoming%20Drivers%20Survey%202013.pdf
- Hokema, D. (2015). Landscape is everywhere: The construction of landscape by US-American laypersons. *Geographische Zeitschrift*, 103(3), 151–170.
- International Union for Conservation of Nature. (2020). *IUCN's goal for the Post-2020 Global Biodiversity Framework Strategic Initiative*. <https://iucn.org/resources/conservation-tool/post-2020-global-biodiversity-framework-strategic-initiative>
- Kabisch, N., & van den Bosch, M. A. (2017). Urban green spaces and the potential for health improvement and environmental justice in a changing climate. In N. Kabisch, H. Korn, J. Stadler, & A. Bonn (Eds.), *Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice* (pp. 207–220). Springer. https://doi.org/10.1007/978-3-319-56091-5_12
- Keshtkaran, R. (2019). Urban landscape: A review of key concepts and main purposes. *International Journal of Development and Sustainability*, 8(2), 141–168. <https://isdsnet.com/ijds-v8n2-06.pdf>
- Lagos State Environmental Protection Agency. (2020). *Urban greening and sustainable environmental development in Nigeria*. Lagos State Government Press.
- Lowenthal, D. (2007). Living with and looking at landscape. *Landscape Research*, 32(5), 635–656. <https://doi.org/10.1080/01426390701552761>
- Makhzoumi, J., & Pungetti, G. (1999). *Ecological landscape design and planning: The Mediterranean context*. E & FN Spon. <https://doi.org/10.4324/9780203223253>
- Opdam, P., Luque, S., Nassauer, J., Verburg, P. H., & Wu, J. (2018). How can landscape ecology contribute to sustainability science? *Landscape Ecology*, 33(1), 1–7. <https://doi.org/10.1007/s10980-018-0610-7>
- Rao, P. N. (2007). *Irrigation development: Issues and challenges*. Discovery Publishing House.

- Redlich, S., Martin, E. A., & Steffan-Dewenter, I. (2021). Sustainable landscape, soil and crop management practices enhance biodiversity and yield in conventional cereal systems. *Journal of Applied Ecology*, 58(3), 507–517. <https://doi.org/10.1111/1365-2664.13821>
- Seyam, A. G., Desoky, S. H., Ghanem, T. H., & Mousa, A. M. (2025). Development and performance evaluation of a machine for planting of turfgrass. *Al-Azhar Journal of Agricultural Engineering*, 8(1). <https://doi.org/10.21608/azeng.2024.324456.1020>
- Simpson, I. A., Dugmore, A. J., Thomson, A., & Vésteinsson, O. (2001). Crossing the thresholds: Human ecology and historical patterns of landscape degradation. *Catena*, 42(2–4), 175–192. [https://doi.org/10.1016/S0341-8162\(00\)00137-5](https://doi.org/10.1016/S0341-8162(00)00137-5)
- Swaffield, S. R. (1991). *Roles and meanings of “landscape”* [Doctoral thesis, Lincoln University]. <https://hdl.handle.net/10182/2483>
- Yu, B. C. (1997). *Perceptual principle and method for urban design*. China City Press.