REVIEW OF INTERNATIONAL GEOGRAPHICAL EDUCATION

ISSN: 2146-0353 ● © RIGEO ● 11(5), SPRING, 2021

www.rigeo.org

Research Article

Integrating Landscape Ecology in Campus Planning: Recommendation for the future Physical development of Shahjalal University of Science and Technology, Bangladesh

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Abstract

The rich biophysical elements of Shahjalal University of science and technology (SUST) include diverse flora and fauna. These are the prominent landscape features that create the identity of the campus. Organically grown campus ecology needs to be conserved and design under a sweeping landscape ecological strategy to protect the existing biodiversity and the natural environment. Therefore, the research aims to identify the potential hotspots for biodiversity and the natural landscape of the campus. The existing and proposed land-use map has been investigated to generate different network diagrams to identify the possible impacts of future development works on campus ecology. The potential ecological conservation areas have been identified by analysing the open space network, green-blue network, and activity zones. The research concludes with a framework combining the scope of future extension and conservation strategy of existing landscape features.

Keywords
Campus Planning, Biodiversity, Landscape, Ecology, Development

To cite this article: Dey G, Hasan M, T, Mazumdar A, and Das S. (2021). Integrating Landscape Ecology in Campus Planning: Recommendation for the future Physical development of Shahjalal University of Science and Technology, Bangladesh. Review of International Geographical Education (RIGEO), 11(5), 3029-3041. Doi: 10.48047/rigeo.11.05.195

Submitted: 02-11-2020 ● **Revised:** 15-02-2021 ● **Accepted:** 25-03-2021

Introduction

In the global context, we can notice the significant change in the learning process at the university level worldwide with more social and environmental responsibilities that indicate specific development on campus morphology. Landscape ecology is a study field that reveals the interrelationships between the environment and the communities in a specific section of a distinct landscape (Troll, 1971). It is also defined as "Landscape ecology emphasises broad spatial scales and the ecological effects of the spatial patterning of ecosystems" (Turner, 1989). Universities have concentrated on reshaping their campus as a model for environmental sustainability since the 1960s (Schoenfeld, 1979). At that time, ecological priorities as biodiversity conservation, protection of habitat, the flow of the ecosystem were prime concerns for the physical development of the universities (Alshuwaikhat & Abubakar, 2008). Though, such ecological priorities are primarily overlooked in physical planning and documents of the universities (Orenstein et al., 2019). In addition, hardly any studies focused on integrating landscape ecological strategies in university design and management.

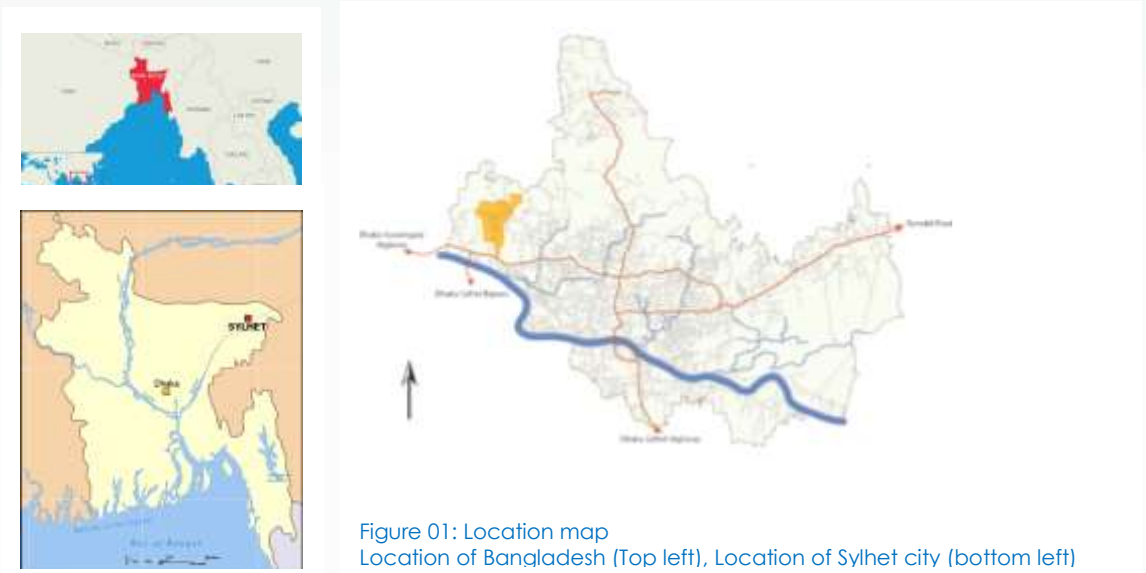

Figure 01: Location map
Location of Bangladesh (Top left), Location of Sylhet city (bottom left)

SUST is one of the dynamic universities with its natural resources, diverse landscape, rich biodiversity, and animal habitation near a rich natural forest of Malinichora tea state. This 320-acre campus can be considered one of Sylhet city's ecological hubs and one of the best places for public recreation. The current expansion proposal of SUST includes several academic buildings, student and teacher accommodations, workshops, and other infrastructure facilities that will occupy approximately 29 acres of land, which is 3.5 times the present footprint. In addition, SUST holds hilly areas and water bodies, a potential food resource, and a habitat for wildlife. Due to frequent changes in the master plan, no planning framework in landscape and biodiversity is maintained. So the question arises how this expansion process could be performed by integrating natural landscape and biodiversity? This research aims to propose a guideline for SUST to protect exiting significant natural resources and biodiversity zones to ensure sustainable development. The campus environment has powerful influences on the psychological and social behaviour of students (Banning, 1989). During field visits, students get familiar with significant, influential aspects of campus as the buildings, trees, walkways, and well-kept lawns (Boyer, 1987); get attached to environments and places that encourage positive stress reduction (Scopelliti & Giuliani, 2004). Fragmented indoor classrooms or dedicated instructional spaces are not enough to ensure total learning as it takes place throughout the entire campus with a long continuous procedure (Strange & Banning, 2001). Spatial planning must respect and co-evolve with landscape ecology to optimise the learning process and knowledge transfer on campus (Ahern, 2005).

Theoretical Framework

Campus Morphology and physical development

Campus landscape engages people with nature through different forms of participation and creates opportunities for biodiversity conservation, education and research on urban and community scale (Orenstein et al., 2019). A sustainable landscape maintains the fundamental environmental, social and economic activities with strong resilience against ever-changing conditions mainly from human activities through meaningful integration of people-place and culture-nature relationships among diverse disciplines as ecology, architecture, economics and more (Wu, 2013). In the case of responsive spatial planning, morphological analysis creates a distinctive basis for design in the context of any existing settled place where preexisting boundaries and patterns that took advantageous positions over time need to be acknowledged on planning for a new addition (Scheer, 2017). University must run with a long term development plan to guide and shape campus life and community activity to cope with the increasing number of students every year (D'Amico & Brooks, 1968). When outdoor recreation and nature use the same space in a landscape, a designed structure with physical barriers for humans can help construct quiet ecological corridors alongside trails by separating. Thus, ecological network planning must include mitigation and compensation of the man-made infrastructure (Wiens & Moss, 2005). By creating a distinct microclimate for users, open spaces can act as a micro-ecosystem to provide habitat for vegetation and wildlife in a natural campus, increasing stormwater infiltration for land and soil (Hamin & Gurran, 2009). Ecologicalizing education interacts with the factors of the inner education system to bridge education and the external environment (Scholl & Gulwadi, 2018).

Landscape ecology and learning environment

A study reveals that the natural environment results in environmental sensibility to the students (Nisbet, Zelenski, & Murphy, 2008). Sense of sight, touch, sound and smell guide people to perceive space; considering these sensations in the design process can enrich people's experience and awareness of the place. Different functions along the circulation would avoid monotony and boringness compared to a rigid linear journey, and accessible courtyards can create interactions among the users both horizontally and vertically. Open space not only supports various activities but also can hold large group gatherings during special occasions. Thus, every campus should provide open spaces in diverse scales to satisfy targeted purposes (Forman, 1995; Yerli et al., 2017). Seeing and stewarding nature positively results in communities with multiple social and environmental aspects, including strengthening social ties, sense of competence, ecosystem services and resilience (Tidball & Krasny, 2013). The participatory design ensures optimum utilisation with active and meaningful involvement of the stakeholders during the planning and implementation period (Kang, Choo, & Watters, 2015). Biophilic concepts act as an organisational metaphor for a campus that breaks down the existing paradigms and drive for integrative campus sustainability through contemplative spaces, ecological consciousness and reflexive dialogue across the existing disciplines (Krasny & Delia, 2015). Waterfronts can play a significant role with unique microclimate through humidity modulation, air quality improvement, environmental protection enhancing species diversity (Lingyun & Yuncai, 2015).

Complexity, challenge and integration

In recent decades, enormous challenges on campus ecology resulted from the construction and modification of university campuses (Zhu & Guan, 2018). University poses enormous effort to fund collection for physical development and involved professionals to develop and expand masterplan for future betterment, where misguided and vainglorious efforts result negatively in many cases (Burns, 2001). Conflicting decisions on landscape development count as a significant mismatch. The expansion of the on-campus area even results in cultural dislocation, whether the active transfer of historical and cultural spirit can reinforce aesthetical, educational and environmental value to the campus landscape (Yan, 2015). Intentional fragmentation of natural areas breaks a habitat or land type into smaller parcels, increasing barriers and diminishing biodiversity. For practical application, works have to be done in laboratories and reserves and living landscapes. Often planners did not completely understand the complexity of ecological models as they have to look after other complex issues as economic and traffic models, land use

trends, production, and urbanisation (Naveh, 1991). Compact development has specific advantages: land use minimisation, encouraging public transport, walking and cycling, reducing resource consumption and pollution, ensuring accessibility to services and facilities, proper scope of infrastructure development, and many more (Burton, 2000). An integrative framework can cover various sustainability issues considering environmental, social and economic factors to construct a healthy campus (Macintyre, Ellaway, & Cummins, 2002). In general practice, compactness and connectivity are considered in socio-educational aspects rather than an ecological framework. Physical planning opens the scope to integrate ecological considerations with future development work (Liu et al., 2021).

Methods

In this research, a theoretical framework was proposed, which includes case studies from local and global contexts to prepare the potential design tools for constructing the ecological framework for the future master plan of SUST. A comprehensive physical survey was conducted to document the existing scenario of landscape ecology by multilayer mapping. To understand the campus morphology, questioner and observation of different stakeholders will run to understand the reaction of user group regarding campus ecology and existing fabric. The study's methodology includes applying a range of instruments widely used in urban morphology as a research method. Physical field survey and measurement, photography and documentation, collecting historical to contemporary maps and records has been used conscientiously in the study. An extensive literature review deduced nine indicators: land use, open space, figure-ground, network and connections, building density, green-blue network, patch matrix corridor, bio-diversity and landscape, and building typology.

Data collection

The strategy for data collection was conducted in three parts. At the initial phase, the data was collected in choropleth maps to compare the study area in a diachronic manner. From these maps, patterns were studied by the researchers. Qualitative methods were also introduced in their later phases to understand user behavioural patterns. A questionnaire survey is conducted among different stakeholders. A total of 120 questionnaires are sent through Google online forms. It is purposive random sampling in nature. To produce the questionnaire Likert scale is used to avoid the extra response category. Among them, 100 questionnaires were returned to yield a response rate of 83.3%. Thirdly to have expert opinions, three KIIs (Key informants' interviews) were done as faculty members of the studied campus. Five open-ended questions were put to them, and later researcher himself interpreted experts opinions and triangulated data for a reliability check. Associated research addresses the potential ecological, cultural, and social benefits of open space and its contribution to campus. The following steps were taken to address figure-ground perception in SUST 's colour plan. At first, the entire setting was outlined for the research. After that, a strategy of colour mapping was introduced to identify the colour identity.

Figure 02: Figure-ground map

Figure 03: Land-use map

Figure-ground relation

Moreover, a colour planning strategy was selected to address the recovery of the foreground/ background architectural character. This study applied a tool using the ArcGIS platform to examine the campus landscape, defining relevant green, blue, and grey spaces and networks for further analysis, composition and configuration. The research showed that ecological corridors incorporated with positive planning strategies within an urban setting could distribute organisms successfully with less dissipation potentiality. The figure-ground map illustrates the relationship between built and non-built areas in the campus area. The land coverage building areas are characterised by solid blocks (mass), and other spaces like roads, canals, and open space are void. The figure-02 exhibits only 7% of land covered by built forms out of 328 acres. Most of the open spaces are agricultural land and hilly area. There is also a significant amount of area covered by trees and wetland.

Landuse

The land use map (figure-03) shows some significant land uses of the university campus, including academic facilities, teacher accommodation, student's hall, administrative facilities, amenities and other infrastructural facilities. In SUST, about 29% of the land has broadly been utilised as academic facilities. There are five academic buildings consist of 4 to 7 stories in SUST. Twenty-five per cent of land out of 328 acres has been utilised as students accommodation facilities, and other residential areas, including teacher's quarters, dormitory, guest house and other temporary accommodation, comprises 5% of the land. Twenty-three per cent of the land has been used as amenities facilities which hold prayer space, cafeteria, gymnasium, auditorium, playing field, teachers club and other facilities. Other land uses like roads, administrative zone, and temporary settlements comprise 4%, 5%, and 9% of the total land area.

Open space network

The open space map (figure-04) tries to identify the character of vacant spaces, including planned and non-planned open spaces. The criteria of open space have been named according to its use and land character. Within 328 acres, about 44% is a hilly area situated on the north side of the campus. These hills can be considered as natural resources, a natural buffer from outside and a potential habitat for biotic and abiotic. About 33% of the total area are currently being used for agricultural purposes. Some of the low vacant lands have been cultivated, and biodiversity and balance the ecosystem. It also acts as a water reservoir during heavy rainfall. Besides all, 3% of the land is used as an active playground, including a central playground, basketball ground, handball ground, and another inner courtyard.

Figure 04: Open space network

Source: Autho

Figure 05: Green-blue network map

Source: Author

Green-blue network

The map (Figure-05) identifies each landscape element, which can be part of the green-blue infrastructure. Lots of flatlands are located on the western side of the campus. The land has temporarily been used for agricultural purposes by local farmers. Rain results in the wetland in the lower area, and sometimes it covers full of water during heavy rainfall. The wetland invites various birds in a particular season of the year. Two linear canals locally named "Chora" connects with low land, which performs as the primary water source and system for storm sewerage inside the campus area. The canal located beside the main entrance road (one-kilometre road) with a row of large trees is the primary water shade that helps to promote biodiversity and habitation for aquatic animals. The other canal run from east to west mostly remain dry due to blockage and insufficient water flow. Although SUST does not have any comprehensive ecological and landscape master plan, nature has composed itself and create rich biodiversity, including the green corridor, water infrastructure, informal forest, and wetland. The network of these landscape elements is well connected organically and creates a potential green-blue campus network.

Network and connection

Figure 06: Network and connection

Figure 07: Activity zone

The campus is controlled and connected with outside by three different entrances (Figure-06). "Y" shaped road network system divides the whole campus into three zones. Due to lack of connection, each road ends with a dead end, and no loops can be observed in the existing network. The permeability of campus affects caused by the insufficient road network and alternative accessibility. The axial pattern network connects with building through narrow streets. The absence of pedestrian facilities and dedicated bicycle lanes are another major issue for degrading walkability inside the campus. Each building is individually controlled, and therefore the connection between buildings only exists on the ground surface but no vertical connection. The campus network is more concerned about vehicles by all accounts, while the existing landscape inspires walking more.

Activity zone

University is a place for furnishing social values and cultural performances for students and other communities besides its academic goal. Being a residential campus, it offers recreation facilities to keep mental health healthy. Although students, teachers, and other staff meet in their workplaces, SUST has no dedicated space to put up stakeholders due to the lack of open social interaction scope. Students meet in the canteen and other food courts outside the classroom,

which is not well equipped and do not acknowledge the natural landscape regarding designing such places. A proper cultural program can be organised in the auditorium, but other cultural activities perform beside the streets and playground. The map (Figure-07) shows a significant activity zone that is interestingly happening beside the roads and buildings.

Patch matrix corridor

Patch, matrix and corridor (Figure-08) are generally used to identify the composition of the landscape. The patch is a mosaic element in the landscape that can be distributed distinctly. In this map, patches define as small Holts with various trees, sizeable green canopy and bushes, sometimes consisting of small contours and wetland. Due to lack of human access and development, patches secure habitation for wild animals and birds. These characters are also found on the backside of each building. Corridor represents linear landscape element in the composition. The central Y shaped street with rows of trees and linear canals beside the road can be categorised as a corridor for SUST. In addition, the canal running from east to east can be another element green corridor. In SUST, the corridor accommodates road infrastructure and green together, turning into a potential green-blue infrastructure. Finally, the matrix represents the utmost portion of the composition. The map represents the flat agricultural land in the eastern part of the campus and the sizeable hilly area on the northern side. The flat land areas are more economical and easier for infrastructure development, while it is more complex and unsustainable for the hilly area. Besides, the existing hilly areas hold a profound amount of biotic and abiotic resources features and food resources for wildlife. Although the matrix covers most of the area, all the land is for agriculture and is effective for future development. Some lands act as for seasonal wetlands to absorb extra water during heavy rainfall.

Campus biodiversity

SUST holds a rich natural landscape and profound biodiversity among the many Universities of Bangladesh (Figure-09). To explore these diverse landscapes, a student organisation of SUST called 'Green Explore Society' had conducted a comprehensive study on existing flora and fauna in the campus area (Figure-10). The study had been conducted from 2012 to 2015. The society concluded with a checklist of sixty tree species, nine amphibian species, fifteen reptile species, sixty-one butterflies, thirty-five bird species, and nine mammal species. The map has developed bases on field surveys, and previous findings from green explore society.

Figure 08: Patch matrix corridor

Source: Author

Figure 09: Campus biodiversity

Source: Author

Species	Verities
Tree	60
Amphibian	09
Reptiles	15
Mammal	63

Figure 10: Some of the species of SUST campus

Source: Green Explore Society, SUST

The typological analysis aims to classify the built form through a systematic analysis of various aspects of building like shape, orientation, height, configuration, zoning, circulation, etc. Empirical study shows that most academic buildings are constructed with a central court like clear story space. The court facilitates ventilation and concentrates inwards while classrooms are set beside the corridor and oriented in all directions due to the "O" shape structure. Buildings are three-storied with two staircases. The classroom has set from the ground floor; therefore, no places are available for social gatherings on-premises. In addition, the enclosed nature toward inwards keeps students away from natural views and ventilation. On the other hand, the residential built forms are more connected with nature due to ample and green open space in the centre of Jahanara Imam Hall, Shahpoaran Hall, and Sirajunnesa Hall. The single-loaded hostel with an open corridor allows more natural ventilation and provides scope for enjoying landscape beauty. However, the buildings on the campus have minimal interaction with outdoor spaces. Integrating green in building design are mostly absent. Besides, the university does not have any dedicated place to explore nature more interactively, like a botanical garden, Green Park, lakeside walking street, etc.

Findings and Results

The analysis has identified some essential landscape elements like water shades, canals, wetland and green corridors. These are essential for a naturally sustainable campus. This element can be improved through conservation and can turn into a dynamic landscape. Rows of large trees and water channels beside the road can be categorised as the significant green-blue network. Some isolated forests developed organically, especially behind the buildings, and it became the place for different flora and fauna. The interweaving technique can potentially connect small green patches and make a green corridor (figure-11). In the same way, a blue corridor can be developed by connecting the water channels (figure-12). The land-use map shows that the academic buildings are situated in groups or clusters, which might be a good approach for future physical development (figure-13). The groups of buildings can share common places and infrastructure so the carbon footprint can be reduced. Other non-academic zones can also be proposed in cluster type to increase sharing of resources and reduce hard surfaces. The map shows massive green land in the eastern part of the ICT building, a new academic zone for SUST. Besides the agricultural land, some portions of hilly areas of the campus are a significant food resource and habitation for different spices. These areas can also be utilised directly as resource labs for some departments, such as forestry, environmental science, geography. The natural conservation of such areas can help to increase biodiversity. The typological studies show that academic buildings are enclosed inward and situated in various climatic directions. There are no sustainable considerations in building design. For the new structure, the building can be more sustainable with bio-integration technique. Campus masterplan can incorporate ecological considerations to guide sustainable development (figure-14). Recommendations have been generated from morphological understanding, expert opinion, and students understanding and comprehensive literature analysis. Some interventions are more applied, where others are managerial proposals.

- Identify and conserve the significant ecological hotspots.
- Increase connectivity of green-blue networks.
- Promote more pedestrian and bicycle streets.
- Specify various zones for development such as academic, residential, recreational zones, etc.
- Some special zone or land use can be arranged to create a sense of place and iconic identity.
- A biophilic approach can be introduced for building design; as a result of this, the building can be part of nature.

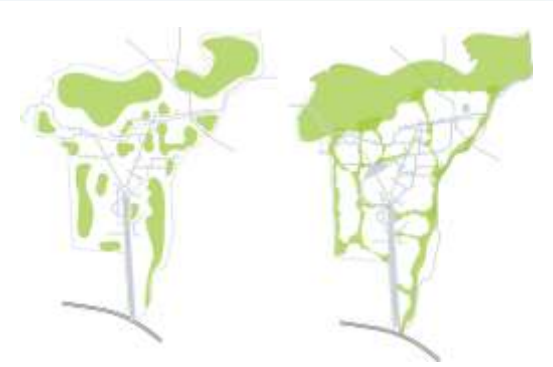

Figure 11: Existing and proposed green network

Source: Author

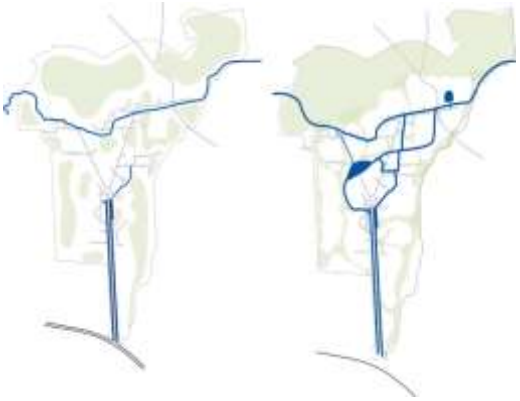

Figure 12: Existing and proposed blue network

Source: Author

To explore these diverse landscapes, a student organisation of SUST called 'Green Explore Society' had conducted a comprehensive study on existing flora and fauna in the campus area (Figure-10).

Figure 13: Proposed landuse plan

Source: Author

Figure 14: Proposed master plan

Source: Author

Conclusion

This research is a primary attempt to identify the landscape resources and biodiversity richness of the naturally green university campus of SUST. Continuously increasing demand for adequate infrastructure and facilities with the increasing number of students each year pushed the authority to go for extensive development expansion in the campus. In the case of significant scale development and construction, the existing natural environment is always an important stakeholder, which often remains unnoticed or neglected in public projects that create a permanent wound in the landscape. Careless development is a significant threat to the healthy environment that gradually developed over a long period of time. A wise, planned, participatory, and responsive approach can successfully balance the natural and built environment. Future planning should include the necessary steps to protect the existing natural identity and enhance this for a sustainable future. A comprehensive master plan should be prepared by engaging the professionals to guide the development work respecting the natural environment. Phase wise development plan considering biodiversity protection and promotion has become a successful approach in this field. Further intensive research on various dimensions and possibilities of the existing landscape elements can create a successive pathway with essential guidelines for the future sustainable development of the public educational campuses of the country. This research tried to address major perspectives of landscape ecology mainly to guide the future development. Detail study on ecological features such as species diversity, complexity and interrelations was not in the scope of the research. Further intensive research on ecological pattern and diversity can enrich the field to control any kind of change in natural landscape.

Acknowledgement

SUST Research Centre funds this research work in the 2019-2020 financial period. The researchers also want to express gratitude to the Department of Architecture, SUST, for all technical support during the entire journey and the students who worked on different phases through the field survey and data collection process. The team is grateful to the expert who managed their valuable time for the interview regarding this research.

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Biography

Gourpada Dey is a teacher and researcher in the Department of Architecture, Shahjalal University of Science and Technology (SUST), a renowned public university in Bangladesh. His research areas include ecology, landscape design, waterscape planning, disaster resilience and sustainability, transportation and facility design, community development and heritage conservation. He developed an early interest in ecological studies and biodiversity conservation, works with local environmentalist organizations and teaches ecology and landscape in the academy. As a professional architect, he was involved in planning and designing large-scale projects, including university campus design, bus terminal design, and community development. Currently, he is working on waterscape development and urban design projects.

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