

GREEN INFRASTRUCTURE DEVELOPMENT AS EDUCATION FOR SUSTAINABLE DEVELOPMENT MODEL IN UNIVERSITI MALAYSIA SABAH

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ABSTRACT

A development of green infrastructure (GI) on university compound has been acknowledged as one of the foundations of Education for Sustainable Development (ESD), an initiative that could provide various benefits to the campus community. The present study shared the experience of the Faculty of Sustainable Agriculture, UMS in the development of GI, namely, a rooftop garden as a medium for ESD. The project was divided into four phases: formation of planning and management team, participatory planning, site inventory and analysis, and GI design and development. The planning and management team involved academic staff and students interested in the project. In the participatory planning, the team members took part in a discussion on strategies to achieve the development of GI as a medium for ESD including taking part in mini training on hard and softscaping at several locations on the campus. This discussion and training prepared the team members for the site inventory and analysis. In the latter, the roof area of the administrative building was finally selected for the GI development. The selected roof area was originally built as an observatory area but was found to have an archetypal problem associated with the urban environment: absence of vegetation, intense solar radiation, and unfit for multifunctional usage. Based on those factors, during the GI design and development phase, the problems were solved using sustainable landscape approaches, for example, increasing the vegetative cover, reducing the solar radiation and glare, and fitting the area with an efficient irrigation system. At the end of the project, the participants had been exposed directly to the keys to identifying environmental issues and their solutions, and by this way, they were carrying out sustainable initiatives on campus environment. The project signifies the potential of GI development in empowering the campus community towards sustainable development and achieving the objectives of ESD.

Keywords: rooftop garden; green infrastructure; campus landscape; participatory planning

1. INTRODUCTION

In response to the concern on sustainability worldwide, higher education institutions (HEI) around the world have formulated action plans to set the course of supporting a responsible management of the campus. The commitment to uphold sustainability ranges from operational and management, infrastructure development, integration into curriculum, research activities and community engagement. Recently, the shift towards green infrastructure (GI) establishment shows positive impacts of responsible physical landform and resource management in the campus facilities. The incorporation of GI is not limited to new development; it can be implemented through retrofitting strategies. It has been argued, however, that by introducing GI may not be sufficient to transform into a 'green' campus or give a significant change of reduction in adverse impacts to the environment (Barkowicz &

Rogers, 2015). Looking through a different perspective, this provides the opportunity of embedding Education for Sustainable Development (ESD) into the relevant university curriculum. Getting the students to be involved in the establishment and management of GI could be a significant method for simulating an interdisciplinary problem and project-based learning. It is crucial as several interdisciplinary experts are needed to provide the solution in mitigating environmental degradation in a real-life situation.

This paper discusses an example of GI model in a university as a medium for ESD. The project involved participatory planning of the stakeholders from the initial planning, site observation, design development and establishment. After the project has been completed, the rooftop garden becomes a multifunctional facility primarily for teaching ESD in several related courses, and also functions as entertainment and passive activities. The paper concludes that integration of green infrastructure in a campus has the potential to become a medium for ESD and simultaneously engage the campus community in participatory planning. The effectiveness of interdisciplinary learning outcomes can be further researched in the future to support the implementation of green infrastructure in higher education institution.

2. LITERATURE REVIEW

2.1 ESD Integration into University Curricula

The inspiring movement of sustainability initiatives in higher education institutions around the world signifies the essential roles they play in encouraging positive mindset and behavioural change of the campus community. Over the recent years, many universities have integrated sustainability into their curricula, and this includes various pedagogical strategies (Ramos et al., 2015). Universities need to empower the students with key competencies in dealing with sustainability issues, and one of the methods is to integrate ESD into the university curricula. This may be implemented through the provision of university required course which covers general sustainability issues (Aktas et al., 2015) or integration into related courses (Lozano & Lozano, 2014). UNESCO's Education for Sustainable Development Goals (SDG) Learning Objectives put great emphasis on the responsibility of academicians to disseminate sustainability knowledge in HEI. In this document, the role of teaching staff is viewed as an impetus to drive the university towards sustainability through teaching and learning as well as research (UNESCO, 2017).

Cortese (2003) highlighted the advantage of initiating sustainable efforts in the HEI, as it constitutes of experts in diverse fields which in turn could provide a holistic approach to dealing with environmental issues. Academicians possess strong knowledge within their respective fields and therefore should be the reference for the sustainable action plan tailored to their campus environment. Moreover, the direct involvement of stakeholders (students, academicians and administration staff) will provide a platform for the campus community to exchange ideas and subsequently disseminate the knowledge to the public (Brinkhurst et al., 2011). However, there are several challenges of ESD incorporation into university curricula. A study by Cebrian et al. (2015) reported that academicians were reluctant to integrate ESD into the curriculum due to the interdisciplinary nature of sustainability, financial constraint, lack of institutional leadership and support as well as difficulty in assessing a large number of students. These challenges should not hinder the pressing needs of addressing sustainability in university syllabus as academicians could initiate the process by incrementally integrating sustainability education into relevant courses' pedagogical and assessment methods. Furthermore, collaboration among

interdisciplinary academicians is crucial to showcase a sound application of sustainability knowledge and encourage a higher level of thinking among the students.

2.2 GI as a model for ESD

The global physical landscape is changing due to the process of urbanisation. By the year 2014, 54% of the world's population resided in urban areas (United Nations Department of Economic & Social Affairs, 2014). Lands are modified to make way for residential, commercial, industrial and institutional zones; encouraging population migration to gain access to these facilities. Gradually the shrinking of urban green spaces results in the loss of biodiversity and disturbance to the natural ecosystem. Furthermore, conventional urban hydrology and storm water management, also referred to as grey infrastructure exacerbates the problem due to the increase rate of volume and velocity of runoff and pollutants on urban impermeable surfaces to the receiving water bodies. Over the recent decades, GI has been a popular planning concept among professionals in urban planning in which they centre the crucial need of integrating GI systems in various scales of existing and new development (Austin, 2014). As opposed to grey infrastructure, green infrastructure concept seeks to mimic pre-development ecological processes through systems such as efficient water management and provision of vegetation and wildlife habitat. Another important aspect of green infrastructure lies in its advantage of being multifunctional which increases the cost-efficiency (Austin, 2014). For example, the bioretention (rain garden) provides several functions to the urban ecosystem; filtering the polluted runoff, providing temporary ponding for runoff infiltration and increasing aesthetic values of the surrounding. There are several benefits of GI instalment which could be observed in terms of their ecological and social benefits (Jerome, 2017). Aside from the environmental benefits, GI also improves the health and well-being of the people as it provides a network of urban green spaces for recreation and socialisation.

Recent works have focused on the potential of GI as a medium to integrate ESD into higher education curricula. The foundation behind this effort is to create a network of small-scale GI as the campus itself is a mini city comprises of its own population and both natural and built environments. An example of linking university's GI development as a medium for teaching and learning is the experience from the Education University of Hong Kong. The establishment of an eco-garden retrofitted from an abandoned space in the campus aims towards a robust learning environment to support the cognitive and affective development of the students. A recent study conducted at the university on the perspectives of stakeholders of expectations on the eco-garden to support ESD has also stressed the importance of incorporating cultural and philosophical aspects to help foster pro-environmental behaviour (Cheang et al., 2017). On the other hand, a project conducted by RMIT University involves landscape architecture students in project-based learning to develop a green infrastructure. The students participated in the planning and development of a green roof project and investigate the impacts of this implementation through the perspectives of economic, environmental and social (Barkowicz & Rogers, 2015). This evidence highlights the opportunity of incorporating ESD in university curricula through the installation of GI. Nevertheless, this effort requires the participation of the institution stakeholders as they are the key to determine the sustainability of the establishment.

It is important to note that community stewardship plays an important role to ensure that GI in a university will sustain in the long term. Firehock (2015) emphasises the importance of community stewardship in GI planning as "...a strategic landscape approach to open space conservation, whereby local communities landowners and organisations work

together to identify, design and conserve their local land network in order to maintain healthy ecological functioning". Participatory planning, therefore, offers the solution in providing the platform for the community to express their insights, ideas, and concerns as well as ensuring social sustainability in the neighbourhood and the city (Lovell and Taylor, 2013). It is not only restricted to the planning stage as it goes further in the implementation and management of the GI. Furthermore, connecting people in caring for the environment requires empowerment of their knowledge and skills. The UNESCO's Sustainable Development Goals (SDGs) underline the importance of sustainability citizens to possess core qualities in spearheading sustainable development. These competencies include integrated problem-solving, critical thinking, anticipatory, systems thinking, normative, collaboration and self-awareness. Experience in dealing with sustainability issues help in developing the core competencies at the individual level (UNESCO, 2017). Therefore, community involvement in sustainable development, in this context GI is an ideal platform to enrich their experience and simultaneously expand their competencies.

3.0 METHODOLOGY

3.1 Formation of Planning and Management Team

The faculty selected in this study, the Faculty of Sustainable Agriculture (FSA), has been operating at its new campus since 2011. The faculty has the capacity of accommodating a maximum of a thousand students with its teaching and learning facilities scheduled for completion at the end of 2017. It comprises a broad complex to facilitate three programmes currently offered by the faculty; Crop Production, Horticulture and Landscaping and Livestock Production. The campus spans over 99 hectares of land, which covers the agricultural plots, administration buildings and campus community residential zones. However, a major disadvantage of the faculty is the limitation of its physical landscape functionally and aesthetically. This difficulty is a consequence to several reasons; the massive earthwork during the campus establishment which caused disturbance to the fertility of the soil, local microclimate and the lack of comprehensive landscape planning.

The Programme of Horticulture and Landscaping perceive these drawbacks as challenges towards the provision of green spaces in the campus. As a solution, the academic staff identified the opportunity to embed the faculty's landscape planning, development and maintenance into relevant courses' syllabus and assessment. This decision directly formed the planning team consisted of the programme's academic staff, administration staff (UMS Department of Development and Maintenance), field staff (FSA Farm Administration Section), and third-year students of session 2016/2017. The planning team participated in the development process as indicated in Figure 1.

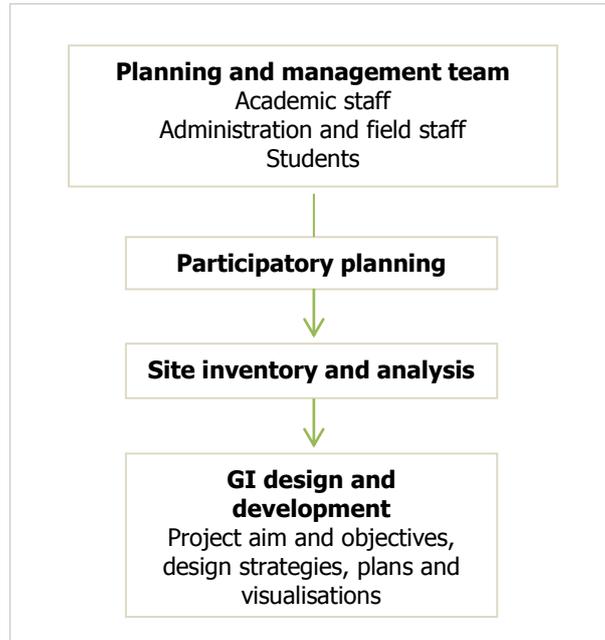


Figure 1: Methodology flow

3.2 Participatory Planning

Initially, the process begins with the observation on the physical attributes (landform, vegetation, soil, microclimate, prevailing wind) and cultural attributes (community, land use, pedestrian and vehicular circulation, utilities, existing buildings) of the campus. Analysis of the findings shaped the foundation for the campus landscape planning. The process of significant data collection was conducted by the third year students enrolled in the Landscape courses; Landscape Horticulture and Landscape Design. Based on the evaluation of the data, strategies were developed to design FSA's Sustainable Landscape Initiatives aiming for campus landscape enhancement through sustainable landscape initiatives. The six practices are; vegetative cover, soil amelioration, project-based learning, efficient irrigation, resilient plants and composting.

The next step was to conduct several small-scale landscape design-and-build projects to create a network of green spaces particularly in the students' residential college and the administration building. As a start, the courtyard garden, located in the centre of the administration building became the first landscape planning and construction project featuring collaboration from the academic and field staff as well as the students. During this trial-and-error learning, the students were exposed to the process of a garden establishment while acknowledging the site condition, materials availability and potential for sustainable initiatives. This was highlighted during plant materials specification, preparation of planting medium for landscape trees and shrubs as well as hardscape materials selection. The outcome of the courtyard project was more than just the creation of a lively green space at the centre of activities in the faculty; it led to the discovery of resilient plant species that can tolerate the microclimate of the campus simultaneously promoting vegetative cover in suitable areas all over the campus.

3.3 Site Inventory and Analysis

Under the 10th Malaysian Plan, FSA received funding for teaching and learning facilities in the campus. The programme managed to obtain financing for campus landscape development including the rooftop garden project. The Department of Horticulture and Landscaping envisions the idea of a green infrastructure establishment, in this case, the rooftop garden, to support ESD and also as a multi-purpose rooftop garden which could transform the space into a meaningful place for the community. The rooftop garden was previously a vacant space located on the fourth floor of the faculty's administration building. The roof space was surveyed to determine the disadvantages that could be further rectified and to assess the potentials of development to achieve the goal of the project. A site visit was conducted by the planning team to gather significant physical data of the rooftop area; this includes the solar orientation in relation to the building, existing landscape elements, visual assessment study, building layout as well as availability of vegetation and hardscape materials.

The data obtained were analysed from four perspectives: education, entertainment, escapism and eco campus. Education, in this case, was whether space is conducive to teaching and learning, and if the answer was no, a solution in term of physical development that contains teaching and learning elements were proposed; the latter will be explained in Section 3.4. Analysis of entertainment involved assessment of the exterior and interior of the space to determine its suitability for organising formal and informal events. Key consideration includes the maximum capacity of users per time and creative spatial organisation to accommodate them, whether by adding indoor or landscape elements. Furthermore, analysis of escapism relates to whether it can provide restorative benefits to the user after long hours of working or studying; which is associated with the availability of plant materials and design. A planting design will be prepared if the space lacks this quality. Finally, evaluation on eco campus focused on the potential of rooftop space in supporting sustainable infrastructure development, which is interconnected with educational perspective as it would display examples of sustainable landscape practices.

3.4 GI Design and Development

At this stage, the planning team evaluated the finding from the site inventory and analysis to establish planning concept and design strategies for the rooftop garden. Based on the discussion among the members, the goal of the project was developed to realise a model of GI in the campus as a medium for ESD. In order to achieve this, design strategies illuminate the objectives of the rooftop garden to serve the following perspectives:

1) Education

The students who were involved in the planning team benefit from the experience of GI development. They learned the process of site inventory and analysis, incorporation of sustainable practices during design development as well as the implementation of the plan on site. On the other hand, other students and the campus community would be exposed to the sustainable approaches featured at the rooftop garden as they can observe and understand its application in relation to the site context. This could increase awareness on the importance of GI as an effective solution for environmental problems. They could also offer ideas to enhance the rooftop garden and participate in collaborative maintenance which could foster the sense of belonging to the place.

2) Entertainment

The rooftop garden would be available to the campus community for entertainment; therefore the planning team came up with a design improvement to increase their attachment to the place. Transforming a 'space' into a 'place' is related to how it is associated with people and the way they utilise the space; thus further enhancing the place attachment within the society (Selman, 2012). The previous layout of the rooftop garden was undefined due to the absence of indoor and exterior elements. As a solution, an effective spatial organisation which deals with the arrangement of indoor or outdoor elements could encourage optimum space usage. Landscape element especially seating were proposed to encourage people to sit and enjoy the place and eventually opens the opportunity for socialisation while supporting items such as diverse plant materials would enhance the surrounding.

3) Escapism

As most of the facilities at the administration building are meant for teaching and learning, the rooftop garden offers a retreat from the stressful working and studying environment. Plant materials can help in providing a restorative effect to the people and promote positive effects towards human's health and well-being. The plant palette for the rooftop garden consisted of resilient species that can tolerate minimum watering and the local microclimate. Furthermore, being away from the stressful conditions of daily lives could give the opportunity for mental restoration (Kaplan, 1995).

4) Eco campus

Physical analysis of the space revealed the potential of maximising the benefit of sunlight and plant materials, utilising durable materials for hardscape and promoting an efficient watering system. The rooftop garden incorporates FSA's Sustainable Landscape Initiatives as a manifestation of the faculty's pledge to support UMS Eco campus transformation plan. The details of the design feature will be highlighted in Section 4.2.

4.0 RESULT AND DISCUSSION

The primary outcomes of this project were the final GI design and development. The findings and discussion were divided into design strategies, design features (hardscape and softscape), and teaching and learning integrated into the project to share the experience of FSA in the development of GI as a medium for ESD.

4.1 Design strategies

Based on the work explained in Section 3.0, the recommended design strategies for the garden are as in Table 1. The planning team recorded the following observation; building layout, solar radiation, surrounding views and landscape elements. Based on these findings, they developed the design strategies with an emphasis on the objectives of the rooftop garden (Section 3.4). The space layout is divided into an indoor area (Solarium) and outdoor area (garden), and there was a lack of spatial organisation. To solve this, the landscape design of the outdoor space features elements that define the spaces into several spots

ideal for socialisation and relaxing (entertainment and escapism). Suggestions include seating, planters and suitable plant materials. On the other hand, the exterior would be equipped with seating and indoor plants.

Solar radiation at the rooftop contributes to thermal discomfort especially from 11 a.m. to 2 p.m. all year round. The Solarium was built of glass walls which further increase the temperature and glare into the interior. The strategy adopted was to use window tint to reduce glare and solar heat. This will also help visible light to enter the Solarium during the day and at the same time reduce the energy to cool the interior (eco campus). Furthermore, the location and elevation of the rooftop offer scenic views overlooking the faculty compound. While users can appreciate the views from the exterior part of the roof area, the interior section had limitation due to the obstruction from the structure of the Solarium. To solve this, the planning team proposed an elevated flooring to maximise the advantage of the view looking outward from the Solarium.

The major disadvantage of the rooftop area was the unavailability of landscape elements which results in a monotonous ambience. On the bright side, the planning team saw this as an opportunity to incorporate sustainable landscape initiatives which embody education and eco campus objectives of the rooftop garden. The hardscape and softscape selection related to FSA's Sustainable Landscape Initiatives; 1) efficient watering (the use of drip irrigation technique for the vertical garden), 2) vegetative cover using resilient species (groundcover or shrubs that can tolerate the microclimate of FSA), and 3) soil remediation (mixture of local soil and topsoil to improve the soil fertility and structure). The details of hardscape and softscape selection can be referred to Section 4.2.

Table 1: Analysis of the rooftop garden and design strategies

Attributes	Observation	Design Strategies
Space layout	Lack of spatial organisation	Exterior design features landscape elements (planter boxes, deck for seating) Interior design features furniture to accommodate indoor activities.
Solar Radiation	Space receives an intensive amount of solar radiation throughout the year (the highest temperature from 11 am to 2 pm).	Glass window panel is maintained to maximise the natural lighting into the indoor of the garden. The panels are tinted to alleviate glare and thermal discomfort. Resilient plant materials; drought tolerant and could withstand intensive solar radiation and the wind.
Surrounding views	Views are overlooking the faculty compound.	Construct elevated indoor flooring to allow access to the surrounding views from indoor.
Landscape elements	The absence of landscape features to harmonise the space with the built feature.	Integrate sustainable landscape initiatives in hardscape and softscape elements.

4.2 Design Features

The rooftop garden preliminary design features a model of sustainable landscape initiatives based on FSA's Sustainable Landscape Initiatives. The principle components of the Rooftop garden comprise of the green wall, the composite wood deck and the glass panels (Figure 2).

1) The Green Wall

The Green Wall features ornamental plants in a vertical arrangement mounted on the rooftop garden wall. It displays the drip irrigation technique which is a method of the efficient watering system supported by water pump and timer. The watering process is set to a particular time and amount and irrigated through the drip emitter.

2) The Composite Wood Deck

Composite wood is an alternative to timber use for outdoor surfaces. Its strength lies in the durability and minimal maintenance without compromising on the appearance of the material (wood-like appearance).

3) The Glass Panels

Space receives an intense amount of sunlight throughout the day; rather than seeing this as a disadvantage, the design intends to maximise the natural lighting during the day. The window tint reduces the heat and thermal discomfort inside the Rooftop garden.

4) Plant Palette

The plant materials are of resilient species; adaptable to the local microclimate and require less maintenance. These factors are crucial as plant materials not only serve their ecological functions but also profoundly influence the way people perceive the landscape as aesthetically pleasing or vice versa.

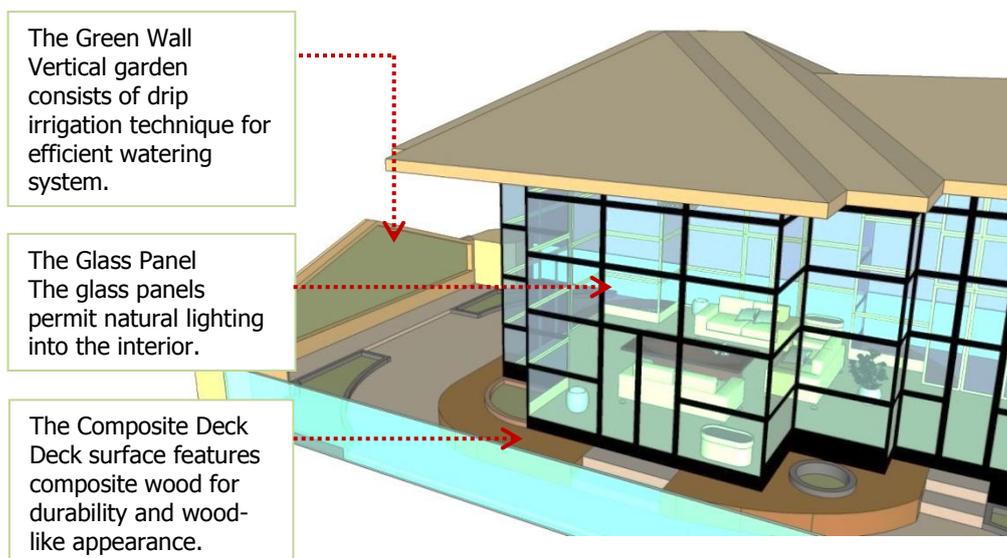


Figure 2: Rooftop garden design features

4.3 Teaching and Learning Integrated into the Project

Upon completion of the rooftop garden in March 2016, the campus community benefits from the rooftop garden in several aspects which contribute to the enhancement of knowledge, skills, as well as physical and mental replenishment. The primary goal of the rooftop garden, which is to become a GI model as a medium for ESD, mainly focus on education and eco campus objectives by encouraging experiential learning as well as critical thinking and problem-solving skills. The process of establishing the rooftop garden in supporting ESD can be divided into two stages; 1) the planning and design development process, 2) implementation and maintenance of the garden. The former involved a batch of third year students enrolled in related courses during the construction of the rooftop garden. Subsequently, the following batches of students were exposed to the maintenance of the garden and given the opportunity to suggest improvements to upgrade the components of the rooftop garden. Table 2 highlights the achievements of ESD integration into syllabus based on the learning outcomes as intended per course.

Table 2: Education for Sustainability- Integration of Various Teaching and Learning Method into Courses Syllabus

Courses	Teaching and Learning Method	Learning Outcomes
Floriculture and Ornamental Plants	Project-Based Learning	<ul style="list-style-type: none"> • Ornamental plants propagation, transplanting and maintenance at the rooftop garden. The planting palette consists of resilient plants which are suitable to the local microclimate (Figure 3 and Figure 4). • Drip irrigation technique for the vertical garden to display efficient plant watering system.
Landscape Horticulture	Experiential Learning	<ul style="list-style-type: none"> • Garden maintenance works including weeding, pruning, tree staking and fertilising landscape plants.
Landscape Construction and Management	Site visit and analysis	<ul style="list-style-type: none"> • Identification of landscape materials and sustainable landscape construction
Landscape Design	Site visit and analysis	<ul style="list-style-type: none"> • A model of rooftop garden design which displays a multifunctional indoor and outdoor landscape (Figure 5).



Figure 3: Soil medium preparation and transplanting plants for planter boxes



Figure 4: Transplanting ornamental plants for vertical garden system



Figure 5: Rooftop garden for leisure and formal activities

5.0 CONCLUSION

The rooftop garden is a successful example of GI established for ESD in a university. It stands as a multi-purpose rooftop garden which accommodates ESD, entertainment and social events, a retreat from stressful daily obligations and manifestation of sustainable landscape practices. The findings from site inventory and analysis helped to identify the potential of existing physical attributes of the rooftop space. These assessments were taken into account during the development of design goal, objectives as well as design features.

Through participatory planning, the project empowers the stakeholders to be active in steering the rooftop garden project. As the key stakeholders of the project, the academicians, supporting staff and students of the programme are aware that they are open for the challenge to improvise the rooftop garden.

GI proves to be a useful medium for ESD as it gives the opportunity for the campus community to be involved during and after the establishment of the project. It seeks to provide a medium for critical thinking and problem-solving for any possible extension of GI on the campus. Furthermore, the objectives of ESD could be achieved by engaging the campus community in participatory planning and management of the green infrastructure establishment. However, it requires profound commitment and involvement from the community to monitor and improve the facility to ensure its sustainability. As a continuous effort from this study, further research on the establishment of a network of small-scale green infrastructure as a medium in ESD could be investigated in the future.

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