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Potential Green Infrastructure in TVET Campus: A Case Study in Teluk Intan Vocational College

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Abstract

Education for Sustainable Development is a crucial agenda to address the issue of globalization. Technical and Vocational Education (TVET) is one of the main agendas in Sustainable Development Education that contributes to the sustainability of human life. To develop a holistic sustainability approach that can incorporate academics, students and institutional management, sustainability efforts should be applied to the campus life of TVET institutions. One of the best approaches is the development of green infrastructure that could benefit the social well-being and health of the people. Accordingly, this study was carried out at Teluk Intan Vocational College to examine the potential of green infrastructure development in the TVET campus. This institution was chosen because Teluk Intan Vocational College is a TVET institution that offers programs in agriculture and is related to environmental study. This research was conducted using observation, inventory analysis and survey. Several green infrastructure strategies have been proposed, such as green roofs, rainwater harvesting, groundwater harvesting, rain gardens and agroecology learning approaches. The development of green infrastructure on the TVET college campuses can support campus management with teaching and learning techniques for managing natural disaster risk in practical settings. Green infrastructure also has potential approaches to environmental issues in the TVET campus from a comprehensive angle, which is essential to meet the multifaceted challenges in education for sustainable development for global change.

Keywords: Green infrastructure; TVET; vocational college

Background of Study

Technical and Vocational Education and Training (TVET) encompasses formal, non-formal, and informal learning that provides young generations with the knowledge and skills required

in the industry. Yunos et al., (2019) agreed that TVET is an academic stream that is closely related to the world of work, which is the industry. TVET is also recognized as one of the most important keys to sustainable development.

Realizing the need to strengthen technical and vocational education, the Malaysian Government through its Tenth Malaysia Plan (2011-2015) aims to develop the country's human capital, with special emphasis on lifelong learning and TVET to raise the overall quality of the workforce by enhancing skills that have immediate applicability in the labour market. TVET transformation was introduced to drive change by directly contributing to the economy, knowledge, technological advances, and mobility of the global workforce (Mohd Yusof et al., 2020) and one of the major changes in the TVET delivery system is the upgrading of vocational secondary schools and technical high school to Vocational College and pilot recruitment began in 2012.

In Malaysia, TVET is a branch of education that has been introduced into the mainstream education system including Vocational College that leads to the certification of the Malaysian Vocational Diploma. The vocational program offered at Vocational College training centres aims to train skilled and semi-skilled workforce for the country and beyond. The programs offered by vocational colleges cater to a wide and varied range of industries including agriculture. Currently, the agriculture programs are offered at 6 vocational colleges, (1) Teluk Intan Vocational College, Perak, (2) Dato Lela Maharaja Vocational College, Negeri Sembilan, (3) Chenor Vocational College, Pahang, (4) Pagoh Vocational College, Johor, (5) Pasir Putih Vocational College, Kelantan, and (6) Lahad Datu Vocational College, Sabah. The selection of agricultural vocational colleges in this study coincides with the agricultural curriculum related to the environment and food sustainability. Therefore, the potential for developing green infrastructure as an essential identity for the campus can also be linked to the teaching and learning process.

Site Introduction

This institution was established in 1982 known as Teluk Intan Technical High School. It has offered TVET programs in the fields of Farm Management, Agricultural Machinery, Horticulture, and Landscape. It was upgraded to Teluk Intan Vocational College in 2013 which offers 11 agricultural programs. Located at 3° 59′ 32′′ N latitude and 101° 03′ 20′′ E longitude, this college is within the city of Teluk Intan which is one of the oldest and most important cities in Perak (Ibrahim et al., 2016). The student population of this college is 532 students, and the land area is estimated to be about 20 hectares. Teluk Intan is a city located 4 meters

above sea level with an average temperature of 27.5 °C with an annual rainfall of 2412 mm (Hilir Perak of Public Works Department).
Figure 1: Location Plan of Teluk Intan Vocational College (Source: Google Earth 2020)

Problem Statement

Teluk Intan Vocational College is located in a flood-prone area. Managing frequent flooding on this campus is necessary for sustainable well-being. Flood risk has increased all over the globe due to floodplain occupancy and the effects of climate change (Vitale et al., 2020). Thus,

this research focused on three (3) major identified issues in Teluk Intan Vocational College: flood, poor drainage system, and lack of vegetation. Flood issues are caused mainly by ditch channels from palm oil nearby when the water flow exceeds the discharging capacity and spills over the ditch to the campus area. Heavy rainfall, poor drainage system, and lack of vegetation also worsen the situation when the ground exceeds the ability to absorb water causing flood.

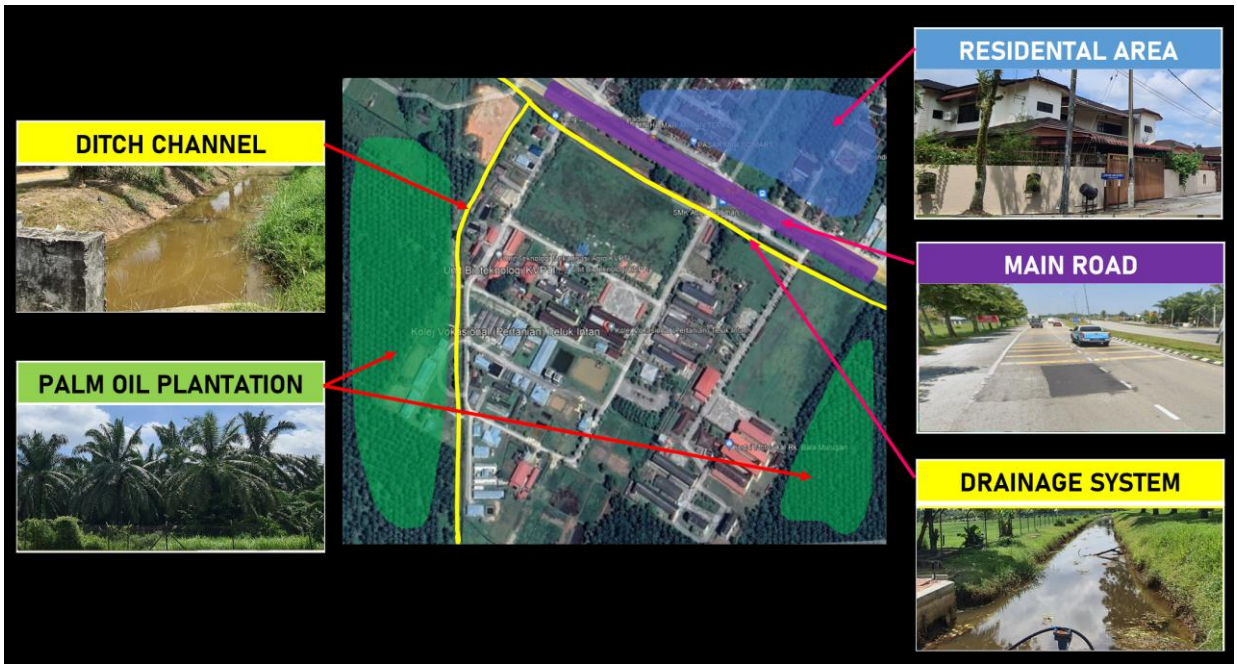

Figure 2: Surrounding Area of Teluk Intan Vocational College

Aims & Objectives

This research aims to propose a resilient landscape which can adapt to climate change and overcome water challenges on campus. Hence, the three focused objectives to achieve the aim are:

i. To evaluate lecturers' perceptions of green infrastructure integration on campus based on the literature review and compare them with the current state.
ii. To propose suitable green infrastructure options that align with the agricultural education system and syllabus.
iii. To maximize the advantages of the existing agricultural education system to cope with the effects of climate change.

Site Observation & Data Collection

The study adopted two approaches namely site visits and surveys. To collect the initial relevant information on the study area in general; the researcher reached out to the Hilir Perak Public Works Department for a formal visitation. The representative shared his view on the background of Teluk Intan and Vocational College. The representative highlights the following general information: Location of Teluk Intan Vocational College, history, topography, landscape, vision, sustainability, future direction, issues, objectives and aims, the improvement required, and management. After the debriefing, the next agenda was site visitation to Teluk Intan Vocational College.

The site visit was done by the researcher herself since she is an academic staff at this college. The tour was assisted by the head of the college development unit, sharing further information and observing the existing condition, interest, attraction, and importance of the site to its surrounding environment and development. Issues on the existing pests, stakeholders, developments, flooding, pandemic, and tourism were also raised and have been developed in the study analysis. Every finding throughout the observation and survey was recorded and photos were attached as valid proof.

A survey regarding this case study was also conducted on 30 respondents as a study sample from the population of 136 lecturers at Teluk Intan Vocational College. According to Creswell (2013), sample sizes of 30 are sufficient for conducting educational research. A questionnaire was used to perform this study utilising a survey methodology. To create this survey form, the question items were divided into four categories: the respondents' backgrounds, the issue of campus flooding, green infrastructure, and open questions. Responses for the level of knowledge on the issue were measured using two question items through a 5-Likert scale. Whereas feedback for the level of knowledge and perception of lecturers regarding green infrastructure was measured using 8 question items with a 5-Likert scale. Respondents were also given the opportunity to suggest solutions to the flood issue through open-ended questions.

Data Analysis

Microsoft Excel software was utilized for data analysis. The analysis performed was descriptive in terms of percentage, mean, and standard deviation. According to the lecturers' perspectives, the level of importance of integrating green infrastructure in campus areas was determined using the findings of a descriptive study. According to Table 1, the mean interpretation scales were obtained from Nunnally and Bernstein (1994):

Table 1: Mean interpretation value

Mean score	Interpretations
1.00 – 2.00	Low
2.01 – 3.00	Medium Low
3.01 – 4.00	Medium High
4.01 – 5.00	High

Source: Nunnally & Bernstein (1994)

Site Analysis & Synthesis

Space Utilization

Based on the site observation, the 5 main clusters of space utilization of Teluk Intan Vocational College have been identified: formal area, informal area, practical area, facilities, and open space. Figure 3 shows the map of space utilization.

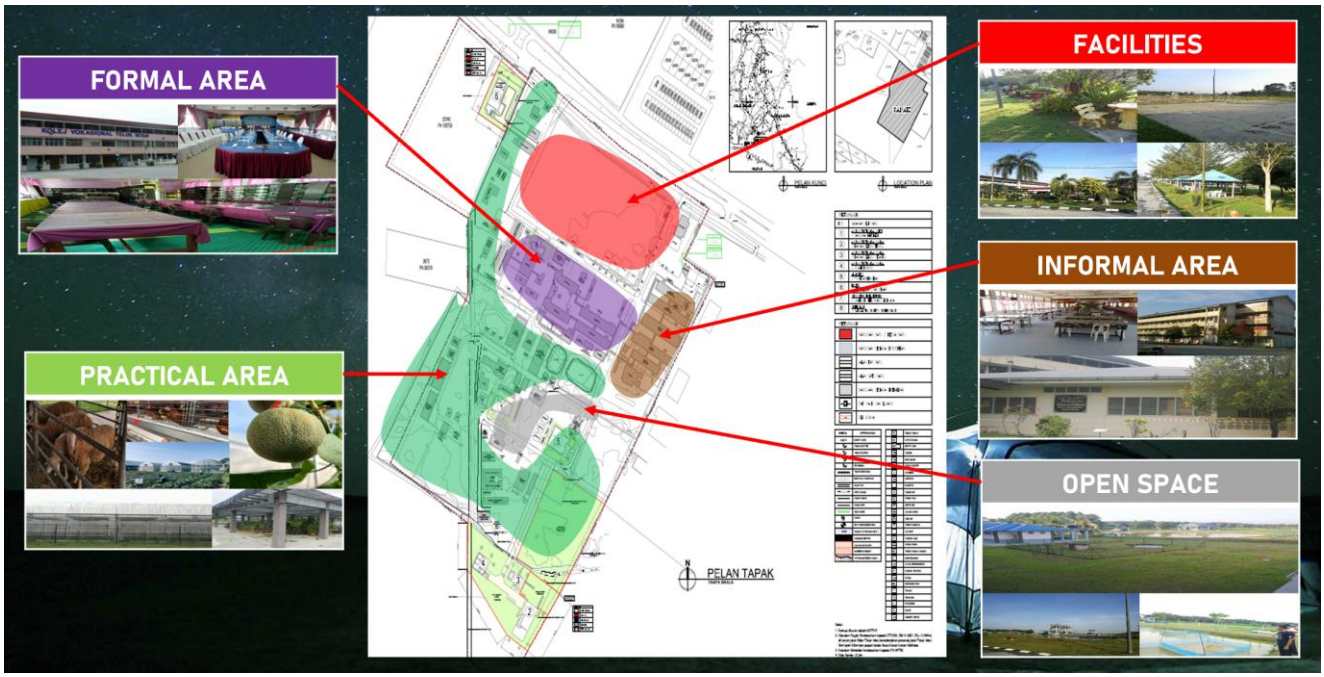

Figure 3: Space Utilization of Teluk Intan Vocational College (Source: Hilir Perak of Public Works Department & Author)

Space Utilization Analysis has also been done considering the time and activities carried out in the area as shown in Table 2. Therefore, green infrastructure development planning can be proposed more effectively according to the users and activities in the related space.

Table 2: Space Utilization Analysis

TYPE OF SPACES	ACTIVITIES	TIME
FORMAL AREA Administration building, lecture hall, tutorial rooms, lecturer rooms, library, laboratory, computer room	This area mostly being used during weekdays. Daily used for educational activities – attend the class, library, and workplace for lecturer and staff	Weekdays: 8.00 am – 6.00 pm Weekend: No activities

INFORMAL AREA Hostel, Dining Hall, Mosque	Resident or home for students. The place for daily activities for students. The place for religious activities.	Weekdays: 5.00 pm – 8.00 am Weekend: All the time
PRACTICAL TEACHING AREA Poultry farm, Pasture, Ruminant farm, machinery workshop, hatchery, design studio, CEF (control environment farming) aquaculture farms, and nurseries.	Daily used for practical educational activities mostly during weekdays. During weekend, some areas are used for final year student.	Weekdays: 8.00 am – 6.00 pm Weekend: 8.00 am – 6.00 pm (If needed)
OPEN SPACE	Near to the pump building, fungiculture farm, and the surrounding aquaculture farm. Students come here for fishing and play.	Every day: 5.00 pm – 7.00 pm
FACILITIES Football field, Rugby field, Volleyball court, Sepak takraw court, Pentanque, Gazebo, gardens.	Recreational activities for students	Every day: 5.00 pm – 7.00 pm

Existing Green Infrastructure

Every existing green infrastructure was recorded and reviewed during this phase to ensure the appropriate strategy for green infrastructure. Groundwater harvesting, the primary water source in the practical teaching area, has been systematically developed since the campus development planning phase as shown in Figure 4. The lecturers' and students' efforts can also be seen when, despite their financial constrain, they create their rainwater harvesting system.

Figure 4: Existing Green Infrastructure - Rainwater & Groundwater Harvesting (Source: Google Earth 2020 & Author)

The campus's existing green infrastructure also includes five composting houses as shown in Figure 5. They were developed for horticulture, agroindustry, landscaping, poultry, and ruminant departments' teaching and learning facilities.

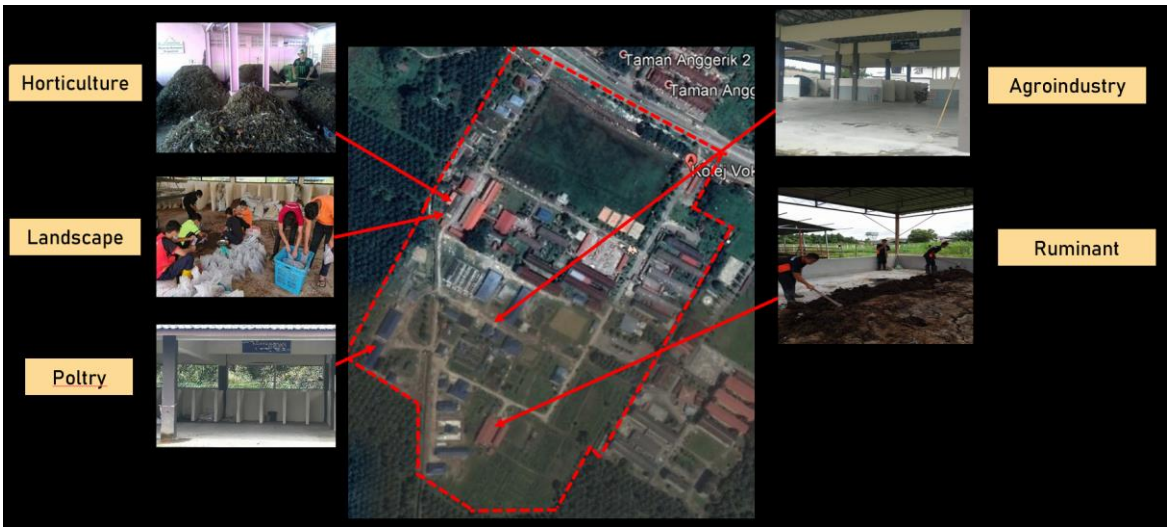

Figure 5: Existing Green Infrastructure – Composting House (Source: Google Earth 2020 & Author)

SWOT Analysis

According to the site observation and literature review, the strengths, weaknesses, opportunities, and threats of the green infrastructure implementation within Teluk Intan Vocational College were figured out in Figure 6.

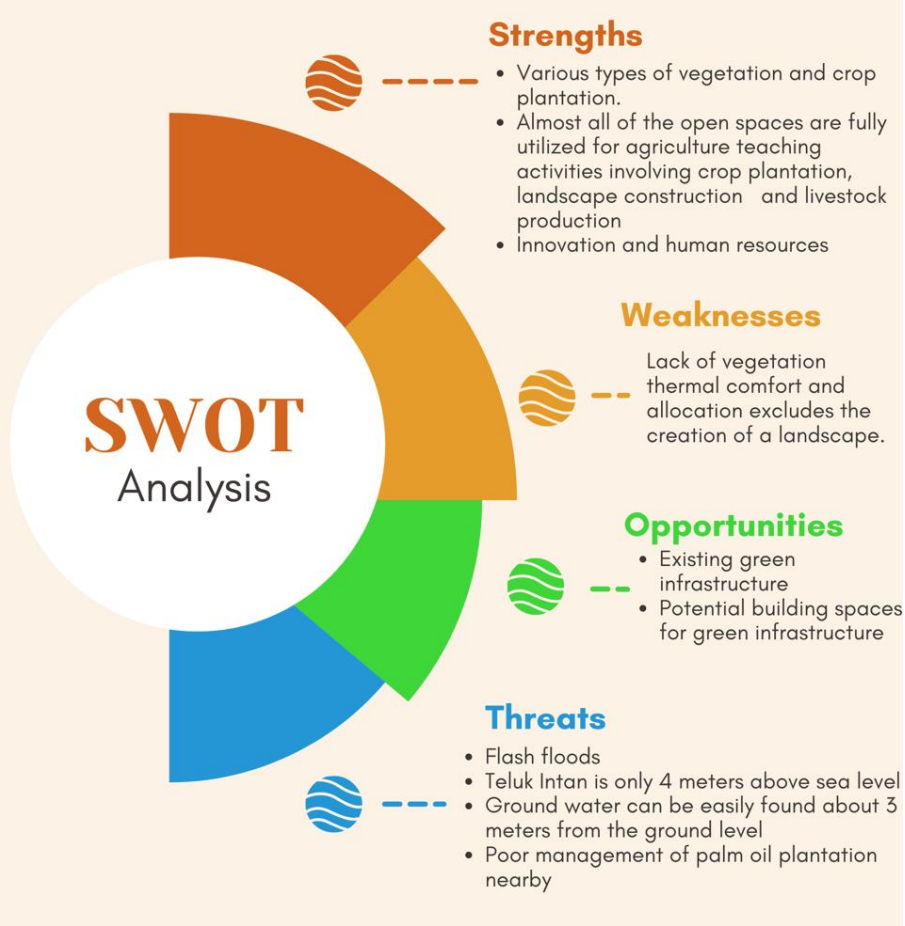

Figure 6: SWOT analysis of Green Infrastructure in Teluk Intan Vocational College

Findings

A survey was conducted to evaluate lecturers' perceptions of green infrastructure integration on campus based on the literature review and compare them with the current state. The findings of the survey indicate that lecturers hold varying perceptions regarding the integration of green infrastructure on campus. The results and findings are presented below: Section B is an analysis of items on respondents' feedback regarding the issue of campus flooding. Table 3 shows the mean score and standard deviation for each item.

Table 3: The issue of campus flooding among the lecturers

	B: Knowledge about the flooding issue	Mean	SD	Interpretation
B1	I am aware of the risk of flooding on the KVPTI campus	4.40	0.56	High
B2	I am aware that the problem of flooding in the campus area can disrupt daily activities including the teaching process.	4.63	0.49	High
	Average	**4.51**	**0.52**	**High**

Based on Table 3 above, the interpretation of the data showed that the lecturers' awareness of the flood issue in the campus area was at a very high level, with an overall mean value of 4.51 and a standard deviation of .52. Data interpretation of the lecturer's awareness of flood risk shows a high mean value of 4.5 and standard deviation of .56. The highest mean scores were lecturer's awareness of floods that disrupt daily activities (M = 4.63, SD = .49)

followed by the lecturer's awareness of flood risk (M = 4.40, SD = .56). Both items recorded mean values at only high.

Section C analysed items to retrieve respondents' perceptions and understanding of green infrastructure approaches. Table 4 showed the score for mean and standard deviations for each related item.

Table 4: Perception of lecturers regarding green infrastructure

	C: Perception of green infrastructure	Mean	SD	Interpretation
C1	I understand that rainwater harvesting is the solution to the flooding problem in the campus area	4.03	0.76	High
C2	I understand that groundwater harvesting is the solution to the flooding problem in the campus area	3.90	0.80	Medium high
C3	I understand that green roof is the solution to the flooding problem in the campus area	3.16	0.98	Medium high
C4	I understand that a rain garden is a solution to the flooding problem in the campus area	4.03	0.66	High
C5	I understand that permeable pavement is the solution to the flooding problem in the campus area	4.13	0.57	High
C6	I understand that bioswale is the solution to the flooding problem in the campus area	4.16	0.64	High
C7	I understand that bioretention is the solution to the flooding problem in the campus area	4.13	0.50	High
C8	I understand that a green wall is a solution to the flooding problem in the campus area	3.43	0.97	Medium high
	Average	**3.87**	**0.73**	**Medium high**

Based on Table 4 above, data interpretation showed that lecturers' perceptions and understanding of green infrastructure potential on the TVET campus were at a medium high level with an overall mean score of 3.87 and a standard deviation of 0.73. This result has shown that lecturers are aware of the importance of green infrastructure as a solution to the flooding issue at a medium high level. All items recorded high and medium high mean scores. The green infrastructure with the highest mean score was "bioswale" with values (M = 4.16, SD = 0.64) followed by "permeable pavement" with values (M = 4.13, SD = 0.57). Next, the green infrastructure was "bioretention" (M = 4.13, SD = .50), "rainwater harvesting" (M = 4.03, SD = .76), "rain garden" (M = 4.03, SD = .66), "groundwater harvesting" (M = 3.90, SD = .80), "green wall" (M = 3.43, SD = .97), and "green roof" (M = 3.16, SD = .98). All items recorded mean values at only high and medium high.

Overall, the items in both Section B and Section C have recorded positive mean scores, which indicate that the lecturers at the vocational college have positive perceptions and understanding of green infrastructure planning on the TVET campus. The results of this survey clearly show that the readiness of TVET lecturers towards sustainable development education in TVET institutions will be expressed by effectively educating the students on sustainability issues. While the results of the survey indicate positive perceptions and understanding

towards green infrastructure planning among the lecturers at Teluk Intan Vocational College, further research could be conducted to identify any potential barriers or challenges that may hinder the implementation of sustainable development education in TVET institutions.

Potential Green Infrastructure Suggestion for TVET Campus

The findings of this study on lecturers' perception of green infrastructure on campus reveal several differences between the literature review and the current state of existing green infrastructure on campus. Similarly, while the campus has implemented several green initiatives, the findings of this study suggest that the level of understanding among lecturers may not be as high as previously assumed. This section will highlight the proposed suitable green infrastructure that aligns with the agricultural education system and the current state of the campus based on on-site observation.

Strategy for Green Infrastructure Implementation

Six green campus principles—ecology, cultural, vocational identity, artistic, pragmatic, and economic—have been identified for TVET institutions (Xue & Gu, 2019). The following are proposed recommendations of strategies for future management and planning of green infrastructure in Teluk Intan Vocational College.

Figure 7: Strategy for Green Infrastructure Implementation

This institution has a higher risk of natural disasters, especially flooding. As a TVET institution that offers agricultural education, it must be well-equipped to manage natural disasters that can disrupt the campus teaching and learning process. Therefore, the strategy is to create a resilient campus environment by implementing green infrastructure development. Fostering green infrastructure initiatives to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters by capitalizing on the available environmental resources in the campus area, such as clean air, land, water, and energy (Liao et al., 2017).

Green Infrastructure Approach – Green Roof

A green roof refers to all systems that enable roof greening with vegetation growing on top of structures (Shafique et al., 2018). It includes several layers present in green roofs that support and enhance system performance. Green roofs frequently consist of multiple plants with a growing medium (substrate), filter layer, and drainage layer as shown in Figures 8 and 9 (van der Meulen, 2019).

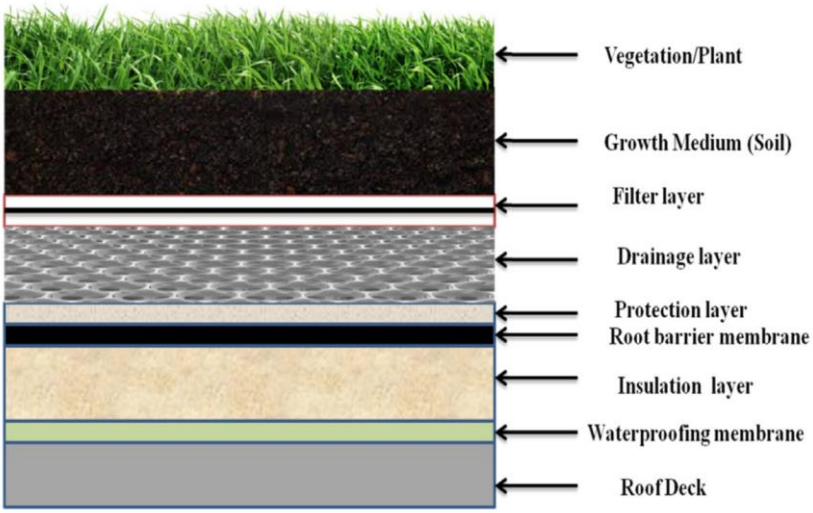

Figure 8: Components of green roof. Adapted from Shafique et al., (2018)

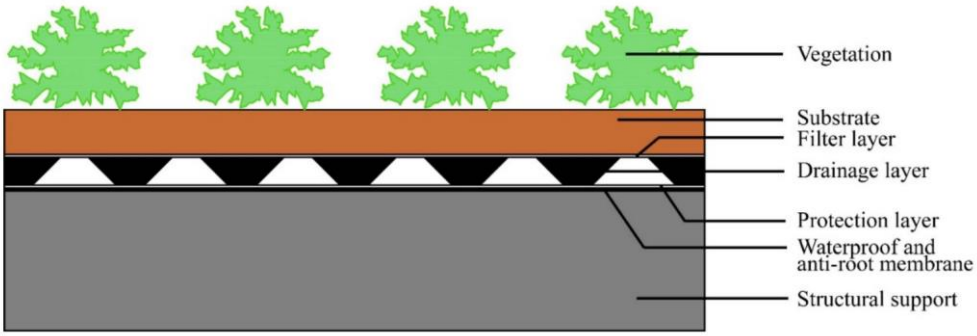

Figure 9: Components of green roof. Adapted from Cascone (2019)

In this study, various spaces on the infrastructure and buildings at this campus have the potential for green roof implementation. Five hotspots have been identified, located in the middle of the campus where there is a lack of vegetation as shown in Figure 10.

Figure 10: Green Roof (Source: Google Earth 2020 & Author)

Green Infrastructure Approach – Rainwater & Groundwater Harvesting Hotspot

The average annual rainfall of the Teluk Intan district, which is 2412 mm qualifies this campus area for rainwater harvesting. According to Hilir Perak Public Works Department, the underground water for the Teluk Intan Vocational College campus area may also be easily retrieved up to three meters below the ground level. Five hotspots for rainwater and groundwater harvesting have been identified as shown in Figure 11. It is located in the students' practical area, where they can apply sustainable management in the teaching and learning process. According to survey responses, rainwater collection can aid in lowering water pressure issues in buildings and laboratories. It can also be used as a source of water for watering plants and managing livestock.

Figure 11: Rainwater and Groundwater Harvesting Hotspot (Source: Google Earth 2020 & Author)

Green Infrastructure Approach – Recreation Field as Detention Area & Recreation

Every year, the recreational field at Teluk Intan Vocational College is frequently threatened by flooding, especially during the rainy season (November - March) as shown in Figure 12. It puts the nearby students' practical spaces at risk, including Biotechnology Unit, Horticulture Unit, Landscape Architecture Unit, and Agro Mechanization Unit. The inability of the soil to absorb rainwater and ineffective irrigation and drainage systems make this situation worse.

Figure 12: Recreation Field as Detention Area (Source: Author)

The concept of "turning disaster into opportunity" can be applied by making this space a detention area and creating a containment for water. It can increase water infiltration to the ground, help runoff water drain easily to the detention areas, and allow space for flooding, as has been done by Chulalongkorn University Centenary Park (Yarnvudhi et al., 2021). This system will sustainably collect and treat water, decrease flood risks, and reduce the campus heat. It also can adapt to climate changes, recreate a healthy ecosystem, and provide a habitat for local birds, pollinators, and insects. It will be one of the aesthetic attractions whereby turning flood problems into something worthwhile.

Green Infrastructure Approach – Open Space as Rain Garden

Rain gardens as bioretention facilities, designed to treat polluted stormwater runoff. It will provide a method to reuse and optimize rainwater, reducing or avoiding the need for additional irrigation (Sharma & Malaviya, 2021). The development of a rain garden in the open space of the campus will improve water quality by filtering runoff, providing localized flood control, creating aesthetic landscaping sites, and providing diverse planting opportunities as shown in Figures 13 and 14.

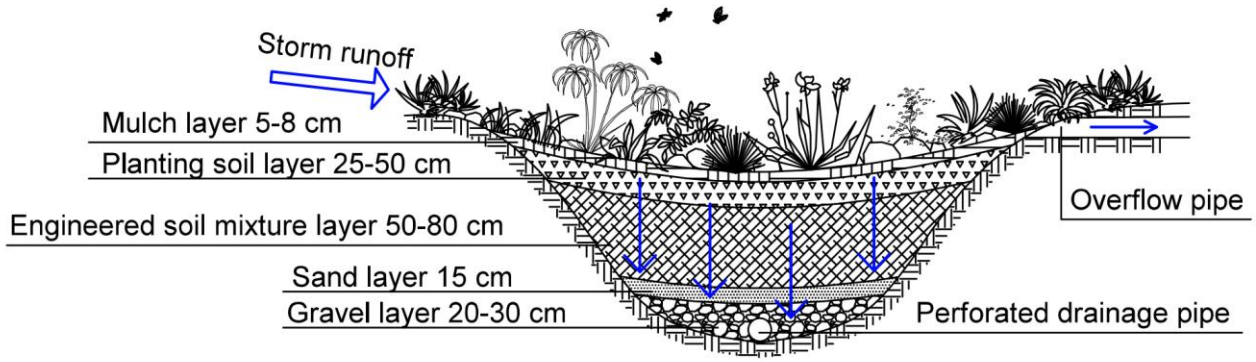

Figure 13: Cross-section of a rain garden. Adapted from Zhang et al., (2020)

Figure 14: Open Space as Rain Garden (Source: Author)

Agroecology as our future teaching and learning approach in TVET agricultural education

Agroecology is an application of ecological principles to agricultural systems and practices. It takes a comprehensive approach to agro-environmental issues to address the complex concerns facing agriculture in the face of global change (Aguilera et al., 2020). To create campus adoption in flood-prone areas, future teaching and learning approaches for agricultural programs in TVET institutions need to go hand in hand with the importance of ecology and natural sustainability. The agroecology approach in TVET is a relatively new concept instead of agrotechnology. Critical analysis of its dynamics, conflicts, and potentials is necessary to ensure that it can meet the marketability needs of graduates but also the sustainability of their lifelong learning (Anderson et al., 2019).

Various strategies can be used for campus development in the future. Build more permeable pavements; natural bioswale, dry creeks, retention ponds, and many green

infrastructure components to absorb rainwater to mitigate flooding. Teluk Intan Vocational College is currently located in a potential floodplain area and these precautionary measures can reduce economic losses due to flooding. Understanding green infrastructure strategy and application using site potentials and regulating services by ecosystem can benefit from cost reduction in the long term.

Anticipated Benefits

These green infrastructure approaches will bring a wide range of benefits that contribute to environmental, cultural, and social improvement in TVET institutions such as:

i. Integrating green infrastructure as one of the sources of income for vocational colleges through learning facilities. Manpower from students is fully utilized in producing products.
ii. Green infrastructure is one of the symbols of higher education learning whereby ecosystem services are entangled with human development and can teach fundamental lessons about system thinking, sustainability, and resilience.
iii. Opportunities for research and innovation in agriculture to adapt to the problem of climate change.
iv. Introducing new educational approaches in agriculture education in line with agro-industry and agro-technology according to climate change for the future generation **Agroecology.**
v. Teluk Intan Vocational College is a model of educational institutes that turn disasters into opportunities **organic education.**

Challenges

Understanding the challenges, constraints, and limitations that lead to an unsustainable campus is critical. Several challenges may vary depending on various factors such as culture, that are related to social awareness and human capital resources, natural resources, and financial capacities. The biggest challenge is financial resource constraints whereby vocational colleges are educational institutions that still depend on allocations from the government. Allocations are often focused on building infrastructure and facilities rather than maintenance, landscape development, and green areas. In addition, management objectives differ between departments and programs in vocational colleges. This is because the 10 programs offered by agricultural vocational colleges have different goals and objectives. It will impact human resource management since students and teaching staff from various programs will be the main drivers for the development of green infrastructure on the campus.

The perception of certain parties is also a challenge in integrating green infrastructure. For them, the construction and maintenance of green infrastructure are expensive and unprofitable. In essence, there is not enough understanding of what green infrastructure will cost to design, construct, and maintain in comparison with traditional approaches. There are many challenges in the implementation. However, identification and understanding of the multi-faceted complex issues are critical to guide the decision to arrive at the best solution.

Recommendation

The study provides recommendations on strategies for encouraging more active management participation in green infrastructure approaches at all levels:

i. All departments and programs in this college need to work together to develop the green infrastructure system with their respective expertise.

ii. Utilize innovation expertise, educational space, and students in developing products and services that can contribute to college income.
iii. Future design for better sense to the user so that the challenges of climate change can be adapted and benefit the environment, economy, and social sustainability for future generations.
iv. More research needs to be done to find scientific answers like the real causes, issues, and problems of nature, drainage, sea level rise, and groundwater solution to find a sustainable solution.
v. Adopted a new approach to new development, urban planning, and management to achieve disaster-prone cities.

Conclusion

Future sustainable planning at the TVET campus requires knowledge about the dynamic environment of the campus itself, as well as adaptation to climate changes which are powers too great for us to control. Therefore, the green infrastructure proposed in this study is compatible with TVET education and the current state of this campus. Through the survey, the lecturers also acknowledged the importance of green infrastructure to reduce flood problems. Green infrastructure is also seen as having the potential to be integrated with the education system and the agricultural curriculum whereby the existing agro-industry approach is potentially aligned with the concept of agroecology. A new education system approach can also be introduced to ensure the sustainability of the TVET educational system for future generations. Therefore, the existing agricultural education system can be maximized to produce resilient students facing the effects of climate change.

Acknowledgement

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