

Urban Environmental Management Practices and Green Roof Technologies in Malaysia: A Path to Sustainable Development

Mohd Hashim Zulkifly¹, Madelyn Shiu Liu^{2*}

¹Enviro Tech, Seksyen 16, Bandar Baru Bangi, Selangor 43650, Malaysia

²Faculty of Engineering, Mansoura University, El Mansoura 1, Dakahlia Governorate 35516, Egypt

Correspondence: shiumliu@gmail.com

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ABSTRACT: Malaysia is the developing country, which develop in contraction, agriculture, and many more kinds of activities. The construction activities for Malaysia is less implemented the green materials technology and the Environmental Management. The Environmental Management Practices is not usually applied by the construction workers. The government also show no enforcement and awareness on the Environmental Management Practices in Malaysia. There are some importance of the Environmental Management Practices is described and also the plan to improve the implementation of Environmental Management Practices under construction of Malaysia. The green roof is one of the technologies of green materials. There three kinds of green roof system as intensive green roof system, semi-intensive green roof system, and extensive green roof system. These three different systems have its own advantages and this advantages. The green materials that can be used for the green roof construction are bamboo, stones, and recycled bricks. The green materials or green roof system help to reduce the environment impact, social impact, and economic impact of Malaysia. The better environment, social life and economic can lead to sustainable development in Malaysia.

KEYWORDS: Malaysia; sustainable development; green materials; green roof; environmental management practices.

1. Introduction

Now a days, green roof is important to be used to sustain the urbanization country and Malaysia is one of the country is still implementing the green roof technology [1]. The green roof technologies able to help to improve the economic of Malaysia such as more people like to implement the green roof technology on the construction building, the marketing business in selling land properties of its income will be increased. If many buildings in Malaysia have apply these green technology It also can help to reduce energy consumption that also help to reduce the payment in using electricity and water from the government supply [2]. Green roof is one of the technologies under green materials. The meaning of green roof is to make green on the roof of construction building by planting different kind of vegetation on the roof of construction buildings [2, 3]. It need to have a landscape of engineering to grow vegetation in a certain layer on the roof and make sure that it can be engineered by including some conditions

in the design are vegetation cover and growing substrate to absorb and relief the heat and radiation from the sunlight. The vegetation cover and growing substrate also can help to improve the quality of air in reduction of carbon dioxide emission released to the atmosphere and reduce noise pollution to the surrounding area. The another conditions need to include in the design landscape are drainage and filter system to have better runoff of rain water on top of the buildings and management and treatment of water as reuse rainwater [3–5]. Living roof same meaning as green roof is one of the approaches to help to achieve the goals of sustainable development in urban area of developing country like Malaysia. It can reduce the climate change, global warming, the ecosystem impacts, environment impacts, the heat absorption of earth's surface, and energy consumption of the buildings [4, 6]. It also can have better improvement in social, economic and environment of a country. For reduction of environment impacts when green roof is being applied at the building of Malaysia, it means to reduce the temperature of surrounding in Malaysia, reduce the carbon emission emitted to the atmosphere, and reduce in wastewater discharged to the sewage. For better social life for the people in Malaysia, this technology can provide work opportunity for the construction and management of the green roof on buildings and also provide habitat or living areas for the species of Malaysia, at the same time, able to sustainable development and living in better environment [2]. The green roof can help the people to have better living and reduce the sickness of human like people easily unconscious [7]. The objective of this review article is to explore the benefits and potential of green roof technology in Malaysia, focusing on its role in enhancing urban sustainability, improving economic conditions, reducing energy consumption, mitigating environmental impacts such as carbon emissions and noise pollution, and contributing to social well-being through job creation and improved living conditions.

2. Current Status and Government Policy on Environmental Management Practice in Malaysia

2.1. Current status on environmental management practice in Malaysia.

Malaysia is a developing country. Malaysia also has fast growth in the percentage of the Gross Domestic Product in 2017. As a developing county, there will be a lot of development activities being implemented, for example, development activities in construction, agriculture, industries or facilities, tourism, and fishery [8]. The population of Malaysia has been increasing for the past 20 years. The population increase led to more activities being implemented, and the amount of waste production will be kept increasing [9]. The activities that help to develop the country will generate more waste and pollution may cause environmental impacts. In Malaysia, construction activities continue to increase, contributing significantly to waste generation. Recent statistics reveal that the construction sector accounts for approximately 44% of Malaysia's total solid waste, amounting to over 12 million tons annually, according to the Malaysian Department of Environment (DOE, 2022). The high level of waste is largely attributed to the limited adoption of sustainable green materials and green material technologies. For example, a 2023 report by the Construction Industry Development Board (CIDB) highlights that only 25% of construction projects in Malaysia actively incorporate green materials such as recycled concrete aggregates and bamboo-based composites, despite their proven environmental benefits. While Malaysia strives to align its construction practices with sustainable development goals, aiming to achieve a balance between environmental

protection, societal well-being, and economic growth, significant challenges remain. Construction activities continue to generate waste, contribute to environmental degradation, and cause adverse socio-economic impacts. By adopting ISO 14001-certified Environmental Management Systems (EMS), the company achieved a 15% reduction in construction waste and improved resource efficiency by utilizing sustainable materials in their projects, such as low-carbon cement and recycled steel. Despite such success stories, broader industry compliance remains limited. As of 2024, only 30% of Malaysian construction companies are ISO 14001 certified, according to the Department of Standards Malaysia, highlighting the need for more robust enforcement and incentives to encourage widespread adoption.

The construction activities also will release or create air pollution to the ambient air, soil pollution caused by soil erosion, water pollution caused by the muddy effluent discharged from the construction, and noise pollution, which will affect the social life of people in Malaysia. The more waste and pollution generated will affect the economic business of Malaysia. For example, the public will send more complaints due to the construction, and the construction company need to pay more penalties and may face a business crisis. The pollution and waste released into the environment may cause the risk to human health [10, 11]. These three impacts cannot be reduced and caused by the construction activities because they have some companies did not fully follow the environment management system provided by the environment consultants or the law and regulations [11]. By following the law of the Environmental Quality Act 1974, an Environmental Impact Assessment (EIA) report needs to be written by the environment consultant's company and submitted to the government. An approval of the EIA report to start the construction activities from the government before starting the construction activities. Many mitigation measures listed in the EIA report helped to reduce the pollution and waste that are released or discharged into the environment or affect the social life of people in Malaysia. However, some construction companies do not follow the mitigation measures when facing problems during construction activities. They also did not ask to have some consultation meetings with the consultant's experts on the environment, when facing new problems that were not listed in the EIA report during the construction activities.

2.2. Current government policy on environmental management practice in Malaysia.

Some sustainable development goals for Malaysia to become a developing country need to be achieved with the important helps from the government. The goals are to provide better health care and education knowledge to the people of Malaysia, minimize air, water, noise, and soil pollution, limit the energy consumption, and provide more work opportunities. The government policy of Malaysia is now more focused on the environmental management practise that can help to sustain the development with the consideration on conserve the environment and biodiversity. The lack of enforcement of environmental management practices in Malaysia's construction sector stems from several systemic issues. First, there are insufficient government-led awareness and training programs to educate contractors and developers about the importance of EMPs, such as ISO 14001 [9]. This knowledge gap results in low prioritization of sustainability initiatives within the industry. For instance, many small to medium-sized enterprises (SMEs) in the construction sector lack the resources and technical know-how to implement ISO 14001-compliant Environmental Management Systems (EMS). Second, weak regulatory frameworks and inconsistent monitoring further exacerbate non-compliance. The current enforcement mechanisms lack a standardized approach for auditing

construction sites, leading to varying levels of oversight. A 2023 study by the Malaysian Institute of Planners revealed that only 30% of construction projects were subject to routine environmental audits. Moreover, penalties for non-compliance are often lenient, reducing the incentive for contractors to adopt sustainable practices [12]. The government also did not force the construction company to follow the guidelines and regulation requirements in control of pollution and did not monitor their construction work during the construction [13]. The government have proposed and published some of the law and legislation for the construction activities to follow which will help to reduce the environmental impacts that lead to climate change, global warming, and air, water, and water pollution [14]. The government was not aware of the important of green materials and implementation of Life Cycle costs to be used for the construction sites that help to sustain the better green technology and reduce the environmental impacts [15].

3. Overview of Planning and Propose of Environmental Management Practice

From the current status of Environment Management Practices, Some plans and suggestions are provided below to improve the Environmental Management Practices (ESM). Public awareness about green materials and green materials technologies needs to be implemented by the government. The government must give support to the construction workers and encourage construction workers to use green materials and green technologies because it can bring more advantages and benefits to the environment, society, and business. These three benefits are available to sustain the development of the construction activities. Another plan and suggestion to improve the EMS is to get reviews and feedback from the experts of construction workers or experienced construction workers. The evaluation and feedback given by the construction workers regarding improving the EMP are very useful in identifying any problems on the construction sites that are commonly not found. It also provided some suggestions or mitigation measures to help improve the Environmental Management Practices in Malaysia [16]. In addition, another planning and suggestion for the improvement in Environmental Management Practices is the government need to run enforcement and set periodic time to monitor the construction work to make sure they will comply with the law and regulation, to create a document of environment management for the construction work and get approval from the government, and implement the mitigation measure of EIA report. The EMP becoming better may lead to better sustainable development of Malaysia, the economic growth of Malaysia will be increased, and the minimization of the environmental impacts and social impacts. Non-compliance with EMPs at construction sites should result in penalties to encourage adherence. Additionally, it is essential for the government or construction companies to provide training and education on EMPs and green materials to construction workers. This will enhance their understanding and enable them to effectively implement sustainable practices, contributing to a greener environment and better environmental protection. To further improve EMPs, the government should make green materials more affordable, increase the cost of non-green materials, and offer subsidies or reduced prices for recyclable or recoverable materials. These measures would incentivize construction companies to adopt green technologies and prioritize the use of sustainable materials. The ultimate goal of EMPs is to ensure that construction activities align with plans to mitigate air, water, noise, and soil pollution. Moreover, EMPs aim to reduce waste generation in Malaysia by promoting the principles of reduce, reuse, recycle,

and recover (4Rs). Another importance of Environmental Management Practices is help to achieve the goals of 2023 Sustainable development for Malaysia (Table 1).

Table 1. Proposed strategies and recommendations for enhancing EMPs in Malaysia.

Plan/Suggestion	Description	Expected Benefit
Public Awareness	Government to implement public awareness campaigns about green materials and technologies.	Increased public support and knowledge about environmental benefits.
Government Support	Encourage and support construction workers to use green materials and technologies.	Enhanced environmental, social, and business advantages.
Expert Feedback	Gather reviews and feedback from construction experts and experienced workers.	Identification of site-specific issues and effective mitigation measures.
Law Enforcement	Government to enforce laws and regulations, set periodic monitoring, and require EMP documentation and approval.	Compliance with laws, reduced environmental and social impacts, and improved sustainable development.
Training and Education	Provide training and education on EMP and green materials to construction workers.	Better implementation of EMP, greener construction practices, and environmental protection.
Cost Adjustment	Adjust costs to make green materials affordable and non-green materials more expensive. Provide low-cost treatment for recyclable materials.	Shift towards green technologies, increased use of green materials in construction.
Pollution Reduction	Ensure construction follows plans to reduce air, water, noise, and soil pollution.	Decreased pollution and waste generation, improved environmental quality.

4. Current Situation of Green Materials for Construction

4.1. Recycled bricks.

Recycled brick is created from recycled materials or waste by using some technologies. The original material to form the brick is clay but the recycled bricks will compost or mix with the recycled materials and waste like plastic bottles, glass, brick waste from the construction activities, treated and stabilized dry sludge and fly ash. The recycled materials or waste will be needed to break into fine pieces and then mix with the dry clay to form a new recycled brick. The recycled brick can help to reduce or fully remove the waste generated by other treatment plants to the final disposal. The recycled bricks as waste disposal also can be recyclable back into new recycled bricks or another green material. [17]. The mixture range between the clay and the recycled materials or treated dry waste will be different due to different recycled materials and treated dry wastes [18]. The stubble is waste generated from agricultural activities that this kind of waste can be used to mix with the clay to form recycled bricks. However, every production of recycled bricks needs to be analyzed for it whether can be used for a long life usage, the durability of the recycled brick, and other kinds of quality checking. The industries that implement the manufacture of recycled bricks must be certified by the government [19, 20]. This green material can help to reduce the waste disposed to the environment. The environmental impact can lead to climate change, and global warming,

destroy the ecosystem of the environment, and cause the extinction of species. The recycled bricks can be used to build up the roof of the buildings (Table 2).

4.2. Bamboo.

Bamboo also is one of the green materials used for the construction site and can help to sustain the development of materials used for the construction. Bamboo can be found in many countries and bamboo will not easily be extinct from the environment [21]. Common knowledge about bamboo is that bamboo can grow faster than the period of growth of another plant and it is also a renewable source that can be taken from the environment and does not affect the environment when the bamboo is removed from the soil. Bamboo can replace some materials of the construction like pillars, steel, slabs, and cement [22]. The production of bamboo materials for construction needs to be certified [23]. This green material will not cause environmental impact like reducing air pollution from the ambient air and it can absorb more air pollution than other plants [24]. The bamboo can be formed into chairs and tables that can be placed in the green roof system. It also can be used to decorate the green roof of the building.

Table 2. Overview of the current status of green materials in the construction Industry.

Green Material	Description	Benefits	Applications
Recycled Bricks	Created from recycled materials or waste mixed with clay. Materials include plastic bottles, glass, brick waste, dry sludge, and fly ash. The mixture varies based on the type of recycled material used.	<ul style="list-style-type: none"> – Reduces waste to final disposal – Recyclable into new bricks or other materials – Reduces environmental impact leading to climate change and global warming 	<ul style="list-style-type: none"> – Used for building construction – Can build roofs of buildings
Bamboo	Renewable material found in many countries, grows faster than other plants, and is a sustainable source for construction.	<ul style="list-style-type: none"> – Replaces materials like pillars, steel, slabs, and cement – Reduces air pollution – Absorbs more air pollution – Environmentally friendly 	<ul style="list-style-type: none"> – Used as construction materials – Formed into chairs and tables – Decorates green roofs
Stones	- Natural and sustainable material that does not produce hazardous pollutants. It has a waterproof system and helps control thermal heat.	<ul style="list-style-type: none"> – Reflects sunlight – Controls thermal heat – Reduces energy consumption – Durable and long-term use – Less environmental impact 	<ul style="list-style-type: none"> – Used for building construction – Recycled into sand, gravel, and small stones – Transformed into mortar, concrete, bricks, and marble – Decorates pavements and forms ponds in rooftop gardens

4.3. Stones.

Natural stones are one of the green materials and it also a sustainable material that can be used for construction [25, 26]. The natural stones do not produce any hazardous pollutants or organic compounds and release them into the environment. Natural stones have a waterproof system that is suitable for use as green material for the construction of buildings. A few advantages of natural stones as green materials for construction buildings are available to reflect the radiation of the sunlight to absorb the heat of the sunlight and control the thermal heat and can help to apply a cooling system in the inner building. The energy consumption of the buildings will be reduced because the temperature of the inner part of the building decrease, and the usage of water for plants and electricity for the air conditioner will be decreased [27, 28]. It also has better durability and can be used for long-term usage and less environmental impact when

purchasing the stones. The stones also can be recycled into sand, gravel, and small stones [29]. The stones also can be transformed into new materials like mortar, concrete, bricks, and marble. Natural stones are the common green materials for construction activities. The natural stones can be used to decorate the pavement area of the green roof system or to form a small pond for the rooftop garden [30].

5. Green Roof Technologies

5.1. Intensive green roofs.

Intensive green roof is one of the types of green roof technology (Table 3). An intensive green roof means planting large and small-scale plants to form a green garden on top of the roof of the building, called a rooftop garden [31, 32]. However, it also needs some layers to be included such as vegetation cover, growing substrate, drainage, water management and filter system. It can plant trees, flowers, mosses, shrubs, grasses, sedums, and herbs [33–36]. The landscape of the rooftop garden will be designed by the engineers, which includes the intensive green roof system. The design needs to include a lawn, pavement area, resting area, park area, small agricultural area and undercover area that can allow people to enter, exercise, sit during rest time, have a playground for children, and may have a small pond [35–39]. The landscape of intensive green roofs shows that the building needs to withstand the heaviest weight of green roof system than extensive green roofs and semi-intensive green roofs. It also needs the depth of soil around 15 to 35 cm or more than that [6, 11, 12]. It also can design the landscape of green roofs to allow the building available to withstand the weight of green roof design around 180 kilograms per meter square to 500 kilograms per meter square [6, 9]. The vegetation cover is being planted for the intensive green roof with different depths of the root of the plant, which is available to plants with longer lengths of the roots than the plants planted in the vegetation cover on the extensive and semi-intensive green roof. The intensive green roof system has some advantages and disadvantages when this system has been implemented on top of the building. First is the advantage of intensive green roofs having better cooling systems of intensive green roofs than the cooling systems of extensive and semi-intensive green roofs. It helps to reduce using the air conditioning inside the building, and it can plant more kinds of plants than the extensive green roofs and semi-intensive green roofs like the bigger size of tree species [13]. The intensive green roof can reduce energy consumption than the extensive green roof and semi-intensive green roof because it helps to reduce the temperature of the building and reuse the rainwater from the treated rainwater. This type of green roof system can reduce more air pollution from the environment than the other two kinds of green roofs [6, 11]. The last two advantages of the intensive green roof are available to beautify the design of the landscape of the roof on the building and can help produce food from the small agricultural area [6]. However, the disadvantage of the intensive green roof system is high maintenance and operation costs such as more money to hire workers to maintain the green roof system and keep the safety of the people visiting the garden on the roof. Also, it needs workers to take care of the small agriculture [6, 9]. Another disadvantage of intensive green roofs is the capital cost for construction intensive green roof systems is more expensive than other types of green roofs such as need cost to buy large-scale trees and fertilizer for the plants, the cost to build up the pavement and parks, and cost for designing landscape [3, 9]. The weight of this intensive green roof is heavier than another two kinds of green roofs, therefore, need to plan a design for the

top of the building that can withstand the weight of the intensive green roof system [2]. The intensive green roof system needs more water usage for irrigation on the rooftop garden or for agriculture than the extensive and semi-intensive green roof [6]. The intensive green roof system will be more suitable to be applied in large areas of the roof on the building, which is considered one of the disadvantages of this type of green roof [14].

Table 3. Green roof technologies.

Type	Description	Advantages	Disadvantages
Intensive Green Roofs	Planting large and small-scale plants to form a rooftop garden. Includes layers like vegetation cover, growing substrate, drainage, water management, and filter system.	A more efficient cooling system compared to extensive and semi-intensive green roofs.	This option involves high maintenance and operational costs, along with significant initial capital investment. Its heavy weight necessitates robust structural support and demands more water for irrigation, making it suitable primarily for large roof areas.
Semi-Intensive Green Roofs	Middle type of green roof system. Includes layers like vegetation cover, growing substrate, drainage, water management, runoff, and filter system. Plants include mosses, sedums, lawns, flowers, and shrubs.	This system promotes biodiversity while effectively lowering energy consumption. It enhances the management of rainwater runoff and offers superior water retention in the soil compared to extensive green roofs. Additionally, it minimizes the reflection of sunlight and heat radiation, ensuring reduced thermal heat transfer for improved overall performance.	This system incurs high maintenance and operational expenses due to the need for regular irrigation and fertilizer application to sustain its functionality.
Extensive Green Roofs	Planting small-scale plants on various roof types. Includes layers like vegetation cover, growing substrate, drainage, water management, and filter system.	This approach features low maintenance and operating costs, along with reduced construction expenses. Its lightweight design supports efficient runoff systems and can serve as a habitat, providing food for birds and insects, contributing to ecological balance.	This system offers limited plant selection and does not support agricultural activities. It is less effective in reducing air pollution and lowering temperatures, with diminished energy savings in regions experiencing high temperatures and drought conditions.

5.2. Semi-intensive green roofs.

Semi-intensive green roof is another one of the green roof technology. This green roof system needs to be done or formed by using different layers such as vegetation cover, growing substrate, drainage, water management, runoff and filter system, which are almost the same as intensive and semi-intensive [6]. It is a middle type of green roof system. The plants that will be selected for the vegetation cover of semi-intensive green roofs are mosses, sedums, lawns, flowers, and shrubs. The height of the growing plant will not be higher than the tree species [7,8]. The depth of the soil layer for the vegetation cover of a semi-intensive green roof grows

about 5 to 25 cm deep. The semi-intensive green roof can include agriculture activities and pavement areas [8]. The semi-intensive green roof has a weight of 120 kilograms per meter square to 200 kilograms per meter square, which is lighter than the intensive green roof system and heavier than the extensive green roof system [6, 9]. This semi-intensive green can provide habitat or living or food for small species like birds, insects, and squirrels [8, 9]. The beautification of the landscape design for the semi-intensive green roof is required the same as the extensive green roof [10]. This system is also available for humans to access to walk, jog or do agricultural activities. The design for the semi-intensive green roof system is needed to ensure that includes the safety railing area surrounding the side of the top roof of the building. For this semi-intensive system, there are some advantages and disadvantages found and described below. The advantage of the semi-intensive green roof is it can sustain the biodiversity of the environment which helps to reduce environmental impacts [8]. It also has the same advantages as the intensive green roof food production and reduction in air conditioning that can help to decrease the energy consumption of the building. The runoff of rainwater for the semi-intensive system is better than the intensive green roof and the retention water of soil for the semi-intensive green roof is greater than the extensive green roof system [16]. Another advantage is a low reflection of the sunlight radiation and heat because the vegetation cover of the semi-intensive green roof will absorb the sunlight and reproduce the photosynthesis of the plants. The thermal heat transfer for the semi-intensive green roof is lower than the extensive green roof system [18]. However, the disadvantage of a semi-intensive green roof is need high cost of maintenance and operation because need to hire workers to care for the agricultural plants and need to pay for the irrigation of the plants. It also needs money to buy fertilizers for the plants to grow [9].

5.2. Extensive green roofs.

The extensive Green Roof system is another one of the green roof technology. The extensive green roof system applied on the top of the buildings is to plant small-scale plant species on the different kinds of roofs on the buildings. It also needs some conditions to build up this extensive green roof system that is the same as the intensive green roof system provided above. The soil layer for the plantation will only need a depth of 1 meter. The types of plant species for the extensive green roof are different kinds of mosses, sedums, grasses, and herbs [1,6]. The selection of plants needs to be available to adapt or tolerate the dry and high radiation area, less water applied, and fewer nutrients for the plants [1]. The vegetation cover in the extensive green roof can be applied on different kinds of roofs like flat surfaces, sloped surfaces, and rough surfaces. The waterproof materials need to be applied on the roof of the buildings before applying the extensive green roof system. The waterproof layer needs to also be applied when using the intensive and semi-intensive green roof system [13]. These waterproof materials need to be applied on the first layer of the roof because it used to avoid the seeping of water flow into the inner building during rain that may cause the building damage easily. The plant species that can be planted on the roof for the extensive green roof can only use the short root of the plants and a layer of substrate with a depth of 5 to 15 cm deep [3, 6]. This extensive green roof system can reduce the temperature of inner buildings but not as much as the intensive green roof, minimize energy consumption, and reduce the air pollution of the environment [6]. It can be applied on small or large scale areas of the roof on the building and needs some protection to prevent the strong wind from destroying the plants of extensive green roof system [8,9]. The

extensive green roof system is not available for humans to visit or access on the roof of the buildings [10]. There are some advantages and disadvantages to this extensive green roof system when it has been implemented on the top of any building. The benefits of the extensive green roof are low maintenance and operating costs to maintain the extensive green roof, and a lower construction cost to build this extensive green roof than the semi-intensive and intensive green roof [15]. The weight of this green roof is low. It can only be available with a weight of 60 kilograms per meter square to 150 kilograms per meter square. The mass of extensive green roofs is less than that of intensive and semi-intensive green roofs. The root of the plants needed to be selected is short for this extensive green roof [10]. Another advantage of the extensive green roof system is it has a greater runoff system than the intensive and semi-intensive green roof. It also can provide habitat or living and food for the bird or insect species [7]. The disadvantages of the extensive green roof system are mentioned below. The first disadvantage of the extensive green roof system is only a limited selection of plants and less than the other two types of green roofs. This green roof system does not include any agricultural activities. Another disadvantage of the extensive green roof is to decrease the air pollution from the ambient air and the temperature of the inner part of the building. Also, extensive green roofs are available to adapt to the dry, high radiation, and hot areas present on the roofs of buildings [6, 16]. The energy consumption of the building is reduced due to the implementation of the extensive green roof but the extensive green roof will be unavailable to help to reduce the energy consumption of the buildings when the extensive green roof is applied in the high temperature and drought area [14].

6. Conclusion

Malaysia, as a developing country, is advancing in various sectors such as construction and agriculture. However, the construction industry in Malaysia has yet to widely adopt green materials technology and Environmental Management Practices (EMP). The lack of implementation of EMP is due to insufficient enforcement and awareness from the government, as well as the construction workers' unfamiliarity with these practices. Despite these challenges, Environmental Management Practices are crucial for reducing the environmental, social, and economic impacts of construction activities. One effective green material technology is the green roof system, which includes intensive, semi-intensive, and extensive green roofs. Each type of green roof has its own set of advantages and disadvantages. Green roofs utilize materials like bamboo, stones, and recycled bricks, which contribute to environmental sustainability. By reducing the negative impacts associated with traditional construction, green roofs help to promote a healthier environment, improved social conditions, and a stronger economy. Adopting green roof systems and other green materials technologies in construction can significantly contribute to sustainable development in Malaysia, leading to a better quality of life and a more resilient environment.

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Author Contribution

Mohd Hashim Zulkifly contributed to the conceptualization of the study, data collection, and writing of the manuscript. Madelyn Shiu Liu was responsible for the data analysis, methodology, and data interpretation. Both authors collaborated to refine the manuscript and ensure the accuracy of the research findings..

Conflicts of Interest

The authors declare no conflict of interest.

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