# Environmental Sustainability in Urban Areas Construction Site: Malaysian Perspectives

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## ABSTRACT

The construction industry is the biggest contributor to every country's economy and development**.** It also uses many natural resources and produces much solid waste. It is important to apply environmental sustainability in the construction industry as construction activities contribute to environmental damage. This study investigates the impacts of construction activities in urban areas on environmental sustainability. The study adopts quantitative data collection via a questionnaire survey of the registered total population of 1,670 G7 Contractors in the Kuala Lumpur City Centre. A sample size of 313 was obtained and a total of 42 responded. The practice of sustainable construction sites in urban areas is still low. The construction sites in urban areas cause four main environmental impact. The highest is the ecosystem ecological impact followed by, public impact, and energy and natural resources impact. Additionally, the challenges of construction sites in urban areas to achieve environmental sustainability were higher initial costs, technical challenges, insufficient training, and lack of awareness and knowledge. The first potential solution was implementing green building assessment tools specifically using MyCREST followed by specific government roles, development of skills and education, and digitalization and Networking for construction site pollution management.

**Keywords:** Sustainable, sustainable development, construction sites, construction activities, construction impact, urban areas, environment, environmental impacts, environmental sustainability

## INTRODUCTION

The national economy and the economic development of any country are greatly affected by the construction industries and have no doubt contributed to the economy and social development of every nation. Construction activities also are expected to increase as the human population increases. This is proven by the yearly construction value increase trend in Malaysia after the COVID-19 pandemic (Figure 1). Nowadays, the construction sector is regarded as one of the main factors to promote national economic development. This is because the construction industry is dynamic, and has both forward and backward links with other fields. Therefore, it plays a beneficial and key role in developing country's economy [1]. In addition, it provides high-quality constructions, infrastructures, maintenance, renovations, etc. The construction industry in Malaysia is a significant contributor to Malaysia's Gross Domestic Product [2]. However, despite the significant contribution of the construction industry, there are adverse impacts caused by construction activities on the environment through the use of non-renewable resources which are also a source of waste products and $CO_2$ emissions.

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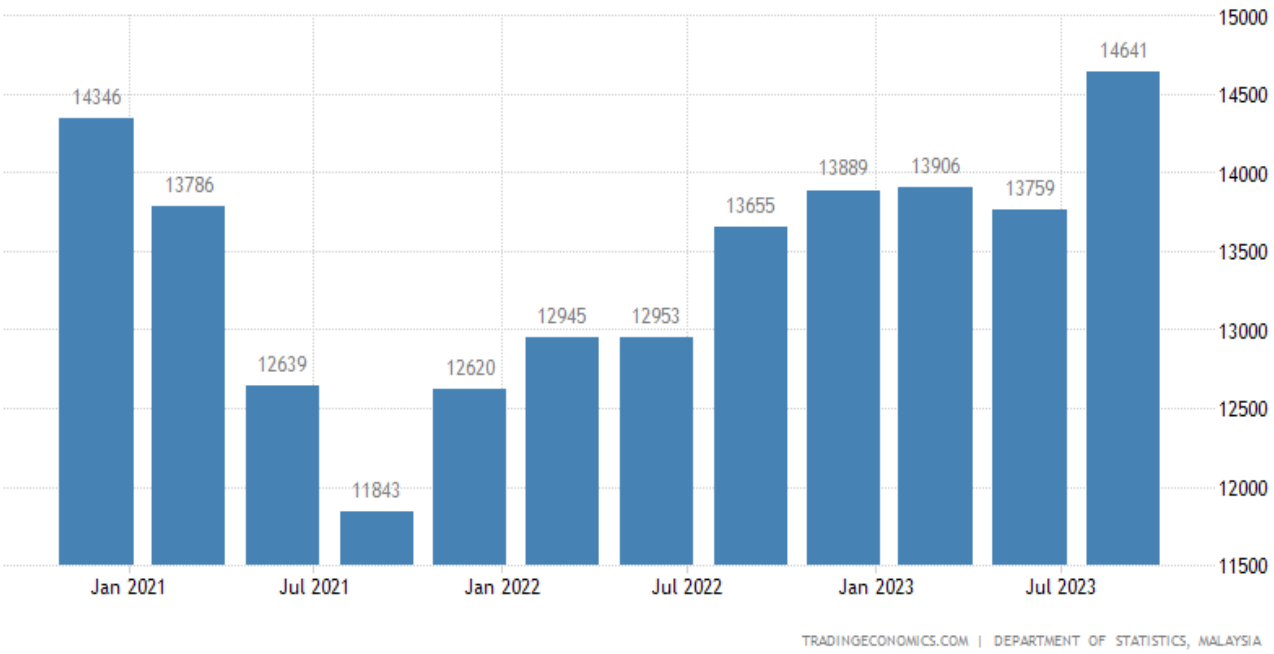


Figure 1: GDP from Malaysian construction industry

Many researchers have discussed the negative impact of construction industry. A report produced by United Nations Program Environment (2019) reported that the construction sector is responsible for 36% of final energy use, and 39% of energy and process-related $CO_2$. A study by [3] highlighted that the construction industries cause 30% of greenhouse gas (GHG) emissions. This impact is felt not only during construction activities but also throughout the building's lifecycle. Not only that, only a small percentage of solid construction trash has been successfully recycled, and up to 36,000 tonnes of collected waste are disposed of annually in various landfills [4].

This situation supported by [5] which shows that construction activities contributed to 40% of total solid waste, which nowadays has become a major worldwide issue. This issue is even worse as the treatment of construction waste has resulted in multiple environmental impacts. This is not good for environmental sustainability, and is an indication of a lack of regard for environmental issues and control over environmental pollutants. It causes health problems for people exposed to the activities. It affects the quality of living, including the loss of neighbourhood peace due to noise and movement disturbances, deterioration of surrounding cleanliness, and deterioration of the atmosphere's environmental conditions.

An urban area is characterized by features like densely populated residential areas, rapid population growth, industrial activities in designated zones, and a substantial proportion of impermeable surfaces [6]. Urbanization involves gathering and transforming both urban and rural areas into urban spaces [7]. This means a high population density, which translate to many people being expose wherever a construction site is in urban areas. Environmental sustainability is the duty to protect natural systems to achieve ecological goals [8]. In the construction industry, this can be translated as the use of renewable resources and recyclable materials, as opposed to non-renewable resources, to limit the amount of energy and waste produced during the construction process [9]. It also delivers the same meaning as the 1987, United Nation Brundtland report: the ability to meet current needs without endangering future ones. It is important to reduce the negative environmental impacts from the beginning to the end of the construction project [10]. In other view, sustainable in construction refers to improving the quality workers and employees lives by achieving economic and social goals without damaging the environment [11]. Implementing sustainable practices will reduces negative impacts on the environment brought by activities of construction sites in urban areas, thus reducing pollution and protecting the health of humans living near these sites [12]. Protecting the environment is an obligation for every human being. The project management teams of construction sites are considered crucial

players in achieving environmental sustainability goals, and ensuring project objectives are reached and delivered successfully. Therefore, they are in a good position to encourage, manage, and promote sustainable building practises in construction sectors [13]. Completing construction activities while sustaining construction site is one of the obstacles for the construction industry. Therefore, this study aims investigate the impact of construction activities focusing in the urban areas towards environmental sustainability. This research addresses the following four research questions:

RQ1: What is the current level of sustainable construction site practices in Kuala Lumpur as urban area?

RQ2: What are the significant environmental impacts caused by the construction sites in urban areas?

RQ3: What are the challenges of construction sites in the urban areas to achieve environmental sustainability?

RQ4: What are the potential solutions to enhance the implementation of sustainable construction sites in urban areas?

# LITERATURE REVIEW

### Sustainable Construction Site

Urban area is where there is high human population and concentration of buildings in large city. It is expected that 70% of the human population will live at the urban area by the year of 2050. Due to this situation, urban areas will face social and environmental problems, including lack of green space, a significant heat island effect, and severe flooding, which all engender-people's physical and mental health [14]. Construction industry is considered important in every developing and developed country. Building and infrastructure construction are necessary to ensure quality education and services in any nation. However, construction activities always related to the negative impacts towards the environment. Many studies have proven that construction activities resulted to climate change, scarcity of natural resources, destruction of animal habitat, water, air, and soil pollution and many more. Also, construction activities are considered an important contributor to waste and environmental pollution [5]. Construction activities are largely innovative compared to other industry. Their practice is more towards traditional ways and there are reluctant to changes. Therefore, it is not surprise if the sustainable construction site was not widely implemented in developing country [15].

Sustainable construction or sustainable construction sites has been debated many decades ago. It refers to the use of renewable resources and recyclable materials, as opposed to non-renewable resources, to limit the amount of energy and waste produced during the construction process. As a result, it reduces the negative environmental impacts from the beginning to the end of the construction project [10]. Another study by [16] defines sustainable construction as the ability to use natural resources more efficiently and environmentally. In short, sustainable construction deals with environmental responsibility, social awareness and economic profitability [17]. Same study also defined sustainable construction derived from seven (7) principles; 1) Minimize resources, 2) Minimize resource reuse, 3) Use renewable or recycles resources, 4) Protect the natural environment, 5) create a healthy, non-toxic environment, 6) Apply life cycle cost analysis and true cost and 7) Pursue quality in creating the built environment. On the other hand, sustainable construction also refers to minimizing the use of material and energy, reuse and recycle materials, and promoting human satisfaction. In fact, sustainable construction site can be the solutions in reducing environmental impacts [18]. The practice of sustainable construction site is not new. Many steps has been taken by the governments to enhance sustainability practice in Malaysia. The recent one is through the emergence of Construction 4.0.

The core values of this plan include sustainability and resilience, productivity, integrity, safety and health, and well being**.** Under the Ministry of Works Malaysia " Construction 4.0 Strategic Plan 2021-2025", there are twelve (12) technologies identified in this IR 4.0 that are expected to changes and enhance the future construction environment; Building information modelling (BIM), pre-fabrication and modular construction, autonomous construction, augmented reality and virtualization, cloud and real-time collaboration, 3D scanning

and photogrammetry, big data and predictive analysis, Internet of Things (IoT), 3D printing and additive manufacturing, advance building materials, blockchain and Artificial Intelligence (AI). The vision and mission, core values including the twelve (12) technologies will be supported by four (4) key enablers: people; economy, integrated technologies and governance. The concept of Construction 4.0 is mainly to improve current and future technologies in the construction industry and achieve better productivity, health and safety towards a sustainability approach. Not only that, Construction 4.0 is considered as a solution towards many issues concerning construction activities and manufacturing for example hazardous environment, health and safety of human labor, efficiency in managing supply chains, reduction in wastages, and saving in time with efficient management of delivery systems. The aim for construction 4.0 is not only to make better things by creating innovative products and services but also 'to make things better' by improving design, engineering, service planning and execution, management, and production process, said the minister on international trade and industry, Malaysia.

## Environmental Impacts

### Ecosystem Impacts

Construction sites produce many negative environmental impacts such as construction waste, noise, dust, and harmful pollutants which can seriously endanger human beings and the ecosystem [19, 20]. Ecosystem impact refers to the construction sites' direct or indirect impact on the environment and habitats or species. Many organisms, including humans, live on the soil for survival, especially soil as a source of food. Thus, soil pollution resulted to ecosystem impacts [21]. Table 1, the destruction of animal habitat, erosion from stormwater, pollution, and loss of arable land are a few examples of ecological impacts [22, 23]. Dust from construction activities and construction vehicle exhausts both produce air pollution in the ecosystem. Emissions such as carbon dioxide, nitrogen dioxide, and sulfur dioxide are released during construction activities. Air pollution led to causes of respiratory illness to humans. Inhalation of different-sized particular matter can cause long-term health issues which also affecting humans' health. Construction activities produce many an enormous quantity of particles into the environment, which may harm construction workers and individuals living in the neighbourhood. Inhalation of construction dust considered as occupational health hazard to the construction personnel which can directly or indirectly affect the labor-intense construction industry. Many of the cases, the effects towards the nearby residents are indirect. However, the symptoms may appears years later [24]. Land clearing from the construction activity generates debris waste. Throughout construction, other solid wastes will also be generated such as concrete, stone, sand, metal, etc [25].

Additionally, wastewater is generated from construction activities such as site cleaning, site sewage, water spraying to remove construction dust, etc. Ecological issues have been a significant part of Environmental Impact Assessment (EIA). One of the primary goals of an EIA is to protect nature's capacity and productivity, particularly the ecosystem, to maintain its sustainability [25]. However, this system has many uncertainties, considering many complex technical activities conducted at construction sites.

### Public Impacts

Most construction site activities are in urban areas, which are areas that are densely inhabited by the public. People working and living near to construction sites are more likely to suffer ill health effects due to the dust, vibration, and noise from the construction activities such as excavation works, driving of piles, etc. Even though health effects are not directly happening, high-risk humans with specific illness will feel unhealthy. The Dust, vibration, and noise lead to uncomfortable in the air and environment quality of the nearby resident. The impact is not only affecting public health, but also public hygiene and it can cause social disruption. The affected public is the on-site workers and the neighbouring residents living nearby the site [26-28]. Not only indirect impacts towards public health, unsustainable construction site also may harm the public life. This is proven from recent accidents during the highways construction of Sungai Besi-Ulu Kelang (SUKE) which cause a serious injury to the public [29].

### Energy and Natural Resources

During the construction process, a variety of natural resources are needed such as land, energy, water, and construction materials. This is proven by [30] that construction activities use 40% of the natural resources, 12% of drinkable water, 40% of stone, sand, and gravel and 25% of timber from the forest. This percentage is expected to increase as the population increases. The construction equipment operations will also require using energy is generated from natural resources, such as electricity and diesel or petrol fuel. Large amounts of fossil fuels to produce the energy consumed by construction activities can lead to the depletion of natural energy resources. The construction sites consume natural resources and produce pollution due to energy consumption during the exploitation and transportation of raw materials [31]. According to [23], construction industries account for over half of total energy consumption in high-income countries. In addition, it is responsible for a significant portion of greenhouse gas emission in developing countries.

### The Challenges of Construction Sites in Urban Areas to Achieve Environmental Sustainability

### Higher Initial Cost

Sustainable construction approaches may increase the cost of construction projects. This is because energy-efficient technologies like high-performance, energy-saving construction equipment need to be imported, increasing the project's total cost [32]. This increase in cost is known as the "green premium." The green premium in some developing nations may reach up to 30% due to a local shortage of suitable equipment and technology. Saleh and Alalouch (2015) also identified another economic challenge, which is construction time. The need to import green materials and equipment would frequently result in construction delays and subsequent construction cost, negatively impacting the reputation of all parties involved. Thus, it becomes a challenge to implement sustainable construction in urban construction sites. Many clients are concerned about the higher cost of constructing a sustainable building project [33]. The cost of acquiring sustainable materials and products is higher than that of traditional materials [32]. Due to the relatively lower initial cost, conventional construction and designs are easier for clients to accept. Although the cost of sustainable construction and the use of sustainable materials in building design require relatively higher initial cost, it can eliminate the negative impacts of urban construction sites on the environment and preserve the environment. As a result, sustainable green building has lower operating cost for the life of the building.

### Scarcity of Green Materials and Green Technology

The lack of technical capacity related to environmental sustainability is also considered a major challenge in the implementation of sustainable construction [34]. Industry stakeholders are uncertain about the performance and cost-effectiveness of various items and technologies. Green materials and green technology are scarce in many developing countries. The use of technological software in sustainability practices is also not very widespread in the majority of developing nations because it is costly [33]. The use of environmentally friendly products and technologies can aid in preserving the environment, particularly at construction sites located in urban areas. In the Ghanaian construction industry, [13] noted that construction workers lack environmental sustainability knowledge. Sustainability in the Ghanaian construction industry is a relatively recent phenomenon and many practitioners have not yet obtained the necessary knowledge and training. Therefore, it is necessary to train practitioners in developing countries in sustainable construction. Practitioners are responsible for understanding the environmental problems caused by the construction sites and to implement sustainable construction. The implementation of sustainable building procedures is contingent on the level of education and training obtained by construction practitioners.

### Insufficient Training

According to [34], a lack of training and dedication from the government may also inhibit the execution of environmental regulations. The contractor's lack of new knowledge has always been an obstacle to the implementation of sustainable construction and reducing the adverse impact on the environment, as evidenced

in the study by [32]. On the other hand, designers have the important role of convincing clients to implement and commit to environmental sustainability for their projects. If the project adopts sustainable construction and design, the pollution released during the construction activities in the urban areas will be reduced.

**The Contractor's Lack of Awareness**

The contractor's lack of new knowledge has always been an obstacle to the implementation of sustainable construction and reducing the adverse impact of urban construction sites on the environment. It makes it impossible for expert developers and the younger generation to establish a consensus. There is evidence in the study by [35] that a lack of information impeded the majority of stakeholder groups within the construction industry. Furthermore, the designers are also act as a very important role in convinced the client to implement environmental sustainability design for their projects. If the project adopts sustainable design, they will use sustainable materials to build the building, so the pollution released during the construction activities in the urban areas will be reduced. Thus, if the designers are lack of knowledge about environmental sustainability, it is hard to persuade their client to implement this practice. In the construction industry, few professionals have the necessary knowledge and skills to build environmentally friendly projects [33]. Study by [17] discover that the level of awareness and understanding towards sustainable construction is only moderate from the perspective of developer in Malaysia. In addition, the knowledge regarding the sustainability was obtained only from written materials like journals, proceedings, newspaper, and website. Other that the written sources, knowledge, and awareness were only obtained from sustainable site experience which according to them is very little practice in Malaysia. Deeper and better understanding of sustainable construction shall be highly promoted in comprehensive and in informal education, training and information dissemination programs.

Table 1: Environmental impacts caused by construction site

| Category | The environmental impact caused by a construction site | Source |
|---|---|---|
| Ecosystem | Destruction of animal habitat | [22, 23] |
| | Soil erosion | [7] |
| | Soil, water, and air pollution | [23, 36] |
| | Loss of arable land | [23] |
| Public | Health effects | [37] |
| | Vibration | [27] |
| | Noise | [28] |
| | Dust | [26] |
| | Public hygiene | [26] |
| Energy and natural resources | Land | [23, 38] |
| | Energy | [31] |
| | Water | [23] |
| | Construction material | [30] |

Table 2: Challenges of urban construction site towards environmental sustainability

| Challenges towards environmental sustainability | Source |
|---|---|
| Higher initial cost | [32] |
| Scarcity of green materials and green technology | [39] |
| Insufficient training | [34] |
| Contractor's lack of awareness | [40] |

**Potential Solutions in Enhancing Sustainable Construction Site Implementation in Urban Area**

**Implementing green building**

Green building use of eco-friendly building materials and digital technologies that can protect the environment. Besides, it minimizes the energy and water consumption compared to the traditional buildings during, throughout, and after the building's construction [41]. Implementing green building practises minimize construction-related energy consumption and $CO_2$ emissions release at the construction sites in urban areas. As a result, it can improve the quality of human existence living in the urban areas. In Malaysia, the green building assessment tool that encourage the practice of sustainable construction site is known as Malaysian Carbon Reduction and Environmental Sustainability Tools or MyCREST. This tool is developed specifically to reduce the built environment's impact during the construction period. The government such as federal, state, and municipal, is responsible to promote and encourage the construction industries to construct the green buildings in urban areas due to high density of people [42].

**Digitalization And Networking for Construction Site Pollution Management**

Digitization is referring to the technology that transfers information from physical to digital information. On the other hand, Networking refers to the technology that allows devices to communicate information via digital communication networks. The growth of digital and network technology has accelerated the evolution of the construction industry [43]. Digitization technology increases the amount of sensor data that can be analyzed and evaluated, whilst Networking technology enables the simultaneous control and optimal adjustment of several technologies. The example of the digitization and networking can be used to manage the local-level pollutant are Internet of things (IOT), cloud and big data and augmented reality [44].

**Specific government roles**

Specific government roles and policy need to be established to achieve environmental sustainability. The government can formulate laws that related to the environmental problems in order to protect the environment caused by urban construction sites and enforce these laws [33]. For example, the government has make compulsory the use of Industrialised Building System (IBS) for all contractors by year 2020 [45]. In addition, cooperation of construction industry stakeholders, the government should create specific laws, norms, or standards pertaining to sustainable construction practises to assure the successful implementation of sustainable construction in the urban areas.

**Development Of Skill and Education**

According to [46], skill development is essential to reduce the environment impacts with the respect to construction sites in urban areas. This is because the technologies and knowledge in sustainable development projects are different from those in conventional projects. Therefore, all companies should send their workers to workshops or training to obtain the new knowledge and soft skills related to the sustainable development of the environment in order to reduce the environmental issues in the urban areas. Besides, education program is very important to achieve environmental sustainability [47]. Courses related to environmental sustainability should be incorporated into the university syllabus. This is because it may greatly promote public awareness and educate the public and professional practitioners. When public awareness is enhanced, more people will pay attention to the importance of environmental sustainability and the benefits of sustainable construction practices.

## METHODS

The research approach employed in this study utilizes questionnaire surveys administered to registered contractors falling under the G7 category of building contractors. The list was obtained from the Construction Industry Development Board (CIDB) official website. The chosen G7 contractor is construction site located

specifically at the Kuala Lumpur City as an urban area. There are 1,670 G7 contractors registered under CIDB Malaysia as of February 2023. Consequently, the sample size calculated represents a population of 313 respondents. The research adopts a confidence level of 95% and a margin of error of 5%. The acceptable range for the confidence level falls between 5% and 8%. Therefore, given the study's population of only 1,670, applying a 5% margin of error is deemed appropriate. Due to the time constraint with only three (3) weeks to spare in distributing the questionnaire survey to the respondents, only 42 or 13% of respondents responded to the questionnaire survey. The respondents rate is consider acceptable as similar study by [17] obtained 12% of the respondents rate.

# RESULTS AND DISCUSSION

### Result of Respondent's Background

In this study, the data analysis methods are frequency distribution and Relative Importance Index technique (RII). RII is indispensable. This is because the value of the index will show the degree of ranking. This is extremely useful for surveys that are using the Likert scale. In addition, Microsoft Excel also introduced the RII function, which was used to determine the index in 2016 [48]. From 0 to 1, the relative importance index is formed. Therefore, the higher the value of the relative importance index, the higher the level. The questionnaire survey of the study is divided into three sections. The first section, that is, Section A, is about demography. It displays a particular characteristic of the respondents. In this part, the questions include working experience, number of completed projects, experience working using sustainable construction, area of majority completed projects, and job position in the company. This section is important to obtain and gather the respondents' background and their characteristics. Results presented in Table 3 shows most of the main contractors have experience more than 10 years followed by seven to ten years, four to six years, and one to three years which contribute to percentages of 42.9 %, 26.2%, 19.0%, 11.9%. The majority of the main contributors also have or have completed more than 15 projects (57.0%), 8 within 10-15 projects (19.0%), 4 within 5-10 projects (10.0%), and 6 having less than 5 projects (14.0%). Last but not least most of the sustainable construction projects experienced by the main contractors were located in urban areas which is 31 (73.8%), 24 (57.1%) main contractors in sub-urban areas and remaining 7 (16.7%) were located in the rural areas.

Table 3: Contractor's background

| Parameter | Category | Number of contractors | Percentage of contractors (%) |
|---|---|---|---|
| Working experience | 1-3 years | 5 | 11.9% |
| | 4-6 years | 8 | 19.0% |
| | 7-10 years | 11 | 26.2% |
| | >10 years | 18 | 42.9% |
| No. of construction projects (completed & ongoing) | < 5 projects | 6 | 14.0% |
| | 5-10 projects | 4 | 10.0% |
| | 10-15 projects | 8 | 19.0% |
| | > 15 projects | 24 | 57.0% |
| Location of completed projects | Urban areas (within towns & cities) | 31 | 73.8% |
| | Suburban areas (fringes of town & city) | 24 | 57.1% |
| | Rural areas (outside town & city) | 7 | 16.7% |

**Result of Contractor Involvement in Sustainable Construction Projects**

Result from Figure 2 shows there are only 13 respondents represent 31% who has experience working on the projects using sustainable construction and 29 respondents represents 69% with no experience in sustainable construction projects. This result has clearly proven that the practice of construction activities is more towards traditional ways and the percentage of the sustainable construction site is still low in Malaysia. Therefore, it is not surprise if the sustainable construction site was not wide implemented in developing country [15].

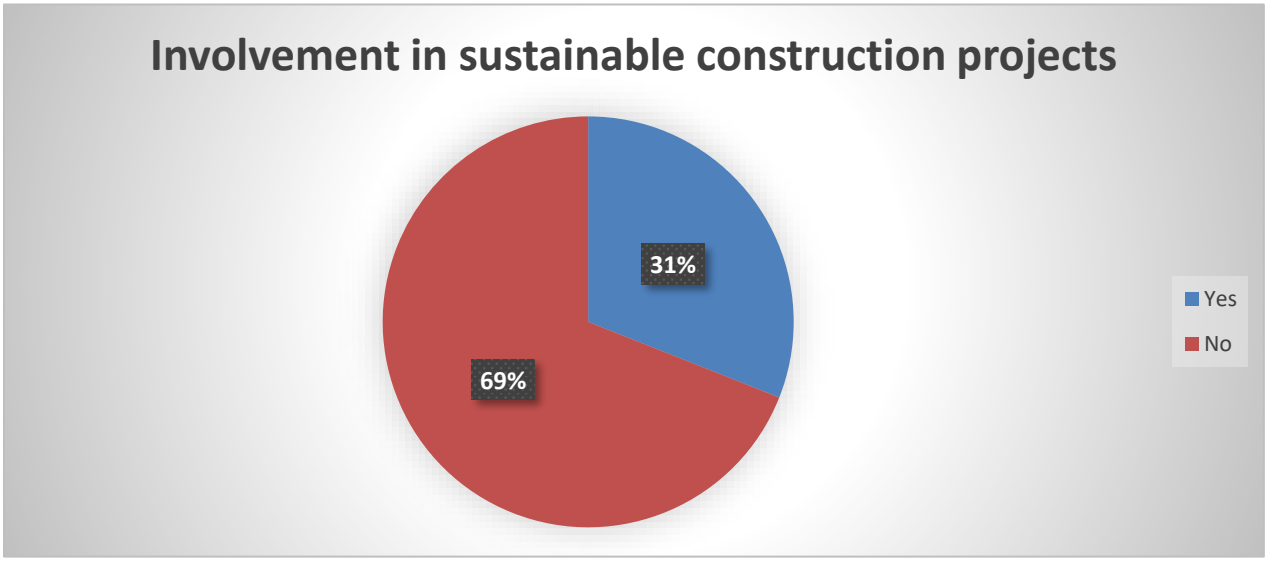


Figure 2: Respondent's involvement in sustainable construction projects

**Result of Environmental Impacts Cause by The Construction Site at The Urban Areas**

The result of the environmental impact can be seen in Table 4 and Table 5. Most respondents agree that soil, water, and air pollution are the most common environmental impacts that contribute to the highest percentage 97.6%. This findings proven that construction activities is the important contributor to waste and environmental pollution [5]. Besides that, air pollution, and pollution are also frequent occurrences; 40 out of 42 which is 95.2% of respondents have seen this impact during the construction activities. The result is also similar to public hygiene and health effects which also contribute to 95.2%. According to [49], they also have observed that construction activities produce a variety of detrimental environmental effects, such as noise, dust, air pollution, water pollution, and hazardous toxins, which pose a major threat to ecosystems. High amounts of dust and noise produced by construction activities can harm the surrounding environment and communities. 33 respondents (78.6%) have observed the impact of the release of energy consumption during construction activities which refers to the amount of energy required to build a project. It includes the materials used and the machinery and equipment involved in the construction process (71.4%) and water (71.4%). The release of energy consumption can have a significant impact on the environment, contributing to greenhouse gas emissions and other forms of pollution. 27 respondents (64.3%) have observed the impact of destruction of animal habitat caused by construction activities, including deforestation, urbanization, etc. 24 responses or 57.1% for loss of arable land respectively. Last but not least, 22 responses, or 52.4% observed that the construction activities will result in stormwater or soil erosion. In summary, as per Table 5, ecosystem ecological impact is the highest ranking with RII 0.8667 and considered as the most significant damage to the environment imposed on by the construction sites in urban areas. The second highest ranking is energy and natural resources impact. The RII of this impact is 0.8238 and lastly followed by public impacts as the third highest ranking impact caused by construction sites in urban areas. This impact has a RII of 0.8333. The noise, dust, and vibration that are generated from the construction will have a severe impact on the public who are living near the construction sites and expose people to risks to their health that may lead to silicosis or lung cancer in both workers and communities nearby. In addition, the public may encounter health issues from excessive amounts of dust.

Table 4: Significant environmental impacts from construction site based on sub-category.

| Main Category | Sub-category of environmental impact caused by construction site | Number of respondents | Percentage | Ranking |
|---|---|---|---|---|
| Ecosystem | Soil, water, and air pollution | 41 | 97.6% | 1 |
| Public | Health effects | 40 | 95.2% | 2 |
| Public | Vibration | 40 | 95.2% | 3 |
| Public | Noise | 40 | 95.2% | 4 |
| Public | Dust | 40 | 95.2% | 5 |
| Public | Public hygiene | 40 | 95.2% | 6 |
| Energy and natural resources | Energy | 33 | 78.6% | 7 |
| Energy and natural resources | Construction material | 30 | 71.4% | 8 |
| Energy and natural resources | Water | 30 | 71.4% | 9 |
| Ecosystem | Destruction of animal habitat | 27 | 64.3% | 10 |
| Ecosystem | Loss of arable land | 24 | 57.1% | 11 |
| Energy and natural resources | Land | 24 | 57.1% | 12 |
| Ecosystem | Soil erosion | 22 | 52.4% | 13 |

Table 5: Significant environmental impacts from construction site based on Main category.

| Main Category | VU | U | N | I | VI | Total Weight | RII | Ranking |
|---|---|---|---|---|---|---|---|---|
| Ecosystem | 0 | 0 | 3 | 2 | 17 | 182 | 0.8667 | 1 |
| Energy and natural resources | 0 | 1 | 6 | 22 | 13 | 173 | 0.8238 | 2 |
| Public | 0 | 0 | 6 | 22 | 13 | 175 | 0.8333 | 3 |

**Result of Challenges Towards Environmental Sustainability for Construction Sites at Urban Areas**

Section B of the questionnaire survey also goes further into the challenges of construction sites in urban areas to achieve environmental sustainability. Table 6 gives a summary of the challenges of construction sites in urban areas to achieve environmental sustainability. The first ranking of challenges for construction sites in urban areas to achieve environmental sustainability is the high initial cost with an RII of 0.8857. Followed by second highest ranking is the scarcity of green material and green technology with RII of 0.8381, the third ranking is insufficient training with RII of 0.8048 and the last one is contractor's lack of awareness with the lowest RII of 0.7952.

Table 6: Main challenges towards environmental sustainability for construction sites at urban areas

| Challenges towards environmental sustainability | VU | U | N | I | VI | Total Weight | RII | Ranking |
|---|---|---|---|---|---|---|---|---|
| Higher initial cost | 0 | 0 | 1 | 22 | 19 | 186 | 0.8857 | 1 |
| Scarcity of green materials and green technology | 0 | 0 | 6 | 22 | 14 | 176 | 0.8381 | 2 |
| Insufficient training | 0 | 0 | 8 | 25 | 9 | 169 | 0.8048 | 3 |
| Contractor's lack of awareness | 0 | 1 | 7 | 26 | 8 | 167 | 0.7952 | 4 |

**Result of Potential Solutions in Enhancing Sustainable Construction Site in Urban Areas**

Referring to Table 7, the first ranking of potential solutions in enhancing sustainable construction sites in urban areas is implementing green building with the RII of 0.8810. Majority of the respondents agreed that implementing green building is the most efficiency way to reduce the environmental impacts due to their energy-efficient design, consume less energy than conventional buildings, and many more [41]. [5, 42], implementing green construction practices is important for the environment. Therefore, it is one of the

potential solutions to overcome the unsustainable construction site. The second ranking is specific the government rules with the RII of 0.8429. ensuring construction projects are conducted in more sustainable way, the government has a duty and responsibility to supervise the construction sector. [33]indicated that the government regulations can aid in resolving the problems associated with unsustainable construction. In addition, government may provide incentives to enforce the construction sector in implementing MyCREST. MyCREST is one of the green building tools and the purpose this tool is to reduce the negative impact towards environment during the construction activities. Hence, the respondents agree that the government plays a crucial role in assisting the nation in resolving the problems associated with unsustainable construction with the respect to construction sites in urban areas. Development of skill and education is the third potential solution with the RII of 0.8381. this factor is one of the reasons for the lack of sustainable construction site implementation in urban areas. Therefore, understanding and awareness level of sustainable construction methods is crucial as it is the key to emerge sustainable construction site. Training related with sustainable construction should be increase and highlighted in every construction company to educate the industry. Lastly is digitalization and Networking for construction site pollution management is the low ranking out of all potential solutions to overcome the unsustainable construction issues with the respect to construction sites in urban areas. The RII of this solution is 0.7286. According to the study of [37], by providing real-time data and analytics on pollution from building sites, digitalization and Networking technologies can aid in addressing unsustainable construction issues. These technologies can enable more efficient and effective pollution management by connecting different parties on building sites. Therefore, these are all the solutions that can implement by the contractors to overcome the unsustainable construction issues with the respect to construction sites in urban areas.

Table 7: Potential solutions towards enhancing sustainable construction site in urban areas

| Potential solution | VU | U | N | I | VI | Total Weight | RII | Ranking |
|---|---|---|---|---|---|---|---|---|
| Implementing green building | 0 | 0 | 1 | 23 | 18 | 185 | 0.8810 | 1 |
| Specific government roles | 0 | 0 | 4 | 25 | 13 | 177 | 0.8429 | 2 |
| Development of skills and education | 0 | 0 | 3 | 28 | 11 | 176 | 0.8381 | 3 |
| Digitalization And Networking for Construction Site Pollution Management | 0 | 2 | 13 | 25 | 2 | 153 | 0.7286 | 4 |

The construction activities in urban areas contribute to the significant impacts towards environmental sustainability is undeniable. This is proven from the data collection and analysis obtained from the respondents' perspective from Kuala Lumpur. Kuala Lumpur is the higest population density in Malaysia with estimated of 7,188 persons per square km and the population growth expected increases by 70% in 2050. This is also proven by the CIDB, that the largest Contractors G7 registered in this city with 1,670 number. The main impacts were towards the ecosystem impact which is soil, water, and air pollution. This result has proven the research from [4, 25] that construction activities result in many negative impacts on the environment. One of the reasons is because of the improper waste management and the attitude of the construction personnel itself. Not only that, other impacts like noise, dust, and vibration are also a significant impact after pollution especially for the public staying near the construction site area. Construction that produces dust specifically from renovation, modification, demolition, hacking, cleaning, etc. has a great impact to the human health and hygiene of the public people living nearby. Another impact was on energy usage, construction materials, and water resources. Many studies have proven that construction activities consume a lot of natural resources. [30] construction of buildings uses 40% of natural resources and 12% of water. Not only that, construction also uses 40% of sand, stone, and gravel and 25% timber from the forest. This number is expected to increase as the population increases and the construction industry should find an alternative to reduce the use of energy and natural resources. Loss of land and soil erosion is another big impact that can be seen from the construction activities, especially in urban areas. Even though these two impacts were at the lowest rate, this impact also needs to be attended to as ignorance of the impact may lead to the worse impact of construction sites in urban areas.

The practice of environmental sustainability requires high initial cost, and it is the most difficult challenge as rated by the main contractors. In addition, it is difficult to change from the existing practice [32]. Sustainable construction requires the use of many technologies, skills, and training and those are not the priority in completing the construction works. The next challenge is the green materials and green technology in the Malaysian construction industry. Many researchers have highlighted this challenge as a barrier in implementing a sustainable environment during construction activities. This challenge was from the category that related to government policy [3]. Lack of contractor awareness is another common challenge that was discussed by many researchers. This has a similar meaning when contractors also lacked understanding in environmental sustainability. This is due to the lack of sustainable construction site practice as proven from previous paragraph findings where the contractors may refer and enhance the knowledge sustainable practice.

## CONCLUSION

Construction sites in urban areas can indeed result in higher levels of pollution and negative impacts on the environment compared to rural areas due to the higher concentration of people, vehicles, buildings, infrastructures, and industrial activities. Although both urban and rural areas can be adversely affected by construction sites, urban areas are more likely to be affected because of the population density. Throughout the whole research, the practice of sustainable construction site in the urban areas is at the very low level. Protecting the environment is important because the wellbeing of both the present and future generations depend on preserving the environment. The study has investigated the significant impact of construction sites in the urban area, and Kuala Lumpur has been selected as the urban city to conduct the study. The study has found that ecosystems was the main impacts on the environmental sustainability that contributed to soil, air, and water pollution followed by the public impact on health, vibration, noise, dust, and public hygiene. Third-ranked were the energy and natural resources. The reason of to the lack of environmental sustainability at the construction site practice was due to the higher initial cost, scarcity of green materials and technology, and lack of training. These challenges need to be boosted to promote environmental sustainability at the construction site. Potential solution highlighted by the researcher are implementing the green building specifically in using MyCREST is the first ranking to enhance sustainable construction site issue. The next solution are specific government roles, development of skills and education, and digitalization and Networking for construction site pollution management. Government and stakeholders need to play an important role during the construction activities, especially at the urban construction site areas. Focusing on the completion of construction without concern about the environmental impacts will bring many negative impacts in the future. A satisfaction survey of environmental sustainability in every construction site targeting the site workers and nearby residents for a certain period is a must and important to ensure the significant impact can be minimized. Further study is recommended to be conducted in urban areas of other states and cities other than Kuala Lumpur. The future research can also explore other types of places including sub-urban and rural construction sites to acquire different perspectives from the respondents. Not only focusing at Grade 7 and building contractors, the following research can attempt to concentrate on different grades of contractors such as Grade 1 to Grade 6 contractors, infrastructure contractors, civil engineering contractors, and demolition and renovation works contractors to study their experience in construction environmental sustainability.

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## CONFLICT OF INTEREST

No potential conflict of Interest was reported by the Authors.

## DATA AVAILABILITY STATEMENT

The data supporting the findings of this study can be obtained from the corresponding author upon reasonable request.

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