DETERMINATION OF EVALUATION INDICATORS FOR PRE-ABANDONED PROJECT BASED ON SUSTAINABLE GOAL DEVELOPMENT ASPIRATION

Siti Norhidayah Abdullah\textsuperscript{a}, Aznah Nor Anuar\textsuperscript{b*}, Mohd Fadhil Md Din\textsuperscript{c}, Shazwin Mat-Taib\textsuperscript{d}

\textsuperscript{a}Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia.
\textsuperscript{b}Department of Chemical and Environmental Engineering, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia.
\textsuperscript{c}Centre for Environmental Sustainability and Water Security (IPASA), Research Institute of Sustainable Environment (RISE), School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, UTM Johor Bharu, Johor, Malaysia.
\textsuperscript{d}Department of Environmental Engineering, School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia 81310, UTM Johor Bharu, Johor, Malaysia.

Article history
Received 02 August 2021
Received in revised form 09 February 2022
Accepted 16 March 2022
Published online 30 November 2022

*Corresponding author
aznah@utm.my

Graphical abstract

Flowchart of Research Methodology

Abstract

Every project management will strive to ensure that one project can operate without any problems. Unfortunately, some projects are still abandoned due to certain reasons. If the abandonment occurs, the requirement to submit an abandonment plan is stipulated on the Environmental Impact Assessment (EIA) Guideline in Malaysia, 2016. Unfortunately, still lack of resources on pre-project abandonment guidelines which will lead to poor project abandonment report preparation and assessment. Thus, this study aims to determine crucial indicators for assessing the pre-abandoned project, proposing a framework of Malaysia Guidelines for Pre-Project Abandonment Plan (PAP), and validating the draft of the Malaysia Guidelines Framework for PAP. The collected data was compiled from various sources, including document review, survey, and Delphi Method (focus group discussion). The survey conducted proved that the most crucial indicators for the assessment of pre-abandoned project were (i) waste management, (ii) allocation of environmental budgeting, (iii) inventory of scheduled waste, (iv) slurry management, (v) method of demolished, (vi) safety and health of workers, (vii) drainage management system, (viii) site management, (ix) type of treatment plant, and (x) site housekeeping. This framework will assist both report preparer and policymakers on project abandonment report preparation and evaluation, respectively. The development of this framework was strengthened by comprising related legislations, and each indicator synchronized towards Sustainable Development Goal (SDG) 2030.

Keywords: Abandoned project, environmental impact assessment, sustainable development

© 2022 Penerbit UTM Press. All rights reserved
1.0 INTRODUCTION

Shared Prosperity Vision 2030 is a commitment to ensure the achievement of sustainable growth and fair and equitable distribution across income groups, ethnicities, regions and supply chains throughout the Malaysian perspective. The commitment aims to strengthen political stability, enhance the nation’s prosperity, and ensure that society is united whilst celebrating ethnic and cultural diversity as the nation-state’s foundation [1]. Sustainable Development Goals (SDGs) 2030 is a plan of action for people, the planet, and prosperity in a global context. Several SDGs supported this study, as shown in Table 1. The goals are very important because all countries and stakeholders will implement this plan [2].

Table 1. The 2030 Agenda for Sustainable Development

| Sustainable Development Goals 2030 (SDGs)                        |
|-----------------------------------------------------------------|
| SDG 6 (Clean Water and Sanitation)                              |
| SDG 13 (Climate Action)                                         |
| SDG 14 (Life below water)                                       |
| SDG 15 (Life on land)                                           |
| SDG 3 (Good Health)                                             |
| SDG 11 (Sustainable Cities & Communities)                       |
| SDG 7 (Renewable Energy)                                        |
| SDG 8 (Good Jobs and Economic Growth)                           |
| SDG 9 (Innovation and Infrastructure)                           |
| SDG 15 (Life on Land)                                           |

According to Table 1, the basis of the shared prosperity being highlighted in the plan is economic growth. Indirectly, towards achieving the goals, many factors such as environmental sustainability development by the nation with effective environmental policy and efficient decision making by the policymakers can affect the effort. One of the ways to increase economic growth is through the rapidity and progress of project development. Recently, there have been many types of projects such as building works (residential, commercial, industrial), civil and heavy engineering works (roads, railways, bridges, sewers, dams, airports, jetties, cofferdams, caissons, tunnels, refineries, power stations), and construction establishments (research institutes, polytechnics and universities) that involve clients, consultants, contractors, manufacturers and distributors, suppliers and sub-contractors, and end-users [3].

1.1 Definition And Technical Terms For The Abandoned Project

Decommissioning could also be termed “abandonment” [4,5]. It can also be seen as the reverse of the installation process [6]. Previously, several factors could contribute to the project abandonment. These factors can be classified into three major groups: (1) economic crisis, (2) social problems, and (3) environmental reasons. Unfortunately, some of the projects were abandoned for many reasons. Several studies revealed that the abandonment of a project causes a negative impact. Chaudhary [7] found that abandonment can also cause the change of land use and is being seen as a major factor contributing to the increase of eco-environmental risk, undesirable changes in the socio-cultural landscape, biodiversity loss, and reduced capacity of the system. Existing studies also show that Anhydrite mine is abandoned because it is no longer used; improper management might cause environmental, social, economic and safety risk issues in the area [8]. Furthermore, some wind power projects abandoned potentially have adverse impacts on raptors [9]. Abandonment of petroleum industries infrastructure would affect climate change. Best management practices must be applied to reduce the negative impact on the environment. Hauck [10], who supported this view, claimed that negative carbon dioxide (CO₂) emissions could be achieved by applying Carbon Dioxide Removal (CDR) technologies. Thus, a project owner needs to know related indicators involved in managing the abandoned project. Lack of indicators determination will cause pollution and problems in the future.

1.2 Project Abandonment Categories

Abandonment of project would happen for either Environmental quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015, Environmental Quality Act (EQA) 1974 or Non-Prescribed Activities. In Malaysia, the approval of the abandonment project plan for Prescribed Activities under EIA Order 2015 is under the jurisdiction of the Department of Environment (DOE) [11], while the Non-Prescribed Activities projects are under Local Authority jurisdiction. Some studies defined abandonment as a progress of a certain work facing too many problems that seem impossible to continue further, resulting in it completely stopping; therefore, it is defined as an abandoned project [12,13]. There are two types of project abandonment in Malaysia: Schedule 1 and Schedule 2, EIA Order [14] (Table 2). This table shows the Prescribed Activities In EIA Order 2015, Environmental Quality Act 1974. For the first schedule, the EIA report should be submitted to the relevant State Offices of DOE, and the second schedule report should be submitted to the DOE headquarters for review and approval. In addition, for the proposed project that traverse two or more states (such as a linear project), even though it is under the first schedule, the EIA Report submission must be made through the DOE Headquarters for review and approval. In this study, the pre-abandoned project research framework is for Prescribed Activity under EIA Order 2015 [14]. The pre-abandoned project plan needs to be assessed by policymakers before the project owner executes the abandonment activities. EIA project involves a certain scale of project and activities; thus, the project abandonment management must be managed well. Lasanta et al. [15], who supported the view, reported that abandonment could cause environmental, socioeconomic, and landscape implications. It can occur in European mountains, known as land abandonment. For this case, environmental implications such as the disappearance of species adapted to man-made environment reduce the biodiversity, propagating fires due to the increased plant biomass and reduction in river flows. In addition, socioeconomic impacts on cultural value and landscape implications such as uniform landscapes through the loss of farmland. Some authors actively favor managing an abandoned field to maintain a mosaic landscape that is very diverse, heterogeneous, and of great environmental and cultural value [16].

Recently, the novel coronavirus pandemic of 2019 (Covid-19) became a new significant cause to project abandonment due to unstable economic development. Falcon et al. [17] claimed that the outbreak of Covid-19 also affected the
economy. Sectors affected include agriculture, trade, tourism, textile, electronics, automobile, iron and steel mineral processing, real estate, and software. The paper industry is affected severely as paper usage has declined to a maximum extent due to the closure of various government and social institutions. Transportation or roadways later fined the government for spending rupees for repairing and social development which is related to human resources, where in the year 2019, approximately 200 million people, as estimated in the global migrant workforce, sent home US$715 billion (£571 billion). Improper management of abundance construction wastes such as debris and residue can harm the environment. Construction waste would increase since the building constructed in mid-1960 will be demolished and reconstructed in future [18]. Thus, the assessment of pre-abandonment project indicators is very crucial.

Table 2. Prescribed Activities in EIA Order 2015, Environmental Quality Act 1974 [14]

| First Schedule                  | Second Schedule                  |
|--------------------------------|----------------------------------|
| 1. Agriculture                 | 1. Agriculture                   |
| 2. Aerodrome                    | 2. Aerodrome                      |
| 3. Drainage and Irrigation      | 3. Drainage and Irrigation        |
| 4. Fisheries                    | 4. Fisheries                      |
| 5. Forestry                     | 5. Forestry                       |
| 6. Industry                     | 6. Industry                       |
| 7. Land reclamation             | 7. Land reclamation               |
| 8. Mining                       | 8. Mining                         |
| 9. Petroleum                    | 9. Petroleum                      |
| 10. Ports                       | 10. Ports                         |
| 11. Power generation and transmission | 11. Power generation and transmission |
| 12. Development in Coastal and Hill Area | 12. Development in Coastal and Hill Area |
| 13. Development in slope area   | 13. Development in slope area     |
| 14. Waste treatment and disposal| 14. Waste treatment and disposal  |
| 15. Dredging                    | 15. Construction of a dam         |
| 16. Housing                     | 16. Transportation               |
| 17. Industrial Estate           | 17. Radioactive material and radioactive waste |
| 18. New township                |                                  |
| 19. Quarry                      |                                  |
| 20. Road                        |                                  |
| 21. Water supply                |                                  |

1.3 Regulatory On Project Abandonment

Most studies in the category of abandonment projects have only focused on the “cause and effect” of the actual abandonment. Debate on the best strategies for EIA project management continues. In this case, insufficient resource documents on the project’s abandonment phase to be referred by the decision-making agencies will cause a negative environmental impact. Table 3 list several countries that have legislation on abandonment project, however lacks guidance on how to preparing the abandonment plan report. The abandonment report is crucial as it would have a notification on the date of project abandonment, management aspects, and mitigation measures to avoid problems related to the abandonment of the project. Both report preparer and policy makers will have adequate information for report preparation and decision-making on the abandonment of a project. The main objective of decision-making is to make a better decision [19]. The abandon report review is a mechanism to monitor and ensure that the abandonment report complies with the legislation. The authority is responsible for policy planning, financing, project approval, quality control, monitoring, and evaluation [20]. To effectively implement the EIA and achieve the goals, a resource is required and must be given attention. The resources needed to implement the EIA should be identified at each stage of the EIA procedure [21]. The project abandon report is one of the EIA’s legal requirements that need to be submitted by the owner. However, very little attention has been paid to studying the abandonment of EIA project reference documents. Therefore, indicators that need to be considered in evaluating the pre-abandonment of EIA project phases are crucial as a guide for the report preparer and evaluation by the policymakers. Sommer et al. [22] quoted that environmental and ecological factors are important to control environmental pollution. Recent evidence mentions that abandoned projects were not given adequate attention for long times, causing a negative effect not only on the construction industry but also on the circular economy concept as a whole. In Malaysia, an Abandonment Plan (AP) is a document prepared by a Project Proponent (PP) detailing the overall decommissioning and abandonment strategy and plan once the project abandonment has been identified [23].

Table 3. Summary of Project Abandonment Legislation in ASEAN and European Countries

| Countries | Malaysia [11] | Singapore [139] | Philippines [140] |
|-----------|---------------|-----------------|-------------------|
| Legislation on abandonment | Yes | Yes | Yes |
| Specific guidelines on project abandonment | No | No | No |
| Countries | Japan [141] | Vietnam [142] | New Zealand [143] |
| Legislation on abandonment | Yes | Yes | Yes |
| Specific guidelines on project abandonment | No | No | No |

1.4 Sustainable Project Abandonment Guidelines

This research is motivated by the fact that improper project management would impact the environment, social, economic and infrastructure management. Abandonment of a project in the operation phase had generated main pollution elements such as residue, effluent, scheduled waste and land contamination. Furthermore, activities involved in abandonment phases such as the demolition process would generate carbon footprint effects [24]. Many studies have been conducted to address these problems; therefore, this study aims to accommodate the main findings of those previous studies to help researchers identify specific areas requiring improvements and priorities. The lack of guidelines for specific indicators for the pre-abandon project has resulted in poor decision making that will influence the quality of pre-abandonment project reports. Besides, clear guidelines will assist the project owner in pre-abandonment indicators screening. This view is supported by
Panigrahi and Amirapu [25], who wrote that the absence of an approach to set the scope of the study makes the quality of the EIA report poor. Thus, it is vital to have a comprehensive guideline that consists of a framework set to be in favour of sustainable development aims. Morrison and Bailey [26] reported that a good understanding between policymakers, consultants and project developers can contribute to the effectiveness of EIA implementation.

2.0 METHODOLOGY

2.1 Data Collection

A rigorous review of all relevant studies conducted in Malaysia and other countries was done to identify relevant existing literature in accordance with the purpose of this study. The methodology flowchart is shown in Figure 1. The literature search was conducted in the main scientific databases, including Scopus, ScienceDirect, Springer, Google Scholar, EZproxy from Universiti Teknologi Malaysia (UTM), related Act, legislation and policy, using the following keywords: abandonment, decommissioning and sustainable development.

2.2 Determination Of Critical Indicators For The Assessment Of Pre-Abandoned Project

Identification of relevant indicators for the assessment of this research was made using secondary data to design the questionnaire of pre-abandoned project indicators for survey purposes. Literature review shows that an online questionnaire is one of the best methods to gain information from the respondents (EIA Registered Consultants). Google Forms, an online survey toolkit, was used to design the questionnaire and circulate it among the survey participants [27] and In-Depth Interviews. Likert Scale approach was used for the Questionnaire survey and the Semi-Structured Interview technique for the In-Depth Interview. The questionnaire was reviewed and refined by 67 Environment Impact Assessment (EIA) Registered Consultants. In-Depth interview sessions conducted involved 3 representatives related to policy/legislation on a project. They are the Public Work Department (JKR), SWCorp and Department of Environment (DOE). The criteria of respondents for the interview are either registered from the Board of Engineers Malaysia (BEM) or Certified Environmental Professional from DOE. The questions on participants’ demographic details sought the participants’ experience on EIA study and experience on project abandonment and level of education (Table 5 and Figure 2). The questionnaire contained 28 questions about indicators on project abandonment that meet Sustainable Development Agenda 2030, which consists of Environmental, Social, Economic and Infrastructural Management assessments.

2.3 Data Analysis

The framework of Malaysia Guidelines for PAP- After screening the survey responses, the selected data were analyzed using descriptive analysis. In total, 68 EIA Registered Consultants took part in this online survey. Statistical Package Social Science (SPSS) version 22 was used to archive, screen, and analyze the data collected. Descriptive Statistics analysis was the main statistical element determining the most critical indicators for the pre-project abandonment assessment. In addition, for the interview analysis, Content Analysis (NVivo-12) was used to find the critical indicators from the pre-abandonment project. Both methods were used to determine the rank of the indicators. This view is supported by Nacos et al. [28], stating that computer-aided software needs to be treated as an aided tool. Results from analysis on crucial indicators from the survey questionnaire and interview were tabulated in rank to indicate the most 10 crucial indicators out of 28 indicators. Validation of the framework and produce a draft of Malaysia Guidelines for PAP- Finally, the analysis was validated by five (5) panels that will review and comment on the draft guidelines (validation process) using the Delphi Method. The Delphi method is an interactive process used to collect and distil the judgement of experts using a series of questionnaires interspersed with feedback. The questionnaires were designed to focus on problems, opportunities, solutions, or forecasts.
Each subsequent questionnaire is developed based on the results of the previous questionnaire [29].

### 3.0 RESULTS AND DISCUSSION

#### 3.1 Determination of Critical Indicators For Pre-Project Abandonment Assessment Checklist

The design of pre-abandoned indicators on the survey questionnaire and an in-depth interview was based on the literature in Table 4. This table indicates that comprehensive assessment for the pre-project abandonment plan is crucial as the assessment indicator will determine the sustainability of project abandonment. In addition, each indicator bonds with related legislations in Malaysia. Thus, the sustainability aspect is not only for the project’s development but also for abandonment.

There are four main assessments for the pre-abandonment project from the literature review: environmental, economic, social and infrastructure management, consisting of 28 indicators. The environmental assessment consists of nine indicators, which are (i) inventory of scheduled waste generated, (ii) slurry management and treatment, (iii) Noise pollution control method, (iv) vibration measurement technique, (v) Sewage management, (vi) waste management (domestic, solid waste and wastewater), (vii) Site management, (viii) type of treatment plant & duration of residual treatment, and (ix) biomass management. In addition, economic assessment consists of seven indicators, which are (i) circular economy concept (reduce, reuse, recycle), (ii) inventory of domestic waste generated, (iii) disposal of scheduled waste cost, (iv) assumption cost of residue treatment, (v) rehabilitation cost, (vi) sustainable consumption of energy and workers, and (vii) allocation of environmental conservation budgeting. Meanwhile, social indicators consist of five indicators, which are (i) workers’ safety and health, (ii) site housekeeping, (iii) vermin control, (iv) heritage project-special management, and (v) disease management control. On the other hand, infrastructure management consists of seven critical indicators, which are (i) information on stream diversion once project abandonment occurs, (ii) method of blasting, (iii) method of demolition, (iv) dilapidation survey, (v) buffer zone, (vi) drainage management system, and (vii) noise barrier. Thus, from the literature, many issues discussed on the pre-abandoned project are related to aspects of environmental management.

| Environmental indicators | References |
|--------------------------|------------|
| Inventory of scheduled waste generated and handling | Scheduled Waste Regulation 2005, Environmental Quality Act 1974 [14]. U.S. Environmental Protection Agency (USEPA) [30], Balde et al. [31], Lydall et al. [32], United Nation Environment Management Group (UNEMG) [33], Martos et al. [24], Soler et al. [34], Al-Khatib et al. [35], Loiseau et al. [36], Scheduled Waste Regulation 2005 [14], Haccuria et al. [37], Copper et al. [38], Holt et al. [39], Galvez Martos and Schoenberger [40], Guereca et al. [41], Hens et al. [42], Holt et al. [43], Zethurajan et al. [44], Hula et al. [45], Hsu et al. [46], Guimaraes et al. [47], Ribeiro et al. [48], Kaya [49], Dodibba et al. [50], Khalig et al. [51], Gollakkota et al. [52], Chaunah et al. [53], Islam and Huda [54], Ahmed and Panwar [55], Agency for statistics of Bosnia and Herzegovina [56], Zhou and Xu [57], United States Environmental Protection Agency (USEPA) [58], Balde et al. [59]. |

### Table 4. The Proposed Sustainable Pre-Project Abandonment Plan Assessment Checklist in Malaysia

| Slurry management and treatment | Standard Specifications for Building Works, Public Work Department (Material generated from construction/excavation work) [60], Li et al. [61], Wu et al. [62], Wu et al. [63], Yuan [64], Ding et al. [65], Zheng et al. [66], Lu et al. [67]. |
| Noise pollution control method | Guidelines for Environment Noise Limit and Control 2017 [68], Sharma [69], Occupational, Safety and Health (Noise Exposure) Regulations [70], Nemerow [71], Department of Safety and Health (DOSH) [72]. |
| Vibration measurement technique | The Planning Guidelines for Vibration Limits and Control in the Environment 2007 [73], Jantunen et al. [74], Environmental Essential for Siting of Industries in Malaysia [75]. |
| Sewage management | Sewage Regulation 2015, Environmental Quality Act 1974 [14], Regulation 7, Environmental Quality Regulations [14], Environmental Essential for Siting of Industries in Malaysia [75]. |
| Domestic or solid waste | Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste) 2018 [76]; Department of Solid Waste Management [77]; Ministry of Environment Japan [78]; Ilvonen [79], Kaza et al. [80], Luttenberger [81], United Nations Environment Programme (UNEP) [82], Bernado et al. [83], Yuan et al. [84], Eurostat [85], Huang et al. [86], Jin et al. [87], Peng and Liu [88], Chang et al. [89], Agamuthu and Dennis [90], United Nations (UN) [91], European Commision [92], Li et al. [93]; EIA Guidelines For Petrochemical Industries [94]; Ajayi and Oyedele [96]; Chinda [97]; Menegaki and Damigos [98]. |
| Wastewater | Department of Environment Malaysia [95]; Industrial Effluent Regulation, 2015, Environmental Quality Act 1974 [14]; |
| Site management (LD-P2M2) | Guidelines on Land Disturbing Pollution Prevention and Mitigating Measures, 2017 [99]. |
| Type of treatment plant and duration of residual treatment | Industrial Effluent Regulation, 2015, Environmental Quality Act 1974 [14]; DOE [100]; Tian et al. [101], Cechinel et al. [102], Wei et al. [103]; Sponza and Oztokln [104], Jabatan Perkhidmatan Veterinar Malaysia [105], Siddique et al. [106]. |
| Biomass management | Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste) 2018 [76]; Hens et al. [41]. |
| Economic Indicators | References |
Circular economy concept (Reduce, reuse, recycle)  
Cluster 3, National Cleanliness Policy 2019 [107]; Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste) 2018 [76]; Boon and Sunikka [108]; Lawania et al. [109]; Jin et al. [87]; Yang et al. [110]; Wong et al. [111], Wahi et al. [112]

Inventory of domestic waste generated  
Regulation 7(3), Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste) 2018 [76]

Disposal of Scheduled waste cost  
Guided Self-Regulation (GSR), Department of Environment Malaysia [113]; Brookes and Locatelli, [114]

Assumption cost of residue treatment  
Morozova et al. [115]; Oliveira et al. [116]; National Hydraulic Research Instituteof Malaysia (NAHIRM) [117], Li et al. [118], Jantunen et al. [73]

Rehabilitation cost  
University Technology Malaysia (UTM)-Low Carbon Asia Research Centre [120]

Sustainable consumption of energy and workers  
Part X1, Demolition, Factories and Machinery (Building Operations and Works of Engineering Construction (Safety) Regulations 1986) [119]

Allocation of environmental conservation budgeting  
Guided Self-Regulation (GSR), Department of Environment Malaysia [113]

Social indicators  
References

Safety & health of workers  
Department of Occupational Safety and Health Act 1994 [121]

Site housekeeping  
Solid Waste and Public Waste Management Act 2007 [76]

Vermin control  
 Destruction of Disease-Bearing Insects Act 1975 (Act 154) & Prevention and Control of Infectious Diseases Act 1988 (Act 342) [122]

Heritage project Special Management  
National Heritage Act, 2005[123]; Boon & Sunikka [108]

Disease Management control  
Prevention and Control of Infectious Diseases Act 1988 (Act 342) [122]

Infrastructure management indicators  
References

Information on stream diversion once project abandonment occurs  
Chapter 5.0 Erosion and Sediment Control Facilities, Diversion channel, Guideline for Erosion and Sediment Control In Malaysia, 2010 [124]; Charlesworth et al. [125], Lashford et al. [126]

Method of blasting  
SubChapter 6.6.1, Pre blast consideration, Malaysian Standard (MS) 2318: 2012 [127]; Nelson L. Nemerow [128]

Method of demolition  
Chapter 6, Methods of demolition, Malaysian Standard (MS) 2318: 2012 [12]; Chan [129], Jaramillo et al. [130], Slavina et al. [131], Oleinik et al. [132], Lautaru et al. [111]

Dilapidation survey  
Sub Chapter 4.1.4, Dilapidation Survey, Malaysian Standard, (MS) 2318: 2012 [127]; Harris [134], Schwartz et al. [135]

Buffer zone  
Chapter 5.2, Erosion Control Facilities, Guideline for Erosion and Sediment Control In Malaysia, 2010 [124]; Environmental Essential For Siting of Industries in Malaysia [75]

Drainage management system  
Subchapter 4.3.4, Drainage Control/Runoff Management, Guideline for Erosion and Sediment Control In Malaysia, 2010 [124]; Warwick et al. [136]

Type of noise barrier  
Annexe E, Guidance on noise control, Guidelines for Environment Noise Limit and Control 2019 [68]

3.2 Survey Participant’s Profile

Two questions were formulated to seek participants’ demographics data, including experience on the EIA project and project abandonment experience, to better understand and analyze the respondents’ responses. More than 50% of the respondents have experience in EIA project study for 15 years and above, followed by 38.8% (6–10 years), 9% (11–15 years), and 1.5% (0–5 years), respectively. However, most of the respondents have less experience in project abandonment study which shows that 52.2% (none), 41.8% (1–5 times), 4.5% (6–10 times), 4.5% 6–10 times and 1.5% (more than 10 times) respectively (Table 5). Nevertheless, due to the lack of abandonment guidelines in major environmental assessments, assessment on the actual implementation at any documentation stated by reports and Environmental Quality Report (EQR) are not adequate to analyse. However, their feedback is very much valuable to be counted due to their position as appointed EIA Consultants endorsed by DOE as mentioned in Section 34A(2C), Environmental Quality Act 1974. The act stipulates that any person intending to carry out any prescribed activities must appoint a Qualified Person to conduct an EIA and submit a report to the Director General of Environment. A Qualified Person is an individual who has met the DOE’s technical and experience criteria; hence he is eligible to be registered as an EIA Consultant. As mentioned in Chapter 6, Post Submission Stage of EIA Report, Subchapter 6.5, (i) Abandonment Plan [11] mention that an abandonment plan shall be prepared if the project proponent intends to abandon a project and EIA Consultant shall prepare the report. Therefore, the respondents are qualified to holistically share their perspectives on the proposed abandonment project’s impact on the environment.

| Question | Distribution (%) |
|----------|------------------|
| Experience in EIA project | |
| 0–5 years | 1.5 |
| 6–10 years | 38.8 |
| 11–15 years | 9.0 |
| 15 years and above | 50.7 |
| Experience in project abandonment | |
| 1–5 times | 41.8 |
| 6–10 times | 4.5 |
| more than 15 times | 1.5 |
| none | 52.2 |

Figure 2 shows that 49.3% of the respondents are Degree holders, followed by 43.3% with Master and 7.5% with PhD. From this, the majority of respondents have higher levels of education. It was expected that these EIA Registered Consultants would have more knowledge on project
abandonment and related legislation by having a high level of education, although less experience in project abandonment.

The questionnaire survey results and in-depth interviews to determine significant indicators for the assessment of pre-abandoned projects were divided into four main assessments: environmental, social, economic and infrastructure management with their indicators, respectively, as shown in Table 6. From this table, respondents significantly favored waste management (domestic/solid waste and wastewater) as the first rank, allocation of environmental budgeting in rank 2, inventory of scheduled waste in rank 3, slurry management in rank 4, method of demolished in rank 5, safety and health of workers in rank 6, drainage management system in rank 7, site management in rank 8, type of treatment plant in rank 9, and site housekeeping in rank 10. Furthermore, the result was synchronized with their respective legislation (Malaysia legislation). In this regard, the legislation’s emphasis is very important so that all parties involved, whether policymakers or project owners, have clear jurisdiction related to the management of the indicators. In addition, it will facilitate the evaluation of the report by relevant parties such as government agencies and project owners to understand the related indicators in the preparation of the pre-abandoned project report. In this case, the Department of Environment Malaysia is the approver for the report.

Table 6. The most significant indicators for Pre-Project Abandonment in Malaysia

| Indicators                                      | Rank | Legislations                                                                 |
|------------------------------------------------|------|-------------------------------------------------------------------------------|
| Waste management (domestic/solid waste and wastewater) | 1    | Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste) 2018 [76] |
| Allocation of environmental conservation budgeting | 2    | Guided Self-Regulation (GSR) – Department of Environment Malaysia [113]     |
| Inventory of Scheduled Waste                    | 3    | Scheduled Waste Regulation [14]                                               |
| Slurry management                               | 4    | Standard Specifications for Building Works, The Malaysian Public Works Department (JKR) [60] (Material generate from construction/excavation work) |
| Method of demolition                            | 5    | Chapter 6, Methods of demolition, Malaysian Standard (MS) 2318: 2012 [127]   |
| Safety and health of workers                    | 6    | DOSH requirement (Regulations Under Occupational Safety and Health Act 1994 (Act 514) [121] |
| Drainage management system                      | 7    | Guideline for Erosion and Sediment Control, Department of Irrigation and Drainage [124] |
| Site management                                 | 8    | Guidelines on Land Disturbing Pollution Prevention and Mitigating Measures (LDP2M2) [99] |
| Type of treatment plant & residual of treatment | 9    | Industrial Effluent Regulations, Environmental Quality Act 1974 [14]           |
| Site housekeeping                               | 10   | Guidelines on Land Disturbing Pollution Prevention and Mitigating Measures (LDP2M2) [99] |

The design of pre-abandoned project indicators on the survey questionnaire and in-depth interview was based on the literature in Table 6. This table indicates that comprehensive assessment for the pre-project abandonment plan is crucial as the assessment indicator will determine the sustainability of project abandonment. Thus, the sustainability aspect is not only for the project’s development but also for the abandonment of the project phase. There are four main assessments for the pre-abandonment project from the literature review: (i) environmental assessment, (ii) economic assessment, (iii) social assessment, and (iv) infrastructure management assessment that consists of 28 indicators.

The environmental assessment consists of nine types of critical indicators, which are (i) inventory of scheduled waste generated, (ii) slurry management and treatment, (iii) noise pollution control method, (iv) vibration measurement technique, (v) sewage management, (vi) waste management (domestic, solid waste and wastewater), (vii) site management, (viii) type of treatment plant and duration of residual treatment, and (ix) biomass management.

Meanwhile, social indicators consist of five critical indicators, which are (i) workers’ safety and health, (ii) site housekeeping, (iii) vermin control, (iv) heritage project-special management, and (v) disease management control. On the other hand, economic assessment consists of seven critical indicators, which are (i) circular economy concept (reduce, reuse, recycle), (ii) inventory of domestic waste generated, (iii) disposal of scheduled waste cost, (iv) assumption cost of residue treatment, (v) rehabilitation cost, (vi) sustainable consumption of energy and workers, and (vii) allocation of environmental conservation budgeting. In addition, infrastructure management assessment consists of seven critical indicators, which are (i) information on stream diversion once project abandonment occurs, (ii) method of blasting, (iii) method of demolition, (iv) dilapidation survey, (v) buffer zone, (vi) drainage management system, and (vii) type of noise barrier. Thus, from the literature, many issues discussed on the pre-abandoned project are related to aspects of environmental management. This relationship is expected that major project abandonment problems are related to environmental problems.

Figure 2. Level of Education of the Respondents

3.3 Critical Indicators For The Assessment Of A Pre-Abandoned Project

The survey research and in-depth interview was based on the literature in Table 6. This table indicates that comprehensive assessment for the pre-project abandonment plan is crucial as the assessment indicator will determine the sustainability of project abandonment. Thus, the sustainability aspect is not only for the project’s development but also for the abandonment of the project phase. There are four main assessments for the pre-abandonment project from the literature review: (i) environmental assessment, (ii) economic assessment, (iii) social assessment, and (iv) infrastructure management assessment that consists of 28 indicators.

The environmental assessment consists of nine types of critical indicators, which are (i) inventory of scheduled waste generated, (ii) slurry management and treatment, (iii) noise pollution control method, (iv) vibration measurement technique, (v) sewage management, (vi) waste management (domestic, solid waste and wastewater), (vii) site management, (viii) type of treatment plant and duration of residual treatment, and (ix) biomass management.

Meanwhile, social indicators consist of five critical indicators, which are (i) workers’ safety and health, (ii) site housekeeping, (iii) vermin control, (iv) heritage project-special management, and (v) disease management control. On the other hand, economic assessment consists of seven critical indicators, which are (i) circular economy concept (reduce, reuse, recycle), (ii) inventory of domestic waste generated, (iii) disposal of scheduled waste cost, (iv) assumption cost of residue treatment, (v) rehabilitation cost, (vi) sustainable consumption of energy and workers, and (vii) allocation of environmental conservation budgeting. In addition, infrastructure management assessment consists of seven critical indicators, which are (i) information on stream diversion once project abandonment occurs, (ii) method of blasting, (iii) method of demolition, (iv) dilapidation survey, (v) buffer zone, (vi) drainage management system, and (vii) type of noise barrier. Thus, from the literature, many issues discussed on the pre-abandoned project are related to aspects of environmental management. This relationship is expected that major project abandonment problems are related to environmental problems.

Table 6. The most significant indicators for Pre-Project Abandonment in Malaysia

| Indicators                                      | Rank | Legislations                                                                 |
|------------------------------------------------|------|-------------------------------------------------------------------------------|
| Waste management (domestic/solid waste and wastewater) | 1    | Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste) 2018 [76] |
| Allocation of environmental conservation budgeting | 2    | Guided Self-Regulation (GSR) – Department of Environment Malaysia [113]     |
| Inventory of Scheduled Waste                    | 3    | Scheduled Waste Regulation [14]                                               |
| Slurry management                               | 4    | Standard Specifications for Building Works, The Malaysian Public Works Department (JKR) [60] (Material generate from construction/excavation work) |
| Method of demolition                            | 5    | Chapter 6, Methods of demolition, Malaysian Standard (MS) 2318: 2012 [127]   |
| Safety and health of workers                    | 6    | DOSH requirement (Regulations Under Occupational Safety and Health Act 1994 (Act 514) [121] |
| Drainage management system                      | 7    | Guideline for Erosion and Sediment Control, Department of Irrigation and Drainage [124] |
| Site management                                 | 8    | Guidelines on Land Disturbing Pollution Prevention and Mitigating Measures (LDP2M2) [99] |
| Type of treatment plant & residual of treatment | 9    | Industrial Effluent Regulations, Environmental Quality Act 1974 [14]           |
| Site housekeeping                               | 10   | Guidelines on Land Disturbing Pollution Prevention and Mitigating Measures (LDP2M2) [99] |
3.4 The Framework Of Malaysia Guidelines For Pre-Project Abandonment Plan

Lack of knowledge on the management of pre-abandonment project indicators will cause environmental problems such as the residual impact that cause climate change effects. This viewpoint is supported by Wang et al. [137], who claimed that the issue of abandoned construction projects tremendously affects the industry in terms of economy, and needs a more serious outlook on this issue to have a better understanding of the problem so that the government could take necessary steps to overcome the issue. The formation of the framework in this study includes the improvement of the existing framework for the pre-abandoned project as well as new assessment aspects that are accompanied by comprehensive indicators that are supported by related legislation and SDG 2030 elements.

From existing literature, the project abandonment framework in Malaysia only caters for environmental assessment for the pre-abandon project, as shown in Figure 3 [4]. This shows that the owner or occupiers who intend to abandon their project need to develop a pre-project abandonment plan that only consists of environmental assessment. Contrary to the finding of this study, the pre-project abandonment assessment must also cover other important aspects of assessment to control pollution problems before the execution of the abandonment project and ensure sustainable project abandonment management.

Thus, the existing framework was improvised by inserting a new comprehensive assessment that not only catered to the environment but also consisted of social, economic and infrastructure management (Figure 4). This figure indicates that this framework is specifically for the project owner, Department of Environment officers and related agencies such as local authorities for decision-making purposes and project owner for the pre-abandoned project report preparation. Therefore, these reports need to be submitted by the owner or occupier six months before the project execution. The approval process will take about three weeks from the date submitted by the project owner. In this regard, the approval of this pre-project abandonment report is also influenced by all related agencies’ consensus. According to Chanitchitpricha and Bond [138], standard guidelines and procedures provide principles that must be adhered to and, at the same time, influence the practice of impact assessment.

In addition, with this new framework, the assessments would also consist of new comprehensive indicators equipped with related legislation and complemented by related Sustainable Development Goal (SDG) 2030 for the preparation of PAP (refer to Table 7). This table indicates the dependence of this assessment and their respective indicators for pre-project abandonment plan on legal or respective legislations and emphasis the importance of supporting the SDGs 2030 agenda by inserting the related goals to this table. Furthermore, legislation is one of the important aspects in ensuring environmental sustainability by all parties. Incorporating legal elements into this framework can be seen as a means of tackling environmental pollution, as project owners will be bound by compliance with such legislation. This framework can be an initial bulwark in controlling environmental pollution management economic, social and infrastructure management before the actual project abandonment is executed. This research divides waste management into domestic/solid waste and wastewater. For this first rank of indicators, the related legislation for the management of solid waste generated from construction area in Malaysia is Solid Waste and Public Cleansing Management (Licensing) (Undertaking of Provision of Collection Services for Construction Solid Waste) Regulation [76], Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste)[76], and Solid Waste and Public Cleansing Management (Scheme for Commercial, Industrial, Institutional Solid Waste) [76]. However, only seven states have adopted this act, namely Johor, Melaka, Negeri Sembilan, Federal Territory of Kuala Lumpur (WPKL) and the Federal Territory of Putrajaya, Kedah, Perlis, and Pahang. States that do not adopt the act will have to use the Local Government Act 1976. Furthermore, through this indicator, wastewater management must comply with Environmental Quality Act 1974 requirements. In addition, this indicator will support SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), SDG 14 (Life below water), and SDG 15 (Life on land). The management of water on land or below water, sanitation and air is important because the residue and the discharge from project management activities may create problems to the surrounding area.

The second and third rank for pre-project abandonment assessment is environmental conservation budgeting and inventory of scheduled waste. The assessment of economic aspects in terms of environmental conservation budgeting indicator has been mentioned on Guided Self Regulation (GSR) [113] through the Environmental Mainstreaming Directive in Malaysia. This indicator is one of the Environmental Mainstreaming Tools (EMT) in the GSR. The inventory of the scheduled waste is believed to enhance economic growth with the circular economy concept implementations: recycle, reduce and reuse approach. Both indicators must be highlighted on the pre-project abandonment report to comply with the environmental regulatory requirements and other environmental-related efforts. Well-manage of Scheduled waste not only protect the environment but also supports SDG 7 (Renewable Energy) and SDG 8 (Good Jobs and Economic Growth) and increase the compliance of Schedule Waste Regulations [14] by the owner of the project.

In the fourth rank, the slurry management indicator is highlighted by the Malaysian Public Works Department (JKR) [60], which is to be well managed. The pre-project abandonment environment assessments of this indicator are generated once the project is executed. Therefore, well-managed indicators would support SDG 6 (Clean Water and Sanitation) which is to avoid water and sanitation pollution from the improper management of slurry, SDG 13 (Climate Action) that is related to the exhaust emissions effect on the air by the transport activities such as transportation of slurry to a disposal area or treatment facilities, SDG 14 (Life Below Water) that will avoid below water pollution that harms species such as aquatic life, and SDG 15 (Life on Land) which is to avoid land contamination.

Assessment of infrastructure management through a demolished indicator method (rank number 5) is important due to the types of technology used to abandon project purposes, as mentioned in Environmental Essential for Siting of Industries in Malaysia [75]. This indicator would support SDG 9 (Innovation and Infrastructure) with the best technologies for pollution reduction strategies and SDG 15 (Life on Land) to protect life on land for better living.
Safety and health of workers indicator are on rank number 6, which to be complied by the project owner on the management of workers as stipulated in DOSH requirements on Regulations Under Occupational Safety and Health Act 1994 (Act 514) [121]. This indicator’s compliance not only reduces the accident level at a workplace or avoids disease but also supports SDG 3 (Good Health) and SDG 11 (Sustainable Cities & Communities).

For indicator rank number 7, which is drainage management system under infrastructure management assessment, the compliance on Guideline for Erosion and Sediment Control, based on the requirement by Department of Irrigation and Drainage [124], is very important to avoid failure of drainage systems such as volume of water flow and velocity of water which influence the flood mitigation management by the respective department. This indicator will support SDG 9 (Innovation and Infrastructure) for a sustainable drainage management approach and SDG 15 (Life on Land) to protect the ecosystem and chain of life on land.

The site management indicator—selected to be in rank number 8 by the respondents—is mentioned in the Guidelines on Land Disturbing Pollution Prevention and Mitigating Measures (LDP2M2) [99]. This guideline mentions that the site management includes the best management practice for erosion control, such as installing silt curtains, holding the fence, and related site management by the project owner. On the other hand, the types of treatment plant and residual of treatment, which ranked number 9, are important due to residue contamination that will affect the surrounding environment. From the literature, the final discharge effluent limitation from industries is under the jurisdiction of DOE Malaysia, as stipulated in the Industrial Effluent Regulations [14]. Both indicators will support SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land).

Finally, the tenth-ranked indicator is site housekeeping, which is under social assessment. The site housekeeping will avoid the improper management of domestic waste produced by the workers and waste generated from the execution of the abandonment of project activities. These indicators are stipulated in the Solid Waste and Public Waste Management Act 2007 [76]. Good management of the indicators will support SDG 3 (Good Health) and SDG 11 (Sustainable Cities & Communities). For example, Kuala Lumpur has Prescribed Activities under EIA Order 2015, such as the Mass Rapid Transit transportation project, so the site’s management is important due to Kuala Lumpur as the heart of Malaysia city. Improper domestic management will affect not only health but also negatively impact tourism industry achievement. Indirectly, this will also affect the economic growth in Malaysia.

Thus, all the indicators will benefit related stakeholders such as policymakers and project owners in terms of assessment and report preparation and mitigation measures before the execution of the abandonment of the project.
Figure 4. The improvised version of the existing project abandonment framework for the Pre-Abandonment Project Plan

Start

Decision for project abandonment

Develop the Pre Project Abandonment Plan (PAP) that consists of comprehensive indicators:

a) Environment
b) Economic
c) Social
d) Infrastructure management

Submit notification and AP to DOE (at least 6 months prior to the Abandonment execution)

Execute Abandonment

Legend

AP Feedback/Approval (within 3 weeks)

Pre-abandonment

Abandonment
Table 7. Comprehensive Pre-Project Abandonment Plan indicators, related legislations and SDG 2030

| Assessment          | Indicator                                                                 | Rank | SDG                                                                 | Legislations                                                                                                                                                                                                 |
|---------------------|---------------------------------------------------------------------------|------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Environmental       | Waste management (domestic/solid waste and wastewater)                    | 1    | SDG 6 (Clean Water and Sanitation) SDG 13 (Climate Action) SDG 14 (Life below water) SDG 15 (Life on land) | As stipulated in Solid Waste and Public Cleansing Management (Licensing)(Undertaking of Provision of Collection Services for Construction Solid Waste) Regulation [76], Solid Waste and Public Cleansing Management (Scheme for Construction Solid Waste) [76], and Solid Waste and Public Cleansing Management (Scheme for Commercial, Industrial, Institutional Solid Waste) [76]. |
| Economic            | Allocation of environmental conservation budgeting                       | 2    | SDG 7 (Renewable Energy) SDG 8 (Good Jobs and Economic Growth)        | Guided Self Regulation (GSR) – Department of Environment Malaysia (EMAINS-Environmental Mainstreaming Tools)[113]                                                                                               |
| Economic            | Inventory of Scheduled Waste                                             | 3    |                                                                      | Scheduled Waste Regulation, Environmental Quality Act 1974[14]                                                                                                                                              |
| Environmental       | Slurry management                                                         | 4    | SDG 6 (Clean Water and Sanitation) SDG 13 (Climate Action) SDG 14 (Life below water) SDG 15 (Life on land) | Standard Specifications for Building Works, Malaysia Public Works Department, Jabatan Kerja Raya [60] (Material generate from construction/excavation work)                                               |
| Infrastructure      | Method of demolition                                                      | 5    | SDG 9 (Innovation and Infrastructure) SDG 15 (Life on Land)           | Chapter 6, Methods of demolition, Malaysian Standard (MS) 2318: 2012[127]                                                                                                                                  |
| Social              | Safety and health of workers                                             | 6    | SDG 3(Good Health) SDG 11 Sustainable Cities & Communities            | DOSH requirement (Regulations Under Occupational Safety and Health Act 1994 (Act 514)[121]                                                                                                                   |
| Infrastructure      | Drainage management system                                               | 7    | SDG 9 (Innovation and Infrastructure) SDG 15 (Life on Land)           | Subchapter 4.3.4, Drainage Control/Runoff Management, Guideline for Erosion and Sediment Control In Malaysia, 2010 [124] Warwick et al. [136]                                                                 |
| Environment         | Site management                                                           | 8    | SDG 6 (Clean Water and Sanitation)                                   | Guidelines on Land Disturbing Pollution Prevention and Mitigating Measures, 2017 [99];                                                                                                                                 |
| Environment         | Types of treatment plant & residual of treatment                          | 9    | SDG 13 (Climate Action) SDG 14 (Life below water) SDG 15 (Life on land) | Industrial Effluent Regulation, 2015, Environmental Quality Act 1974[14]                                                                                                                                   |
| Social              | Site housekeeping                                                        | 10   | SDG 3(Good Health) SDG 11 Sustainable Cities & Communities           | Solid Waste and Public Waste Management Act 2007[76]                                                                                                                                                      |

4.0 CONCLUSION

The conducted survey proved that 28 indicators for the assessment of the pre-abandoned project are crucial and the developed framework was strengthened by comprising related legislation and each indicator synchronized towards SDG 2030. Next, the identified framework that consists of comprehensive indicators will further validate using the Delphi method based on the survey conducted among experienced and expert panels. In the future, this framework is planned to be integrated into the development of the Malaysia Guideline for Pe-Project Abandonment Plan draft, which could be used by owners of a project as guide and decision-makers to prepare or make decision regarding pre-abandonment project.

Acknowledgement

The authors fully acknowledged Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia for the scholarship provided to support the student tuition fees.
References

[1] Kementerian Hal Ehwal Ekonomi. 2019. Dokumen Wawasan Kemakmuran Bersama. Retrieved from https://www.meia.gov.my/ms/content/wawasan-kemakmuran-bersama-2030

[2] Rosa, W. 2017. A New Era in Global Health: Nursing and the United Nations 2030 Agenda for Sustainable Development. New York: Springer Publishing Company.

[3] Tanko, B. L., Abdullah, F., and Ramly, Z. M. 2017. Stakeholders Assessment of Constraints to Project Delivery in the Nigerian Construction Industry. International Journal of Built Environment and Sustainability, 4(1): 56–62. DOI: https://doi.org/10.110113/ijbes.v4.n1.160

[4] Department of Environment, Ministry of Energy, Science, Technology, Environment and Climate Change (MESTEC). 2019. Environmental Guidelines for Decommissioning of Oil and Gas Facilities in Malaysia 2019. Retrieved from https://tinyurl.com/25snr6rk

[5] Techera, E. J., and Chandler, J. 2015. Offshore installations, decommissioning and artificial reefs: Do current legal frameworks best serve the marine environment? Marine Policy, 59: 53–60. DOI: https://doi.org/10.1016/j.marpol.2015.04.021

[6] Welstead, J., Hirst, R., Robb, G., Bainsfair, B. 2013. Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms. Scottish Natural Heritage.

[7] Chaudhary S, Wang Y, Dietl AM, Khanal NR, Xu P, Yan K, Liu Q, Lu Y, Li M. 2019. Eco-environmental risk evaluation for land use planning in areas of potential farmland abandonment in the high mountains of Nepal Himalayas. Sustainability (Switzerland), 11(24): 1–20. DOI: https://doi.org/10.3390/SU11246931

[8] Zhang, B., Wang, H., Wang, L., Mei, G., Shi, L., Xu, N., and Li, J. 2020. Large-scale field test on abandoned deep anhydrite mine-out for reuse as crude oil storage – A case study. Engineering Geology, 267. DOI: https://doi.org/10.1016/j.enggeo.2020.105477

[9] Nishikizawa, S. 2015. Environmental impact assessment research in Japan: Retrospective and prospective. Journal of Environmental Assessment Policy and Management, 17(1): 1–9. DOI: https://doi.org/10.1142/S1464333215500131

[10] Hauck, D., and Hof, A. F. 2017. Abandonment of natural gas production and investment in carbon storage. Energy Policy, 108: 322–329. DOI: https://doi.org/10.1016/j.enpol.2017.06.002

[11] Department of Environment Malaysia. 2016. Environmental Impact Assessment Guidance in Malaysia. Putrajaya, Malaysia: Ministry of Natural Resources and Environment Malaysia.

[12] Doraisamy, S. V, Omar, P. U., Tun, U., Onn, H., Yunus, R., Tun, U., and Dawodu M.B. 1987. Housing Strategies in Nigeria.

[13] Lana-Renault, N. (2017). Space –time process and drivers of land use planning. In: Field, C.B., V.R. Barros, Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White [eds.]]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 195-228.

[14] Khan, S. and Ashori, F. 2015. A Paradigm Shift from Emergency Response to Reconstruction and Rehabilitation: Creation of Peak National Body for Disaster Management in Pakistan. International Journal of Built Environment and Sustainability, 2(3): 168–176. DOI: https://doi.org/10.11113/ijbes.v2.n3.78

[15] Abdul Rahman Mahmud. 2018. Penilaian Terhadap Pelaksanaan Penambahan Laporan EIA Di Malaysia Dalam Aspek Kajian Hakisan Tanah Dan Sedimentasi. Bangi: Universiti Kebangsaan Malaysia

[16] Sommer, B., Fowler, A. M., Macreadie, P. I., Palandro, D. A., Aziz, A. C., and Booth, D. J. 2019. Science of the Total Environment Decommissioning of offshore oil and gas structures – Environmental opportunities and challenges. Science of the Total Environment, 658: 973–981. DOI: https://doi.org/10.1016/j.scitotenv.2018.12.193

[17] Department of Environment Malaysia. Environmental Impact Assessment Guidance In Malaysia. 2016. Putrajaya, Malaysia: Ministry of Natural Resources and Environment Malaysia.

[18] Galvez-Martos, J. L. J., Styles, D., Schoenberger, H., and Zeschmar-Lahl, B. 2018. Construction and demolition waste best management practice in Europe. Resources, Conservation and Recycling, 136: 166–178. DOI: https://doi.org/10.1016/j.resconrec.2018.04.016

[19] Panigrahj, K. J., and Amirapu, S. 2012. An assessment of EIA system in India. Environmental Impact Assessment Review, 35: 23–36. DOI: https://doi.org/10.1016/j.eiar.2012.01.005

[20] Morrison-Saunders, A. and Bailey, M. 2009. Appraising the role of relationships between regulators and consultants for effective EIA. Environmental Impact Assessment Review, 29(5): 284–294.

[21] Narayanaswamy V.R. and Harinarayana N.S. 2016. Online survey tools: A case study of Google Forms Online. National Conference on “Scientific, Computational and Information Research Trends in Engineering, GSSS-ETW, Mysore.” 1–12. DOI: http://dx.doi.org/10.11113/ijbes.v2.n3.78

[22] Nacos, B. L., et al. 1991. Content analysis of new reports: Comparing human coding and computer-assisted method. Communications, 12: 111-128.

[23] Skulmoski G.J., Hartman F.T. and Krahn, J. (2007). The Delphi Method for Graduate Research. Journal of Information Technology Education: Research, 6: 001–021. DOI: https://doi.org/10.28945/199

[24] U.S. Environmental Protection Agency (U.S. EPA). 2016. Electronic Products Generation and Recycling in the United States, 2013 and 2014 USA.

[25] Balde, C.P., Forti, V., Gray, V., Kuehr, R., Stegmann, P. 2017. The Global E-Waste Monitor 2017: Quantities, Flows, and Resources. Bonn/Geneva/Vienna. DOI: https://doi.org/10.1016/j.proci.2014.05.148.

[26] Lydall, M., Nyanjowa, W., James, Y. 2017. Mapping South Africa’s Waste Electrical and Electronic Equipment (WEEE) Dismantling, Pre-processing and Processing Technology Landscape. Pretoria, RSA. DOI: https://doi.org/10.1016/j.relmic.2009.12.007

[27] United Nations Environment Management Group (UNEMG). 2017. United Nations System-wide Response to Tackling E-Waste. Geneva, Switzerland

[28] Soler I. P., Gemar, G., and Jimenez-Madrid, A. 2017. The impact of municipal budgets and land-use management on the hazardous waste production of Malaga municipalities. Environmental Impact Assessment Review. 65: 21–28. DOI: https://doi.org/10.1016/j.eiar.2017.04.001

[29] Al-Khatib, I.A., Kontogianni, S., Nabaa, H.A., Al-Sari, M.I., 2015. Public perception of hazardousness caused by current trends of municipal solid waste management. Waste Management. 36: 323–330. DOI: http://dx.doi.org/10.1016/j.wasman.2014.10.026

[30] Loiseau, E., Junqua, G., Roux, P., Bellon-Maurel, V., 2012. Environmental assessment of a territory: an overview of existing tools and methods. Journal of Environmental Management. 112: 213–225. DOI: http://dx.doi.org/10.1016/j.jenvman.2012.02.032

[31] Haccuria, E., Ning, P., Cao, H., Venkatesan, P., Jin, W., Yang, Y., Sun, Z. 2017. Effective treatment for electronic waste - selective recovery of valuable components in used computers. Journal of Cleaner Production. 152: 150–156. DOI: https://doi.org/10.1016/j.jclepro.2017.03.112
Copper, C., Dorsey, J., Drayton, H., Harris, J., Kim, J., Stafford, D., 2013. Improved Information Could Better Enable EPA to Manage Electronic Waste and Enforce Regulations. Washington, USA.

Holt, S. P., and Berge, N. D. 2018. Life-cycle assessment of using liquid hazardous waste as an alternative energy source during Portland cement manufacturing: A United States case study. Journal of Cleaner Production, 195: 1057–1068. DOI: https://doi.org/10.1016/j.jclepro.2018.05.214

Galvez-Martos, J.L., Schoenberger, H. 2014. An analysis of the use of life cycle assessment for waste co-incineration in cement kilns. Resources, Conservation and Recycling, 86: 118-131.

Guereca, L.P., Juarez-Lopez, C.R., Torres, N., 2015. The Co-Processing of municipal waste in a cement kiln in Mexico. A life-cycle assessment approach. Journal of Cleaner Production 107: 741-748.

Hens, L., Block, C., Cabello-Eras, Sagastume-Gutierez, A. J. J., Garcia-Lorenzo, D., Chamorro, C., Mendoza, K. H., Haeseldonckx, D., Vandecastelee, C. 2018. On the evolution of “Cleaner Production” as a concept and practice. Journal of Cleaner Production 172: 3323-3333.

Holt, S. P., and Berge, N. D. 2018. Life-cycle assessment of using liquid hazardous waste as an alternative energy source during Portland cement manufacturing: A United States case study. Journal of Cleaner Production. DOI: https://doi.org/10.1016/j.jclepro.2018.05.214

Sethurajan, M., vanHullebusch, E.D., Fontana, D., Akcil, A., Devechi, H., Batinic, B., Leal, J.P., Gasche, T.A., Ali Kucuk, M., Kuchta, K., Neto, I.F.F., Soares, H.M.V.M., Chmielarz, A. 2019. Recent advances on hydrometallurgical recovery of critical and precious elements from end of life electronic wastes - a review. Critical Reviews in Environmental Science and Technology. 49: 212–275. DOI: https://doi.org/10.1080/10643389.2018.1540760

Hula, A., Jalali, K., Hamza, K., Skerlos, S.J., Saitou, K., 2003. Multi-criteria decision-making for optimisation of product disassembly under multiple situations. Environmental Science and Technology. 37: 5303–5313. DOI: https://doi.org/10.1021/es034542d

Hsu, E., Barmak, K., West, A.C., Park, A.H.A., 2019. Advancements in the treatment and processing of electronic waste with sustainability: a review of metal extraction and recovery technologies. Green Chemistry 21: 919–936. DOI: https://doi.org/10.1039/c8gc03688h

Guimaraes, Y.F., Santos, I.D., Dutra, A.J.B., 2014. Direct recovery of copper from printed circuit boards (PCBs) powder concentrate by a simultaneous electroleaching—electrodeposition process. Hydrometallurgy 140: 63–70. DOI: https://doi.org/10.1016/j.hydromet.2014.06.005

Ribeiro, P.P.M., Santos, I.D., Dutra, A.J.B., 2019. Copper and metals concentration from printed circuit boards using a zigzag classifier. Journal of Materials Research and Technology 8: 513–520. DOI: https://doi.org/10.1016/j.jmrt.2018.05.003

Kaya, M., 2016. Recovery of metals and nonmetals from electronic waste by physical and chemical recycling processes. Waste Management, 57: 1–7. DOI: https://doi.org/10.1016/j.wasman.2016.08.004

Dodibia, G., Nagai, H., Wang, L.P., Okaya, K., Fujita, T., 2012. Leaching of indium from obsolete liquid crystal displays: comparing grading with electrical disintegration in context of LCA. Waste Management. 32: 1937–1944. DOI: https://doi.org/10.1016/j.wasman.2012.05.016

Khaliq, A., Rhamdhani, M., Brooks, G., Masood, S., 2012. Metal extraction processes for electronic waste and existing industrial routes: a review and Australian perspective. Resources 3: 152–179. DOI: https://doi.org/10.3390/resources30100152

Gollakota, A. R. K., Gautam, S., and Shu, C. M. 2020. Inconsistencies of under multiple situations. Environmental Science and Technology. 37: 21: 919–936. DOI: https://doi.org/10.1039/c8gc03688h

Hsu, E., Barmak, K., West, A.C., Park, A.H.A., 2019. Advancements in the treatment and processing of electronic waste with sustainability: a review of metal extraction and recovery technologies. Green Chemistry 21: 919–936. DOI: https://doi.org/10.1039/c8gc03688h

Zheng, L., Wu, H., Zhang, H., Liu, J., Dong, B., Liu, G., Zuo, J., Song, Q., 2017. Characterising the generation and flows of construction and demolition waste in China. Construction and Building Materials 136: 405–413.

Lu, W.S., Yuan, H.P., Li, J.R., Hao, J.L.J., Mi, X.M., Ding, Z.K., 2011. An empirical investigation of construction and demolition waste generation rates in Shenzhen city, South China. Waste Management 31(4): 680-687. DOI: https://doi.org/10.1016/j.wasman.2010.12.004

Department of Environment Malaysia. 2019. Guidelines for Environmental Noise Limits and Control Retrieved from https://www.doe.gov.my Accessed November 2021.

Sharma, S. K. 2016. Environment Engineering and Disaster Management, New Delhi: Infinity Press.

Ministry of Human Resources, M., and Health, D. of O. S. and. 2019. Noise Act 2019. pdf. Malaysia. Retrieved from https://www.doh.gov.my/index.php/ms/regulation-regulations-under-occupational-safety-and-health-act-1994-act-514/3174-00-occupational-safety-and-health-noise-exposure-2019/file (Accessed Mac 2020).

Department of Safety and Health, M. 2018. Industrial Noise Control Module. Malaysia. Retrieved from https://www.doh.gov.my/index.php/competent-person/form/occupational-health/osh-info/industrial-hygiene-ergonomic/pamphlet/3026-kawan-kebisingan?path=osh-info/industrial-hygiene-ergonomic/pamphlet (Accessed June 2021).

Department of Environment Malaysia. 2019. The Planning Guidelines for Vibration Limits and Control in The Environment. Putrajaya, Malaysia: Ministry of Natural Resources and Environment Malaysia.

Jantunen, Jorma & Kauppi, Tommi & Räisänen, Marja & Komulainen, Jorma & Kauppila, Tommi & Soini, Eija & Raumio, Anne & Marttunen, Mika & Mustajoki, Jyri & Kemppainen, Antti & Leppänen, Matti & Tornivaara, Anna & Pasanen, Jorma. 2006. The National Biennial RCRA Hazardous Waste Report (Based on 2011 Data). DOI: http://www3.epa.gov/epawaste/inforesources/data/bri1/index.htm

Balde, C.P., Wang, F., Kuehn, R., Husman, J. 2015. The Global E-Waste Monitor. 2014. Bonn, Germany. DOI: https://doi.org/10.1007/978-3-662-4794-9_4
publications, Finland 11/2015. Ministry of Employment and the Economy, Finland

[75] Department of Environment Malaysia 2017 Environmental Essentials for Siting of Industries in Malaysia, (October), 177.

[76] Department of Solid Waste Management 2018 Solid Waste and Public Cleansing Management (Licensing) (Undertaking of Provision of Collection Services for Construction Solid Waste) Regulations. Waste Management, Kuala Lumpur: Attorney General’s Chamber.

[77] Department of Solid Waste Management, 2012. Solid Waste Data, Malaysia. DOI: http://www.kpkt.gov.my

[78] Ministry of Environment Japan. 2016. History of EIA Systems and Measures taken around the World. Washington, D.C.: World Bank Group.

[79] Ivonen, O. 2013. Assessing release of hazardous substances from construction products – review of 10 years of experience with a horizontal approach in the European Union. Build. Environ. 69: 194–205. DOI: http://dx.doi.org/10.1016/j.buildenv.2013.08.010

[80] Silpa Kaza, Lisa Yao, Perinaz Bhada-Tata, and F. V. W. 2018. **What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.** Washington, D.C.: World Bank Group.

[81] Luttenberger, L. R. 2020. Waste management challenges in transition to circular economy - Case of Croatia. *Journal of Cleaner Production*, 256. DOI: https://doi.org/10.1016/j.jclepro.2020.120495

[82] United Nations Environment Programme (UNEP), 2019. *Luttenberger, L. R. 2020. Waste management challenges in transition to circular economy - Case of Croatia. Journal of Cleaner Production*, 256. DOI: https://doi.org/10.1016/j.jclepro.2020.120495

[83] Environmental Essentials. Solid waste, Recycling, and Waste Management. Malaysia 2017. (Accessed October 15 2019).

[84] Menegaki, M., Damigos, D., 2018. A review on current situation and horizontal approach in the European Union. *Build. Environ.* 69: 194–205. DOI: https://doi.org/10.1016/j.buildenv.2013.08.010

[85] Yuan, H., Lu, W., Jianli Hao, J., 2013. The evolution of construction waste sorting on-site. *Renewable and Sustainable Energy Reviews* 20, 483-490. DOI: https://doi.org/10.1016/j.rser.2012.12.012

[86] Eurostat, 2017. Generation of Waste by Waste Category, Hazardousness and NACE Rev 2 Activity. DOI: https://doi.org/10.1016/j.resconrec.2017.07.034

[87] Bernardo, M., Gomes, M.C., de Brito, J., 2016. Demolition waste generation for development of a regional management chain model. *Waste Management*, 49, 154-169. DOI: https://doi.org/10.1016/j.wasman.2015.12.027

[88] Peng, H., Liu, Y., 2016. A comprehensive analysis of cleaner production policies in China. *Journal of Cleaner Production* 135: 1138-1149

[89] Chang, I.-S., Wu, J., Qiao, H., Zhang, Z., 2015. The spatio-temporal waste recycling decision. *Civil Engineering and Environmental Systems* 33: 214-226. DOI: https://doi.org/10.1080/10286608.2016.1161030

[90] Minsegaki, M., Damigos, D., 2018. A review on current situation and challenges of construction and demolition waste management.
[120] UTM-Low Carbon Asia Research Centre. 2014. Low Carbon Society Blueprint for Iskandar Malaysia 2025-Summary for policymakers. UTM-Low Carbon Asia Research Centre. Johor Bahru: Universiti Teknologi Malaysia.

[121] Department of Safety and Health. 1994. Occupational Safety and Health Act 1994. Kuala Lumpur, Malaysia

[122] Ministry of Health Malaysia. 1988. Prevention and Control of Infectious Diseases Act 1988 (Act 342) The Commissioner of Law Revision Malaysia Kuala Lumpur, Malaysia.

[123] Department of National Heritage Malaysia. 2006. National Heritage Act 2005 Kuala Lumpur, Malaysia: Publisher

[124] Department of Irrigation and Drainage Malaysia. 2010. Guideline for Erosion and Sediment Control Kuala Lumpur, Malaysia: Department of Irrigation and Drainage (DID).

[125] Charlesworth, S., Warwick, F., and Lashford, C. 2016. Decision-making and sustainable drainage: Design and scale. Sustainability (Switzerland), 8(6): 1–11. DOI: https://doi.org/10.3390/su8060782

[126] Lashford, C.; Charlesworth, S.; Warwick, F.; Blackett, M. 2014. Deconstructing the sustainable drainage management train in terms of water quantity; preliminary results for Coventry, UK. CLEAN Soil Air Water 2014, 42, 187–192.

[127] Malaysia Standard. 2012. Malaysian Standard (MS 2318: 2012) Demolition of buildings - Code of practice First revision, Kuala Lumpur, Malaysia.

[128] Nelson L. and Nemerow, F. J. 2009. Environmental Engineering. Sixth Edition. Canada: John Wiley and Sons, Inc.

[129] Chan, D. W. M. 2019. Sustainable building maintenance for safer and healthier cities: Effective strategies for implementing the Mandatory Building Inspection Scheme (MBIS) in Hong Kong, 24.

[130] Ruiz-Jaramillo, J., Mascort-Albea, E., and Jaramillo-Morilla, A. 2016. Proposed methodology for measurement, survey and assessment of vertical deformation of structures. Structural Survey, 34(3): 276–296. DOI: https://doi.org/10.1108/SS-02-2016-0006

[131] Slavina, A., Bychkov, A., Dzhusesov, G., and Borisova, M. 2019. Reduction of terms of demolition works of fully assembled residential buildings in Moscow. E3S Web of Conferences, 91. DOI: https://doi.org/10.1051/e3scnf/20199108008

[132] Oleinik, P., and Cherednichenko, N. 2019. Organisation of demolition works during production buildings reconstruction. IOP Conference Series: Earth and Environmental Science, 403(1): 1-7. DOI: https://doi.org/10.1088/1755-1315/403/1/012189

[133] Lautaru, V., Kovacs, M., Gireada, A., and Irimia, A. 2020. Impact of demolition work of the environment, generated by mine closures in Jiu Valley, 00036. Romania: EDP Sciences.

[134] Harris, S. Y. 2011. Building Pathology: Deterioration, Diagnostics, and Intervention, Portland, USA: Wiley and Sons.

[135] Schwartz, Y., Raslan, R., and Mumovic, D. 2018. The life cycle carbon footprint of refurbished and new buildings – A systematic review of case studies, 81: 231–241.

[136] Warwick, F., Charlesworth, S. 2013. Sustainable Drainage Devices for Carbon Mitigation. Management of Environmental Quality: An International Journal 24: 123–136. DOI: https://doi.org/10.1088/14777831311291186

[137] Wang, G., Wu, P., Wu, X., Zhang, H., Guo, Q., and Cai, Y. (2020). Mapping global research on sustainability of megaproject management: A scientometric review. Journal of Cleaner Production, 259. DOI: https://doi.org/10.1016/j.jclepro.2020.120831

[138] Chanchitpricha, C. and Bond, A. 2013. Conceptualising the effectiveness of impact assessment processes. Environmental Impact Assessment Review, 43: 65–72.

[139] Singapore Statutes Online. 2021. Singapore Statutes Online Current version as at 03 Aug 2019 PDF created date on: 03 Aug 2019, 2019(Chapter 351). Retrieved from https://ssso.agc.gov.sg/Act/ETA2010. (Accessed January 2020).

[140] Department of Environment and Natural Resources, P. 2004. Procedure Manual Title III of DAO 92-29 “ Hazardous Waste Management.” Retrieved from https://www.env.go.jp/en/recycle/asian_net/Annual_Workshops/2012_PDF/D1S2-2 [PHILIPPINES].pdf. (Accessed January 2020).

[141] Minister of the Environment, G. of J. 1994. Environmental Impact Assessment Act 1994. Retrieved from http://law.epa.gov.tw/en/laws/379692190.html. (Accessed March 2020).

[142] Ministry of Industry and Trade Vietnam. 2016. Introduction of Vietnam seafood industry. Retrieved from http://vasep.com.vn/1192/OneContent/tong-quan-nganh.html (Accessed April 2020).

[143] NZ Parliament. 2013. Health and Safety at Work [Mining Operations and Quarrying Operations] Regulations 2016, (April). Retrieved from https://www.legislation.govt.nz/regulation/public/2016/0017/latest/whole.html?search=qs_act%40bill%40regulation%40deemedreg_abandonment_resel_25_h&p=1&DLM6732028%0A%0A (Accessed May 2020).