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Risk Assessment and the Environmental Impact of Industrial Projects in Malaysia: A case study of SAMUR, Sabah

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Abstract

To ensure high performance of projects, risk factors and their impact towards the environment need to be addressed during and after the construction phase. This research aims to assess the risk factors and the impact of industrial projects to the environment and surrounding areas. The research employs multi-method strategies: this case study includes several interviews, observations, analysis of project documents and questionnaires distributed among the occupants living in the surrounding area. The results of the research indicated that the project is perceived to have negative environmental impact measured under ecosystem, natural resources, and public impact.

Keywords: risk assessment, risk factors, environment impact, industrial projects

1.0 Introduction

The high depletion rate of natural resources and the increasing consumption of non-renewable resources particularly in the construction industry has led to environment deterioration (Ali, Jainudin, Tawie, & Jugah, 2016). Rapid urbanization and the pursuit of a better quality of life has caused Malaysia to shift towards environmental degradation resulting from the series of challenges evolving from environmental issues (Mei, Wai, & Ahama, 2016). These issues could stem from various causes including unsustainable construction practices. The concept of sustainable development parallels the principles of Quality of Life through community involvement (Kamaruddin, Ahmad, & Alwee, 2016). According to Annod (2014), many construction projects suffer from mismanagement despite continuous improvement in the field of project risk management. From the general overview, the lack of implementation of standard risk management methods in the construction industry has led to construction projects that suffer from poor performance, and consequently give negative impact to the environment. To avoid this and other problems, a standard construction risk management model that contains an in-depth study of the construction environment needs to be designed for future use; showing that employers must have vast knowledge and awareness on the effects of their activity towards the environment. Furthermore, they must ensure that pollution is kept within the perimeters to prevent further disruptions to the surrounding community. This study aims at prioritizing the most frequent environmental impacts, in order of their impact level, by investigating their frequency and consequences of occurrence.

2.0 Sabah Ammonia Urea (SAMUR)

SAMUR project will be the case study for this paper. Based on the project documentation, Spitang Oil and Gas Industrial Park (SOGIP) will serve as a new focal point for oil and gas investment within the Sabah, Brunei, and Labuan economic centers. This project (SAMUR) will approximately cost RM 4.6 billion (USD 1.5 billion) and will produce about 1.2 million tons per annum of granulated urea. SAMUR in SOGIP is located close to the sea to the east of the site. This project is Malaysia's first mega urea fertilizer

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plant built by PETRONAS Chemicals Fertilizer Sabah Sdn Bhd with a capacity of 1.225 MMTPA. This project consists of 3 main areas (ammonia plant, urea and granulation urea utility, and offsite plant) and also a jetty located at 2km north of the plant.

3.0 Literature Review

3.1 Risk Management

Risk management is a method of minimizing risk factors and maximizing opportunity factors by identifying and eliminating or mitigating, the risk factors (Park, Park, Cha, & Hyun, 2016). Risk management is the key function of project-based organizations, and this system is designed to measure and manage all complex risks of their projects (Khameneh, Taheri, & Ershadi, 2016). The risk management cycle (the risk assessment phase) can be viewed in three stages: risk identification, risk analysis and risk response (Zayed at al., 2008).

3.2 Environmental Impact

Protection of the living environment is one of the most important fields of our time, and it is more than logical that the society should pay special attention to this area (Aliu, Aliu, Mustafi, & Kamberi, 2011). Besides, global warming may also contribute to the break-up of ice shelves and create a loss of habitat for animals dependent on the ice shelves (Hanifah & Hashim, 2016). Climate change is a substantial energy security concern not only because direct flooding and natural disasters can damage power plants and transmissions lines but also because it has severe impact on food security, health, and environmental refugees that can all lower the income base of Asian countries and add to government debt, further complicating attempts at sound energy policy making (Sovacool, 2014).

3.3 Overview of the Environment

An environment is the physical surroundings and conditions, affecting people's lives and condition or circumstances of living, with external conditions affecting the growths of plants and animals. Other terms to describe environment are: surroundings, atmosphere, climate, habits, territory, biosphere, ecosystem, and nature. The term may also include aspects such as cities, town and villages (the urban or built environment), culture in all its manifestations, history, lifestyle and quality of life (Lawrence et. al, 2012).

3.4 Impact of Construction Activity towards the Environment

The environment is threatened severely by many problems, including those caused by the activities of construction projects (Ijigah et al., 2013). For impact assessment, it should be built into in the early phases and flow through along the whole planning procedures especially where resource management and land use decision are concerned (Shafie, Omar, & Karuppannan, 2013). This is because any development project plan to improve the quality of life has some built-in positive and negative impacts. The development project should be planned in such a manner that it has the maximum positive impact and minimum negative impact on the environment (Kaur and Arora, 2012). Environmental impacts are categorized into three safeguard subjects: (Li et al., 2010; Chang et al., 2011 and Zolfagharian et al., 2012).

a) Public impacts
b) Natural resources impacts
c) Ecosystem impacts

a) <u>Public Impacts</u>

Most construction projects are located in densely populated areas. Thus, people who live at or close to construction sites are prone to harmful effects on their health because of dust, vibration and noise due to certain construction activities such as excavation (Li et al., 2010).

b) <u>Natural resources impacts</u>

Construction equipment operations consume a lot of natural resources, such as electricity and diesel fuel. The construction sector is responsible for consuming a high volume of natural resources and generating a great amount of pollution as a result of energy consumption during extraction and transportation of raw materials (Li et al., 2010; and Zolfagharian et al., 2012).

c) <u>Ecosystem impacts</u>

The accumulated amount of adverse environmental impacts like the waste, noise, dust and hazardous emissions still occur during the construction process which causes serious damages to humans and ecosystems (Chen et al., 2004; and Zolfagharian et al., 2012). With the rise in the number of construction of new buildings, the ecosystems impact of construction has become an important issue (Zolfagharian, 2012). These adverse environmental impacts include waste, noise, dust, solid wastes, toxic generation, air pollution, water pollution, bad odor, climate change, land use, operation with vegetation and hazardous emissions (Kaur and Arors, 2012)

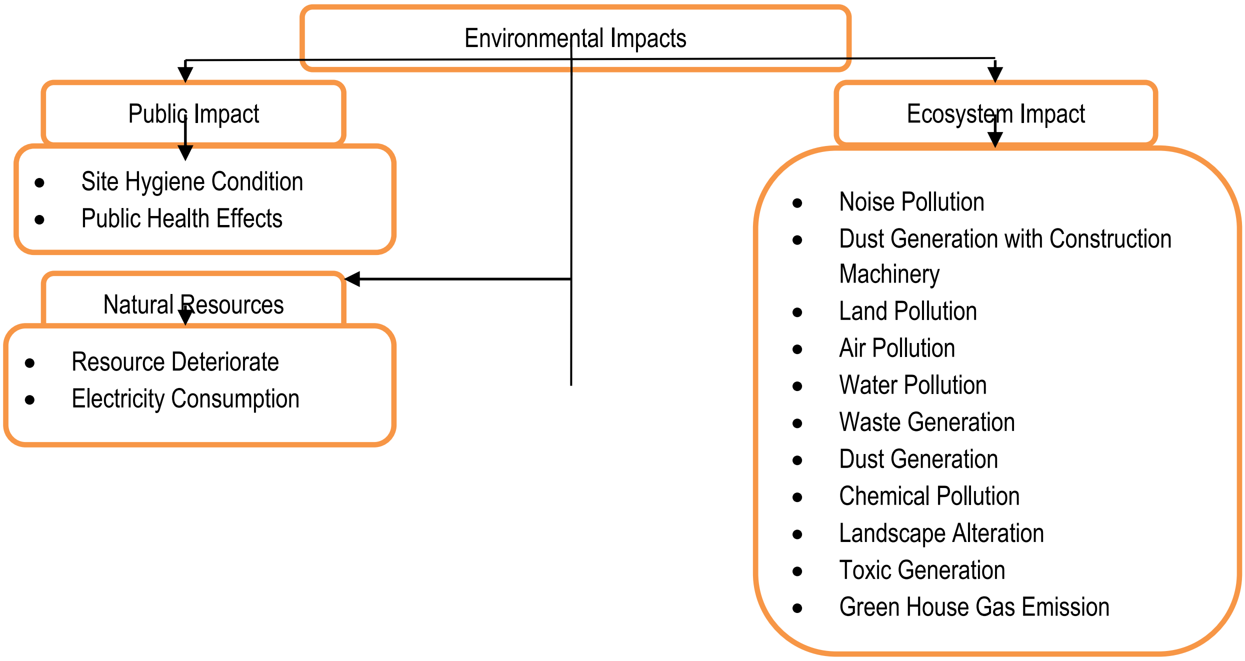


Figure 1: Environmental Impacts of Construction Processes
(Source: Li et al., 2010; Chang et al., 2011 and Zolfagharian et al., 2012)

4.0 Methodology

Semi-structured interviews were conducted with parties involved in the SAMUR Project, consisting of the Project Manager, Engineer and Safety Officer. It was carried out to investigate the risk assessment for SAMUR project to mitigate the environmental impact. At the same time, documentation from the SAMUR project was also analyzed to gather more information about the risk assessment procedure. For the questionnaire survey, 200 questionnaires were distributed among the community around the SAMUR project to gain their perspective on the environmental impact of the project. The questionnaire consists of 5 sections, namely: demographic information, general environment concerns, effects to the community, level of general environment concerns and general view of the environment.

Limitations

SCOPE	LIMITATIONS
WHAT	• To explore the risk assessment tools and methods for risk factors in within construction projects in Malaysia • To identify the environmental pollution by construction industry
WHY	Because: • Construction activity cause of pollutions • Lack of awareness of environmental pollution
WHERE	This is an on-going research but the scope of this paper is the case study of SAMUR
WHO	Informants for this research are: • Project participants (Project Managers, Engineer, Safety Officer) • Community in the surrounding area
HOW	The research employs a mixed method approach encompassing the quantitative and qualitative methods with data collection using questionnaires, interviews and case study

5.0 Discussion and Results

5.1 Risk Assessment for SAMUR

For this project, PETRONAS Global Technical Solutions Sdn. Bhd (PGTSSB) Process Safety Management (PSM) team was engaged by Mitsubishi Heavy Industries Ltd. (MHI) to conduct a Quantitative Risk Assessment (QRA) for SAMUR project. The main purpose of the assessment was to verify if the offsite risk results meet the Department of Environment Guideline Criteria (DOE, 2004) regarding offsite risks. According to Respondent 1, the QRA method is the most suitable risk assessment method for chemical construction. To gauge the environmental impact, the Environmental Impact Assessment (EIA) was also done to evaluate the environmental impact of the construction activity. The QRA identified risk factors that may arise during the construction project that may potentially cause problems in the project such as, explosion, air blowing, fatality, etc. These risk factors will also cause environmental impact to the surrounding site area, such as air pollution and waste pollution. This assessment was conducted using EIA by identifying risk factors using QRA method that may cause pollution to the environment.

5.2 Quantitative Risk Assessment (QRA)

The basis for the current QRA study is DNV's (Det Norske Veritas) proprietary risk modeling software, PHASTRISK 6.54, the latest version. The PHAST consequence modeling results are regularly reviewed and where required re-calibrated, based on the most recent available accident and test data. Various aspects of the hazard identification were performed, to allow a definition of the failure cases, which should be consistent with the scope and objectives of the risk assessment applicable to the SAMUR project.

5.2.1 Leak Sizes Model

A question to address is what leak sizes to model (and specify in the failure case definition), as leak sizes may vary from pinhole leaks to equipment rupture. The following leak sizes ranges may be considered for modeling in a risk study:

Small leaks	1 to 10 mm; equivalent size 5mm
Medium leaks	10 to 50 mm; equivalent size 25mm
Large leaks	50 to 150mm; equivalent size 100mm
Line ruptures	Pipe diameter
Instantaneous	Vessel inventory released

For flammable release, small leaks are excluded from the modeling as they have a very low historical ignition probability (1 percent) and hazard range, and consequently make a negligible contribution to the level of risk.

5.2.2 Release Durations Model

The following assumptions were made based on the time required to detect a leak and isolate facilities within individual process area, tank farms, and other operational areas.

Process Areas: The time to detect a leak, investigate and then initiate an emergency shutdown is estimated as 10 minutes.

Tanks Farms: The time to detect a leak, investigate and then initiate an emergency shutdown is estimated as 10 minutes.

Non-isolatable Inventories: Leaks will continue until inventory is exhausted, but subject to a modeling cut-off limit if 60 minutes.

Leaks on jetty loading arms will be isolated within 1 minute via local ESD button (attended operation).

5.2.3 Release Surface Model

The following assumptions were made on the release surface, which affects the extent of spill spreading and hence pool fire, pool evaporation and flash fire results. Within PHAST, the type of surface may be specified as:

Deepwater, modeled within PHAST with a maximum spill depth of 5mm.

Concrete (flat), modeled within PHAST with a maximum spill depth of 10mm.

Wet soil, modeled within PHAST with a maximum spill depth of 3mm.

Dry soil, modeled within PHAST within a maximum spill depth of 50mm.

5.2.4 Failure Case Selection

Consistent with the objective to create a Fully Comprehensive Risk Model, all process equipment within each process area and all flammable and toxic materials are included in the failure case definition and hence the PHST risk model, whether capable of producing an offsite risk or not.

5.2.5 Failure Case Definition Methodology

The basis for failure case definition is all process equipment and process lines inflammable or toxic service within each process unit that are in use during normal operations. Start-up lines and other normally isolated systems (e.g. manual vent and drain lines) are excluded from the failure case definition. Where there are duplicate facilities such as duty and standby pumps, compressors, filters, only the duty equipment is included in the failure case equipment count to calculated leak frequencies.

5.3 Environmental Impact Assessment

The condition of the project sites was studied covering the physical-chemical, biological and socioeconomic environments. The main sensitive areas around the project site are the mangrove habitats, fishing ground, and villages. The nearest village is Kg. Kuala Mengalong, located at the distance of approximately 3.7 km southwest of the project site. Altogether there are ten fishing villages in the area with a total 258 registered fishermen. The majority of the fisherman reported a daily income ranging from RM 100- RM 500, with the catch normally sold to wholesalers.

The present EIA study focuses on the environmental impacts from other aspects of the plant that have been addressed in the *Preliminary Environmental Impact Assessment for the Sabah Ammonia Urea (SAMUR) Plant,* Prepared by Golden Ecosystem Sdn. Bhd. in May 2011 and approved by Department of Environmental (DOE) in June 2011.

5.4 Respondents Perception of the SAMUR Project

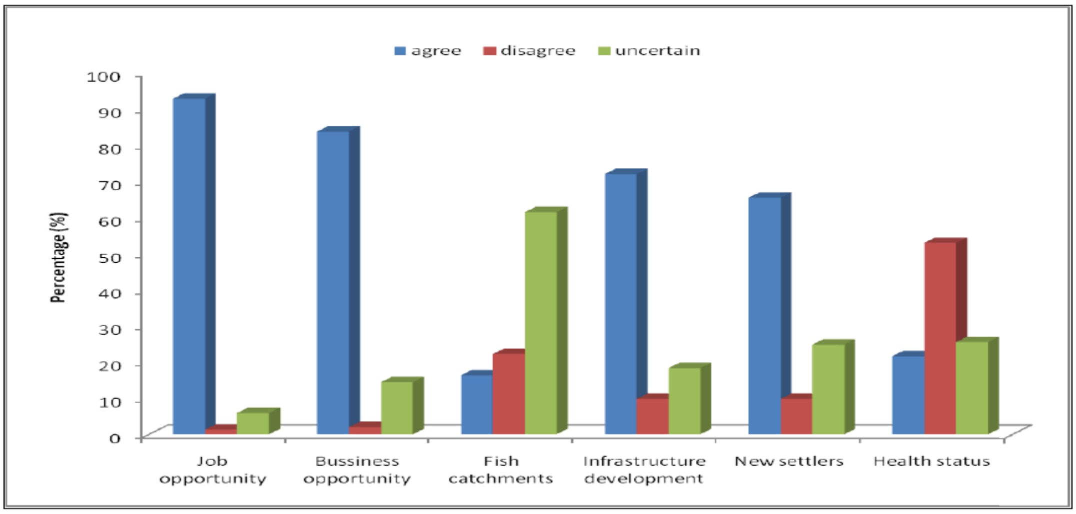


Figure 2: Respondents from Community

Based on findings from the environmental impact assessment (EIA), it can be concluded that the population of Sipitang responded positively towards the proposed SAMUR project as they foresee the project as a potential for upgrading their living standard. SAMUR development is seen as their potential source of income such as the agriculture and fisheries sectors. At the same time, job opportunities will also be created for the locals and the SAMUR development will result in the transformation of a small township into a busy oil and gas hub with self-sustaining facilities.

5.4.1 Impact assessment, mitigation measures and monitoring program

The table below shows several examples on how the impact assessment including mitigation and monitoring was carried out using the environmental impact assessment (EIA) for this project.

Table 1. An example of impact assessment

No	Issues	Impact Significance	Mitigation Measures	Monitoring Program	Frequency / Responsible
1	**Morphological Impacts** • Permanent morphological impacts owing to the footprint of the jetty structure are limited to immediately around the projects area. • Minor changes, however, non-cumulative	Minor	No specific measures	Coastal profile monitoring at the mangrove shoreline area	Monthly during dredging and reclamation phase, tri-monthly during reminder of jetty construction and six months after completion
2	**Sediment Plumes**	Minor	Still curtains aroura the	• GPS location and	• Monthly

	during Construction Impacts of suspended sediments arising from the capital dredging and disposal, reclamation and piling works are overall minor. The minor effect at a local scale.		dredging area and temporary disposal site (outside the bund wall). Regular maintenance of dredge and pipeline to prevent accidental leaks and spillage. Monitoring of overflow sediment concentrations from the temporary disposal site. Regular maintenance of bund wall temporary disposal site.	photographic documentation of installer drain the temporary pond and site trap and bund walls, the location of all sediment control measures to be shown on the map. • Verification of site curtain construction.	
3	**Water pollution impacts** Construction phase • Other than suspended plumes, impact during construction includes contaminants from sediment due to dredging activity and water exchange between tides and oil from construction machinery and transportation vehicles. • Minor changes to local conditions impacts are temporary, reversible however cumulative.	Minor	Discharge of scheduled wastes according to the DOE guidelines. Diesel storage areas at least 50m away from the waterfront.	• GPS location and photographic documentation of storage area	• Monthly
	Operational Phase • Operational impacts include ammonia and urea spillage by ammonia and urea vessels and oil and grease spill and ballast water by marine vessels. Assuming the implementation of mitigation measures, the impacts of water quality may be considered minor. However, the risk of water contamination is permanent.	Moderate	Plant emergency response plan. Hazardous material spill response plan.	• -	• -
4	**Waste** • Development on the site will produce various types of solid waste, including domestic waste, construction waste, and scheduled waste. • Minor changes to local conditions, impact, is temporary, reversible and non-cumulative	Minor	Waste storage bins. Waste collection area at least 30m away from site or shoreline. Disposal of construction wastes at the designated area within the SAMUR plant (temporary facilities area).	• Regular maintenance and inspection of waste storage • Ensure no pen burning incidents occur • Ensure waste is to the designated dumping • Inspection of transportation to waste storage are temporary facilities.	• Monthly (environmental officer) • Daily (environmental officer) • Weekly (environmental officer)
5	**Dust generation from disposal sites** • During the disposal,	Minor	Covering the ground cover at disposal sites	• Document installation of speed limit signage (photographs GPS location)	• Monthly (environmental officer) • Daily (environmental

	the amount of dust is expected to be low • Minor effect on local condition impacts is temporary, reversible however cumulative		Covering/blocking dust sources Vehicle speed limit to 30km/hr	• Observations of speeding vehicles • Sir quality monitoring	officer) • Weekly (environmental officer)
6	**Noise Impacts** • No noise impact on the human environment is likely to occur during the construction activity due to distance. • The minor effect of local condition impacts is temporary, reversible and non-cumulative.	Minor	specific measures	• Noise Monitoring	• Tri-monthly (EMP consultant)

5.4.2 Summary

The table above summarizes the environmental impacts, mitigation measures and monitoring requirements identified for the proposed SAMUR project including jetty development. The schedule shows the location of the key mitigation measures and monitoring stations around the project site; while indicating the impact significance (minor or moderate). The EIA for the project was approved by DOE on 20th June 2011 and for the earthworks was approved by EPD on 19th December 2011. This indicates that several impacts to the environment have already been identified, including guidelines on how to mitigate the listed impacts.

5.5 Environmental Impact for Case Study

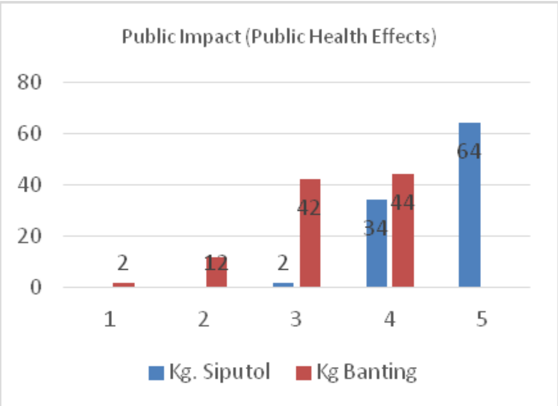
This study uses a questionnaire survey to measure the environmental impact to the surrounding area, and distributed among the community around the SAMUR project (Kg. Siputol and Kg. Banting). Two hundred questionnaires were distributed and collected, giving a response rate of 100%. The questionnaire was divided into five sections namely: demographic information, general environment concerns, the effect to the community, level of general environmental concerns and general views about the environment.

a) **Demographic Information**

Based on data from the two villages, the majority of the population is male, age 21-30 years old with a minimum education of SPM and equivalent. Regarding the occupation, most of the villagers in Kg. Siputol is currently working within the government sector (60%) and for Kg. Banting, most are working in the private sector (52%). The self-employed group for both villages is almost at the same percentage, as some of the villagers own businesses. The highest size of family for both villages is at "1 to 5 people"; which is 64% for both Kg. Siputol and Kg. Banting.

b) **General Environmental Concerns**

c)



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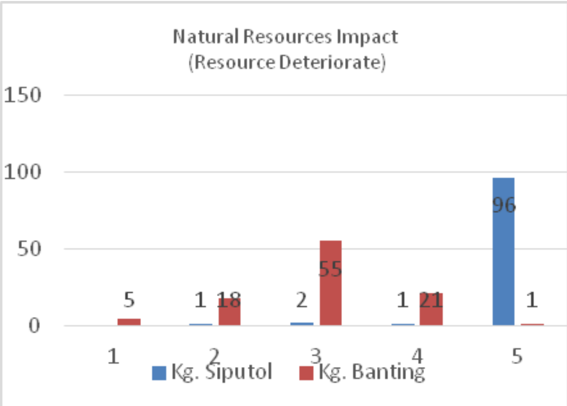

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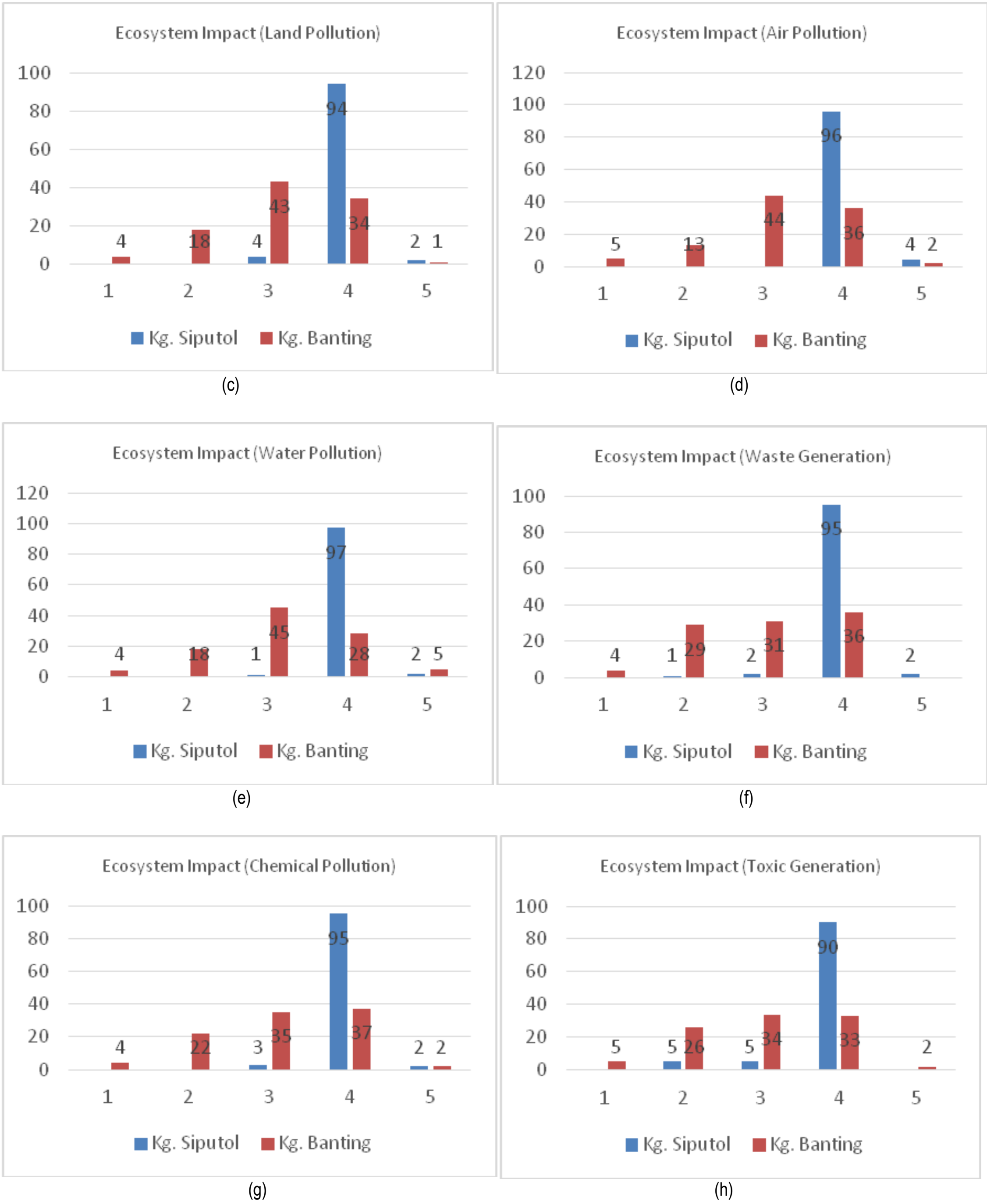


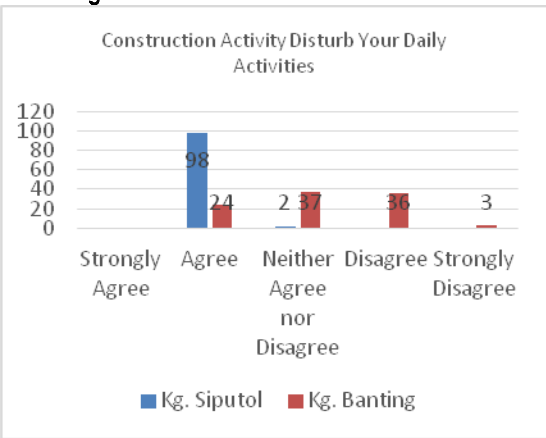
Fig. 3. (a) Public Health Effects; (b) Resources Deteriorate; (c) Land Pollution; (d) Air Pollution; (e) Water Pollution; (f) Waste Generation; (g) Chemical Pollution; (h) Toxic Generation.

This section measures the general environmental concerns using the Likert scale. For the two villages, the results indicate that the highest pollution is on public health effects and resource deterioration effects. Further investigation, through interviews, suggested that the pollution caused by the construction works proved to be unhealthy to the villagers within the community, especially for farmers and fishermen. They said that their earnings were mostly affected because the river is polluted by waste products from the construction. Other than that, fruits on their farm were also not producing well due to the effects of the ammonia pollution.

d) Effect to the Community

Section 3 measures the impact of the pollution to their properties, daily activities and the surrounding area. All the respondents (100%) agreed that the construction had affected their activities and the surrounding area. According to the respondents, the construction activity at SAMUR project has given negative effects regarding health, earnings and limited of daily activities. The roads are also damaged due to heavy vehicles (e.g. lorries).

e) Level of general environmental concerns



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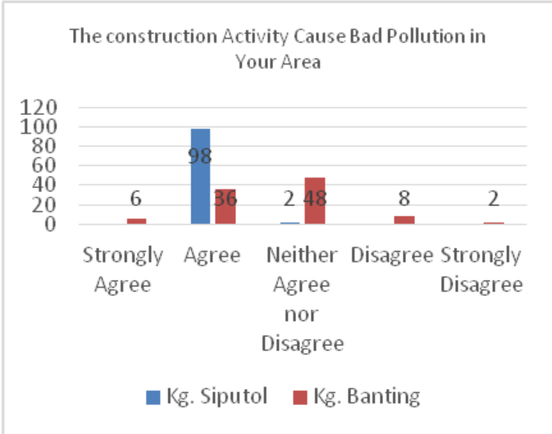

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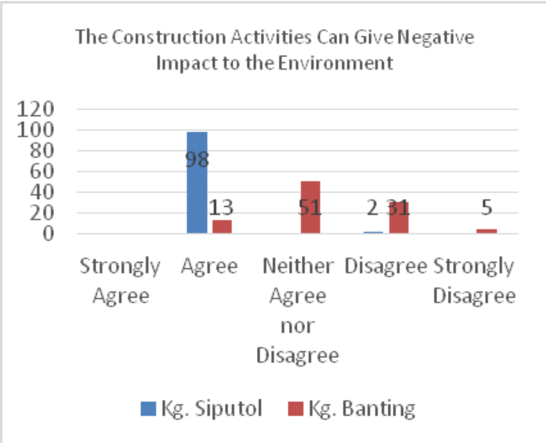

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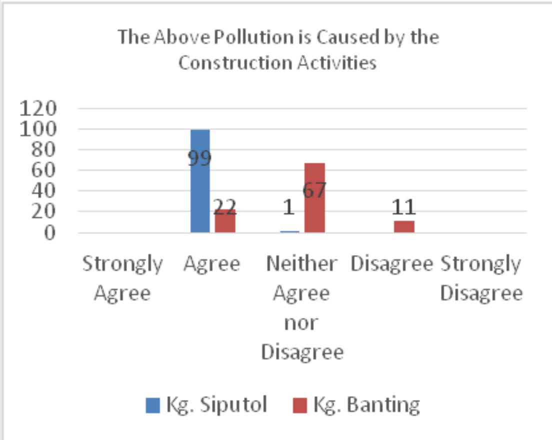

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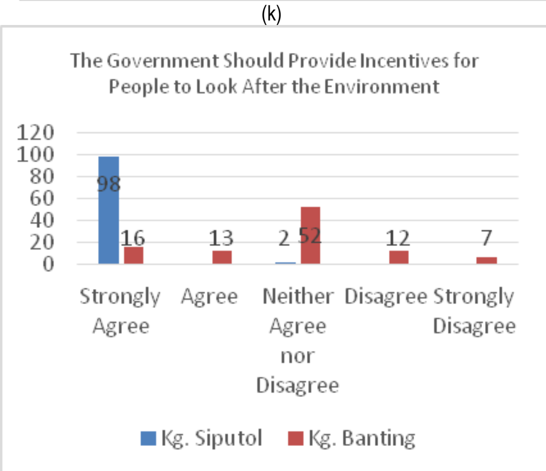

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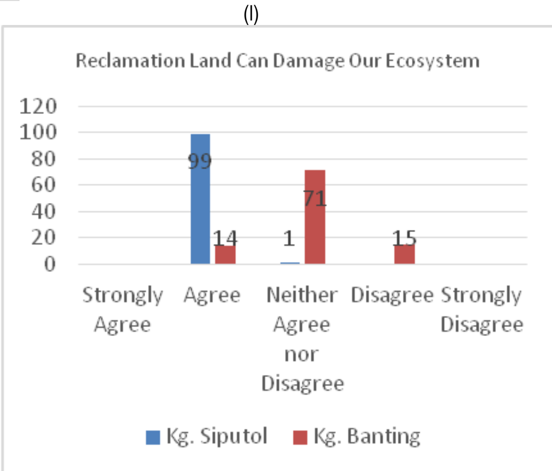

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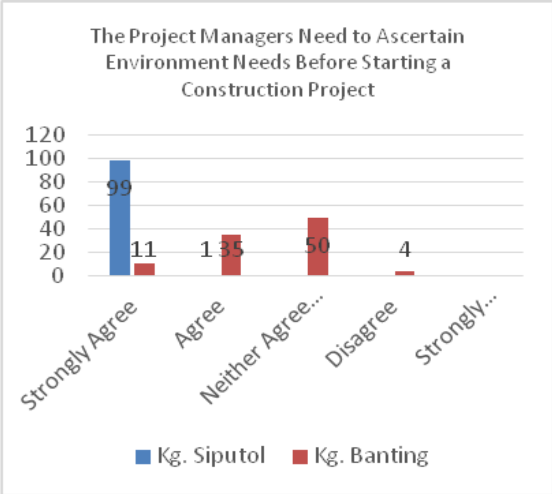

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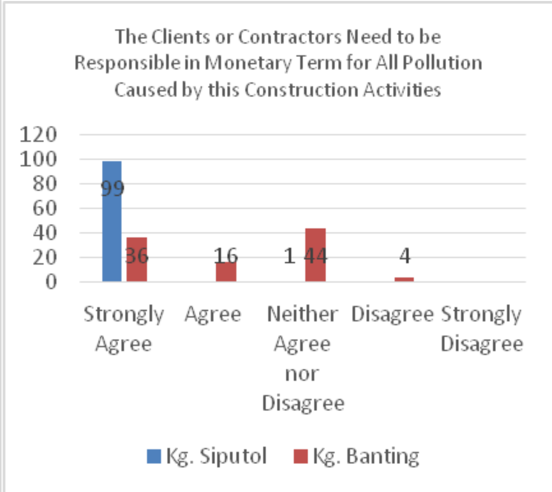

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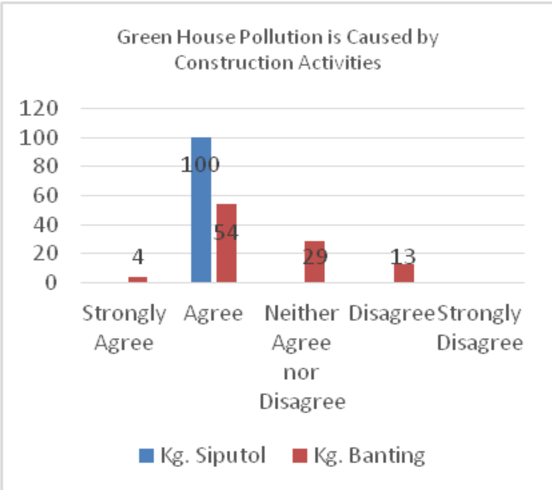

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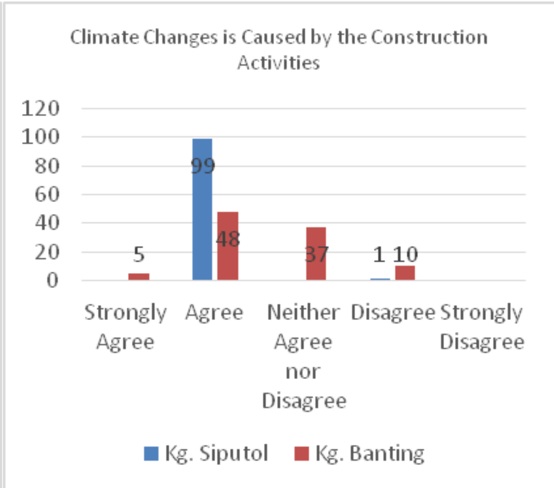

(r)

Fig. 4. (i) Construction activity disturb your daily activities; (j) The construction Activity Cause Bad Pollution in Your Area; (k) The construction Activities Can Give Negative Impact to the Environment; (l) The above pollution is caused by the construction activities; (m) The government should provide incentives for people to look after the environment; (n) Reclamation land can damage our ecosystem; (o) The project managers need to ascertain environment needs before starting a construction projects; (p) The clients on contractors need to be responsible in monetary term for all pollution caused by this construction activities; (q) Greenhouse pollutions is caused by construction activities; (r) Climate changes is caused by the construction activities

This section measures the level of general environmental concerns. Most of the villagers strongly agree to these statements:

I. The government should provide incentives for people to look after the environment
II. The project managers need to ascertain environment needs before starting a construction project
III. The clients or contractors need to be responsible in monetary terms for all pollution caused by the construction activities

This also indicates that the villagers want the parties involved in the construction to be more responsible especially regarding maintaining a healthy and pollution-free environment within the surrounding area.

f) General views about the environment

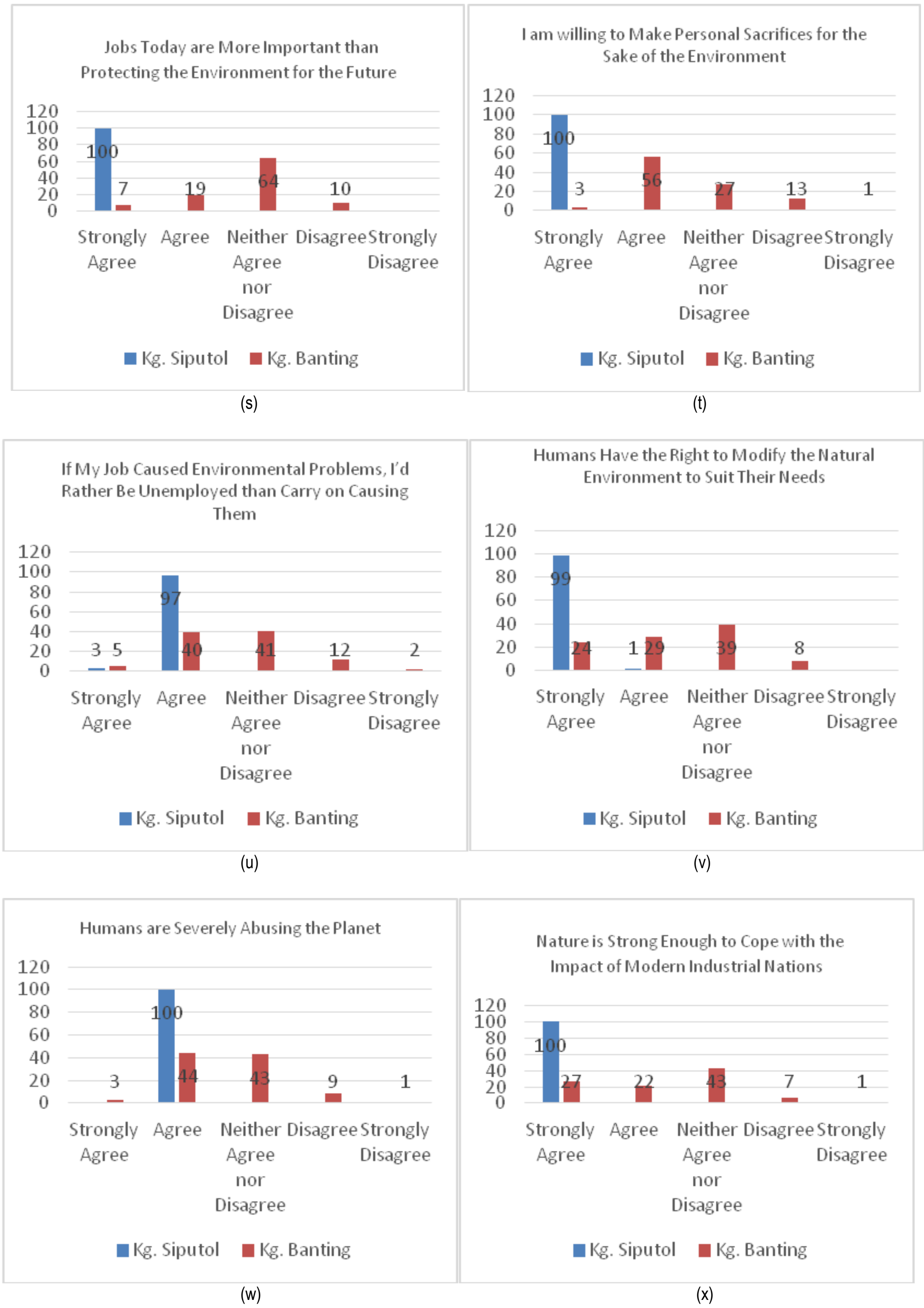

Fig. 5. (s) Jobs today are more important that protecting the environment for the future; (t) I am willing to make personal scarifies for the sake of the environment; (u) If my job caused environmental problems I'd rather be unemployed than carry on causing them; (v) Humans have the right to modify the natural environment to suit their needs; (w) Human are severely abusing the planet (x) Nature is strong enough to cope with the impact of modern industrial nations.

- Section 5 measures the general views on the environment. Most of the villagers strongly agree with the statement:
  I. Jobs today are more important that protecting the environment for the future
  II. I am willing to make personal sacrifices for the sake of the environment

III. Humans have the right to modify the natural environment to suit their needs
IV. Nature is strong enough to cope with the impact of modern industrial nations

Based on the results, although the villagers acknowledge the importance of protecting the environment, most also felt that there is a need to allow development and progress even though the environment may be at stake.

5.6 Relationship between risk assessment and the environmental impact

This study was focused on the assessment of the environmental impact and risk assessment for the industrial project, due to heavy pollution generated by the SAMUR project. Based on the findings, it can be deduced that the community are exposed to numerous chemicals every day from environmental sources such as air pollution and water pollution that are generally caused by construction activities. Some of these chemical are threats to human health and also cause damage to the environment. An overall risk assessment is important to ensure that projects are carried out in a safe and cost efficient manner and that priorities are assigned accordingly. For the SAMUR project, chemical waste in the river (water pollution) did not pose a great enough threat to the environment to justify a costly clean up action. Also, risk assessment is a process to evaluate the potential risks that may exist in the project, and therefore, without the risk assessment process or inspection from the QRA method, the chemical from the SAMUR project could easily leak, spill out or blow up to cause air and water pollution. As one of the important tools in risk assessment is environmental impact assessment, it enables environmental factors to be given due weight, along with economic or social factors, when applications for new projects are being considered.

6.0 Conclusion

This study investigated the risk assessment and the level of environmental impacts of the construction process for industrial buildings in Malaysia. Semi-structured interviews with the construction parties were conducted to determine the risk assessment flow and frequency of the environmental impacts of the case study. The results demonstrate that **resources deterioration, water pollution,** and **air pollution** have been identified as the highest environmental impact risks on construction sites. The results can be an influential assessment tool to assist construction practitioners in improving the on-site environmental performance within the risk assessment process. Furthermore, the research is expected to enhance the existing knowledge and data on risk assessment used related to environmental issues in Malaysia and also expected to expose more types on environmental impact due to construction activities. For further research is needed to see more detail of the risks and problem from different projects, countries, environment and how they design the risk modelling until the project become successful. In summary, the outcomes of this study can help organizations and managers prepare better sustainability plans and also increase the knowledge of partners within construction projects through training and awareness programs.

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