Jurnal Pendidikan Geografi:
Kajian, Teori, dan Praktik dalam Bidang Pendidikan dan Ilmu Geografi, 28(2), 2023, 168-177
ISSN: 0853-9251 (Print): 2527-628X (Online)
DOI: 10.17977/um017v28i22023p168-177

Economic and environmental benefit of informal waste scavenging at landfill sites: A case study at Bukit Gemuk, Tawau, Sabah, Malaysia

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Paper received: 26-10-2022; revised: 01-03-2023; accepted: 17-05-2023

Abstract

Recycling is an important part of the solid waste management system. However, community engagement in this activity remains relatively low. The presence of a group of individuals engaged in collecting recyclable materials at landfill sites has contributed to improving solid waste management performance. This paper aims to identify the background and activities of scavengers in collecting recyclable items at landfills, as well as the environmental impact of the scavenging activity. This study was based on questionnaires distributed to 46 scavengers in the study area. The Life Cycle Assessment (LCA) method was used to assess the environmental impact of using recyclable materials in manufacturing products. The LCA analysis could identify the contribution of recycled materials to the total savings of carbon dioxide (CO_2), methane (CH_4), and nitrogen dioxide (N_20) by using recycled materials in the production of a new product. According to the study, the majority of those involved in the scavenging activity are immigrants from Indonesia and the Philippines. Despite safety and health concerns, their efforts to earn a living through waste scavenging are extremely valuable. Furthermore, the findings show that their contribution to the collection of recyclable materials cannot be denied. It is because the presence of this group is essential in a country where recycling awareness is low. Furthermore, the indirect contribution to the environment is important, particularly in reducing the use of natural materials in producing new materials. As a result, the government must devise a more effective strategy for recycling programs by involving all stakeholders.

Keywords: garbage collection; scavengers; recycling; green house gas

1. Introduction

Garbage or solid waste is a by-product of human activity that is no longer required and should be disposed of. Organic waste, paper, newspaper, plastic, bottles, glass, and other materials are all types of solid waste. Without realizing it, the high proportion of solid waste discarded each day is a recyclable material (Kassim, 2006). Solid waste management is defined as waste generation, storage, collection, transfer, and transportation. However, the current system has not yet reached a satisfactory level. Therefore, the contribution of other sectors is required to improve the quality of waste management services and achieve the goal of sustainable management.

As a developing country, Malaysia should be prepared for the annual increase in waste produced. To that end, solid waste management has always been a top priority in Malaysian development plans. For example, in the 11th Malaysia Plan, integrated waste management

(strategy B5) was highlighted as a strategy to achieve sustainable consumption and production. The integrated strategies should include all stakeholders, such as the private sector, NGOs, and society (Economy Planning Unit, 2015).

Solid waste is a major source of environmental problems in many municipalities across the country. The problem of urban waste is not new; it has existed for many years. It is due to inefficient waste management, particularly the collection and disposal system. Inefficiency is also caused by an increased population, which produces more complex waste. Malaysia's solid waste generation rate is estimated to be 27,000 tonnes per day. According to these projections, the target of 30,000 tonnes of solid waste per day by 2020 will be met sooner than expected (Mapa, 2017). Reporting on the issue, the waste generated in Malaysia rose to 38,000 tons per day in 2018. It has exceeded the Japan International Cooperation Agency (JICA) study's proposed rate of 30,000 tons per day in 2020 (Mohamad & Keng, 2019).

Malaysian solid waste management still has flaws in areas such as collection services, technology, and landfill management, particularly in urban areas. It is because most of the landfill sites will be complete in the near future (Mapa, 2007). Future management need to assesses Malaysian solid waste management with a realistic perspective of solid waste management, particularly in source separation and recycling. Through SWCorp, Malaysia implemented a Strategic Plan for 2014–2020 focusing on technology, facilities, and delivery systems (Moh, 2017).

In many developing countries, the informal sector recovers recyclable materials. It is due to factors such as economic insecurity and rural-to-urban migration. Thousands of urban poor people are earning a living by collecting recyclable items. The study's findings indicated that respondents involved in waste scavenging were earning a living. Scavenging encourages family members to separate materials from waste in exchange for money (Ibrahim, Saidu, Abubakar, Aliyu, & Adamu, 2022). Indirectly, this industry has significantly contributed to enhancing the efficiency of solid waste management, particularly in the metropolitan area (Mapa, Sakke, Gulasan, & Asis, 2016).

In general, waste disposal should be done holistically. Solid waste management can refer to how waste is managed from generation to disposal. This includes storing, collecting, transporting, processing, and disposing. As a result, this process typically involves the interface of all of these activities and does not end once the waste is collected. A landfill is the final destination for waste generated in a particular location. Waste is increasing occasionally due to flaws in the waste management system. A landfill is the oldest and the most common form of disposal of waste. It is well known that the impact of MSW landfills can cause environmental pollution (Vaverková et al., 2018). According to recent estimates, only 30% to 70% of waste in developing-country cities is collected for disposal. The remainder is disposed of in other places, such as rivers, lakes, and ponds (Ezeah, Fazakerley, & Roberts, 2013). Therefore the proper implementation of waste management systems, such as education, laws, and taxes, will be led to a significant reduction in landfilling of waste as in Sweden (Bolton & Rousta, 2019).

The significance of waste collection for recycling cannot be ignored. However, community involvement has become a major impediment to recycling programs in some countries. Relying solely on the community to increase recycling rates will likely take longer. The major driver is the internal motivation of the community for caring and preserving the environment (Lawrence, Cooper, & Kissoon, 2020). As a result, the participation of all

stakeholders is required. In some countries, the contribution of informal waste collectors known as "scavengers" is significant. This group of people is known as street scavengers and can also be found in landfill sites as landfill scavengers (Mapa, 2007). This informal sector helps reduce waste from highly populated urban areas of a third-world countries, such as Pakistan (Kamran, Chaudhry, & Batool, 2015). For example, many of the things gathered in Zaria City's residential areas are a combination of plastic, paper, textiles, and glass. Cardboard cartons are the most common type of waste collected in market and business zones. According to Nzeadibe (2009), the composition of garbage recovered by "scavengers" is less than the total weight of waste generated. According to the study, the quantity of recyclable materials collected by scavengers is 14,400 kg of plastic, 550 kg of non-ferrous metal, 18.120 kg of ferrous metal, and 8,005 kg of glass bottles.

According to Oteng-Ababio (2012), the demographics of the population engaged in waste scavenging are dominated by men. According to Rockson, Kemausuor, Seassey, and Yanful (2013), men dominate solid waste collection activities. They also discovered that individuals aged 15 to 60 are actively involved in this activity. However, Muhammad and Manu (2013) discovered that women's participation is 55% higher. They also discovered that children are heavily involved in scavenging (40%) and that 5% of those involved are male. Furthermore, Katusiimeh, Burger, and Mol (2013) discovered that men, mostly aged 32, are among the characteristics of informal waste collectors. Thirty-five scavengers were interviewed, 49% were male, and 51% were female. Their average age was 30.7, the youngest being nine years old and the oldest 66 years old (Mapa, Powell, Asis, Sakke, & Gulasan, 2019). According to Ezeah et al. (2013), "scavengers" are usually considered unclean, diseased, homeless, criminals, unemployed, poor, and inappropriate in a modern waste management system.

According to Wee (2004), the "scavengers" group also plays an important role in socioeconomic aspects. Scavenging activities performed by this group can be classified as either a part-time or full-time work. In Malaysia, 30% of "scavengers" work full-time. Recycling is a type of job and a source of income for poor individuals or social groups in the economy (Medina, 2000). Despite their poor working conditions, these activities allow them to survive, especially in areas with high unemployment. They rely heavily on this activity to earn their living because they lack the necessary skills and education to work in the formal sector (Wilson, Velis, & Cheeseman, 2006).

The involvement of "scavengers" in waste collection contributes significantly to the conservation of natural resources. Their participation in the activity is informal, but it has the potential to provide numerous benefits, such as reducing the use of natural raw materials in the manufacturing sector. "Scavengers," according to Wilson, Velis, and Cheeseman (2006), are capable of supplying secondary raw materials to the manufacturing industry that can replace the use of raw materials. It indirectly lowers the production cost in an industry prevalent in many developing countries. This activity also allows for a reduction in the amount of capital required to produce a product. According to Oguntoyinbo (2012), companies in Lagos, Nigeria, acquired 48% of their raw materials from "scavengers." This demonstrates that the recycling sector or corporations may save money on raw materials. According to Asim, Batool, and Chaudhry (2012), "scavengers" could also help the government reduce the cost of recycling. It will indirectly assist the companies involved in solid waste collection in the region. According to the sensitivity analysis, increasing the waste collection rate, the proportion of paper and

plastic waste, recycling rate in 2025 will raise the energy and environmental advantages of recyclable resources (Cudjoe et al., 2021).

The environmental impact of recycling materials is also significant. The greenhouse gas (GHG) emissions from MSW landfill and control methods to eliminate or minimize these impacts is important to be evaluated (Wanichpongpan & Gheewala, 2007). All natural resources employed in the process will have an environmental impact. For example, the energy required to manufacture plastic bottles from raw materials is 40.82 gigajoules (GJ) per tonne. The net GHG footprint of heterogeneous post-consumer plastic waste recycling is 0.04 kg CO2-eq./kg waste feedstock processed, which includes credits from avoided production of virgin olefins, electricity, heat, and credits for the waste feedstock's partly biogenic content (van der Hulst et al., 2022). Furthermore, McDougall, White, Franke, and Hindle (2008) indicated that employing recyclable materials results in a carbon dioxide release of around 1706675 g and a nitrogen dioxide release of -51.1 g per tonne. The utilization of recycled materials can save 15.42 GJ per tonne of energy (Table 1). The overall amount of electricity saved by recycling solid waste from 2005 to 2017 was 3743.3 Mtce. During the period, solid waste recycling resulted in a 43.2 percent reduction in power use. Solid waste recycling saved 4765.9 billion kg of CO_2 and 22.502 billion kg of methane emissions. The overall amount of electricity saved by recycling solid waste from the year 2005 to 2017 was 3743.3 Mtce. During that time, solid waste recycling resulted in an average savings of 43.2 percent on electricity. In conclusion, solid waste recycling saved 4765.9 billion kg of CO_2 and 22.502 billion kg of methane (Cudjoe et al., 2021).

Table 1. Energy Saving and Gas Emission from Using Recyclable Plastic Bottle Recycling (Tonne)

	Recyclable Material in Manufacturing (tonne)
Energy saving (tonne)	15.42
Carbon Dioxide	1706675
Nitrogen Dioxide	-51.1

Source: Modified from McDougall et al. (2008)

The primary goal of this research is to determine the role of "scavengers" in waste collection and recycling at the landfill site. The objective of this study are identify the backgrounds of "scavengers", the composition of waste collected by "scavengers", and analyse the contribution activities of "scavengers" to the environment.

2. Method

This study was conducted at the Bukit Gemuk Landfill. The Tawau Municipal Council is in charge of the operation of the landfill. Tawau District grew as a city from a fishing village of about 200 people in 1892. In 1931, the population had grown to 1,840 people. This figure rose to 4,282 in 1951. According to census data, Tawau had a population of 361,473 people in 1992. Malay, Chinese, Bugis, Suluk, Tidung, Bajau, Bolongan, Java, Banjar, Butun, Kadazan, Murut, and Orang Sungai are among the ethnic groups that live in the area.

Immigrants from neighboring countries such as Indonesia and the Philippines majorly contribute to the area's population growth. Migration from the two countries only began in the 1970s due to the region's rapid economic growth. Civil war events in the southern Philippines in the 1970s are one of the reasons for the population's migration to Sabah, with Tawau being one of the target areas.

Tawau district has an area of 6,196.99 square kilometers or 619.699 hectares or acres 153,1309.58 and is bordered in the south by Kalimantan, Indonesia, and surrounded in the east by the Sulu Sea and the South Sulawesi Sea. The latest data on population, published on the Department of Statistics Malaysia's website, indicated that the total population of Tawau in 2018 was 506,700 people (DOSM, 2019). The area's high population density has contributed to solid waste generation. During the research period, a private company - Hasil Benua SDN-handled the waste collection operation.

The appointed private companies operate within the proportional area established by the local government. The company's operations and the landfill area are supervised by a municipal council health inspector. The Bukit Gemuk landfill is located 12 kilometers from the city center and operated in oil palm plantations. Our research location is shown in Figure 1.

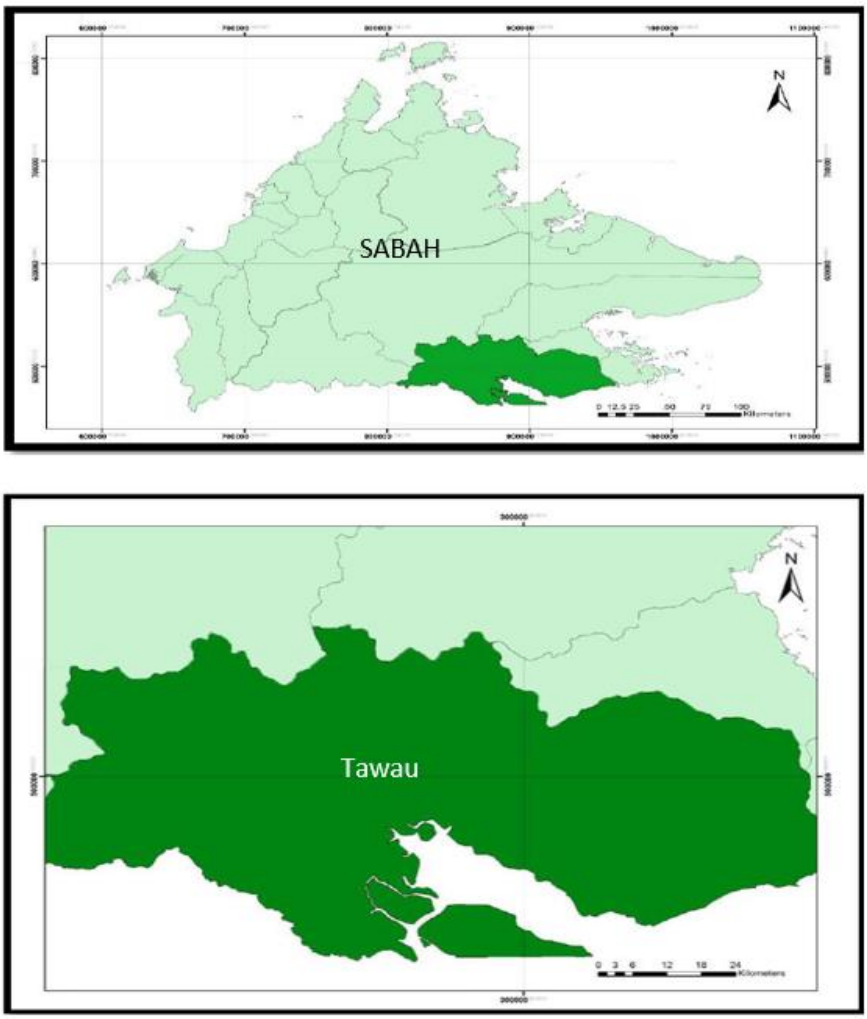

Figure 1. Research Location

The methodology aims to understand the methods used throughout the research process. This study used both questionnaire forms and interviews, while LCA (Life Cycle Assessment) analysis was used to assess the environmental impact of using recycled materials. The interview was used to assess respondents' attitudes, perceptions, views, and socioeconomic backgrounds. This method is simple and inexpensive, and it can help save time.

Aside from that, using an interview form makes it easier to gain cooperation from respondents. This study's sample comprised 46 people who work as "scavengers" in a landfill. The SPSS software was used in this study to obtain frequencies and perform cross-tabulation analyses. While the LCA analysis employs McDougall's model, it focuses on the contributions of recycling (McDougall et al., 2008). In this study, a LCA was undertaken to quantitatively investigate the environmental impacts of used recycled material in the manufacturing stage. In this analysis, two environmental contributions are used: energy savings and greenhouse gas emissions into the atmosphere.

3. Results and Discussion

Scavengers are a legitimate group, especially in developing countries, but local municipalities virtually ignore them formulating solid waste management policies (Kimbugwe & Ibitayo, 2014). This study shows that the majority of males (32 respondents) compared to females (14 respondents) are working as scavengers. The average age of the "scavengers" is 37 years, with the youngest at 20 years old and the oldest at 81 years old. The research also revealed that the majority of “scavengers” are not Malaysian citizens (60.9%), and only 39.1% are Malaysians. The study also discovered that four ethnic groups are actively involved in this activity: Bajau, Bugis, Suluk, and Bisaya. Bugis is the highest with 45.7 percent whilst the lowest is Bisaya at 6.5%. There are 32 individuals in the sample who are married (69.6%).

The overall number of scavengers in the landfill site was unknown in this study. The majority of them come to search for material that could be sold and then leave to return home. Most scavengers have stayed in the temporary shelter onsite with other families. The whole point of living in the landfill site is to make it easier for them to work without having to commute home every day. It is understood that around 2,000 families are estimated to live and work at Bantar Gebang, the largest landfill site in Jakarta (Hodal, 2017).

Furthermore, scavenging is often associated with those with a low level of education. The study found that 15 respondents (31%) never went to school. Whereas a total of 18 people (39%) have had primary education, and the rest have never obtained an education in secondary schools. Most of the scavengers are unskilled Java workers, some of whom have been scavenging their whole lives (Hodal, 2017).

The construction of a shelter on the site also shows that they rely heavily on this activity as a major source of income. It was found that 37 respondents were engaged in the activity on a full-time basis and a small number on a part-time basis. Despite the fact that they work full-time, their income remains uncertain. This study found that their monthly income is between RM100 and RM500 ($20-$100). But many of them have earnings between RM201 and RM300, and only a few of them can earn between RM400 and RM500 per month. Another study indicated that the total amount of recyclable materials recovered by scavengers is about 525 tons per month, which generates an income of US$ 30,875 per month (Asim et al., 2012).

Although many types of waste are disposed of onsite, this group only collects certain types of waste. Only four types of waste are collected: plastic bottles, aluminum cans, iron, and electric cables. There is a similarity in the type of waste collected at the Kayu Madang Kota Kinabalu landfill (Asis, Mapa, Suwardi, & Antie, 2013). These types are in high demand from recycling companies. A similar study also revealed that scavengers sell recyclables to contractors, which resell these to middlemen or recycling industries. Most of the recyclable

materials consist of various kinds of paper, cardboard, metal scrap, plastics, pet bottles, etc (Asim et al., 2012). In this study, the collected items are shown in Table 2.

Table 2. Types and Price of Recyclable Items

Type	Price
Plastic Bottle	RM 0.30/kg
Aluminium Can	RM 3.50/kg
Metal Can	RM 0.30/kg
Electric Cable	RM 14.00/kg

The primary reason for collecting recyclable materials is to earn money to support their family. This is an important survival strategy for disadvantaged populations throughout the developing world (Medina, 2000). Not only that, but their activities have significantly impacted the environment. Scavenging activities create more space in the landfill, allowing it to last longer. Recycling materials diverted from landfill sites also provide raw materials to the manufacturing industry. This will help reduce the demand for natural resources, preventing them from depleting. Not only that, but scavenging also saves the municipality's expenditures in sweeping, transporting, and disposing of waste (Asim et al., 2012). In some cases, increasing recycling will reduce almost 78.0% of waste management costs and 79.5% of landfill avoidance costs (Agunwamba, 2003).

A brief analysis was performed in this study to determine the contribution of recycled materials to the environment. The result of LCA is to improve the environmental performance of solid waste management strategies (Diaz & Warith, 2006). From the life cycle analysis, using recycled materials results in less energy consumption during manufacturing. In this study, with an average of 8,540 tonnes of plastic bottles and 8,795 tonnes of metal collected by "scavengers" in a landfill, the energy required to produce new material is only about 392 816 GJ. It means that for the same product, up to 250419.3 GJ of energy can be saved (see Table 3). Another study suggests that the environmental outcomes can be optimized by separately treating recyclates (Demetrious & Crossin, 2019).

Table 3. Comparison of Energy Saving Using Virgin and Recyclable Materials

Material	Energy Usage for Virgin Material (GJ)	Energy Usage for Recyclable Item (GJ)	Total Energy Saving
Plastic	348602	216916	131686.8
Metal	294632.5	175900	118732.5
Total	643235.3	392816	250419.3

As shown in Table 4, effective energy savings will have an impact on greenhouse gas reduction. The carbon dioxide and metal gas savings from recycled materials are 1457510g and 16534610g, respectively, and the amount of methane gas savings from metal is 78099600g. The landfill CH4 emissions in developed countries have largely stabilized, emissions in developing countries are increasing as more controlled (anaerobic) landfilling practices are implemented. These emissions could be reduced by accelerating the implementation of engineered gas recovery, increasing waste minimization, and recycling rates and implementing alternative waste management strategies that are affordable, effective, and sustainable (Bogner et al., 2008).

Table 4. Gas Reduction from Using Recyclable Materials

Material	Carbon Dioxide	Methane
Plastic Bottle	1457510	-
Metal	16534610	78099600

4. Conclusion

The waste problem is a phenomenon faced worldwide, including in Malaysia. The increase in solid waste is due to the increase in population every year. However, the presence of "scavengers" at landfills by separating waste such as plastic bottles, aluminum cans, steel cans, and wires helps authorities increase recycling rates. The results of this study have proven that the collection of waste for recycling purposes has benefited the environment. Recycling waste collection includes reducing the use of electricity and greenhouse gases. Their contribution to the environment is undeniable. Diverting waste from landfills and using it as a raw material in the manufacturing sector can save natural resources. When there is no formal waste segregation, this activity is mainly in the hands of the informal sector, where scavengers are the main stakeholders. A recommendation from this study is that since this group is not given the opportunity to work formally, the government's attention is needed since there are legal concerns regarding the scavengers' citizenship status and work permits. It can be improved if the government sector helps them by providing medical and health facilities and PPE. Living in landfills exposes them to toxic gases as well as safety and disease issues.

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