DEVELOPING A SUSTAINABLE SOLID WASTE MANAGEMENT SYSTEM USING ANALYTICAL HIERARCHY PROCESS (AHP) METHOD IN PONDOK INSTITUTIONS IN KELANTAN

by

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THESIS DECLARATION

I hereby declare that the work embodied in this Report is the result of the original research and has not been submitted for a higher degrees to any universities or institutions.

……………………………………………………………

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Date : 28 January 2021

I certify that the Report of this final year project entitled Developing a Sustainable Solid Waste management System Using Analytical Hierarchy Process (AHP) Method In Pondok Institutions In Kelantan by Siti Nur Solehah Binti Shaikh Azahari, matric number E17B0109 has been examined and all correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Sustainable Science) with Honors Faculty of Earth Science, University Malaysia of Kelantan.

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Developing a Sustainable Solid Waste Management System Using Analytical Hierarchy Process (AHP) Method in *Pondok* Institutions in Kelantan.

ABSTRACT

Solid waste management is not a new issue in Malaysia. Most of Malaysia's solid waste management sends their waste directly to dumpsite or landfill without any pre-treatment and proper control. This inappropriate technique has resulted in various negative impacts on the earth’s ecosystem. These issues are believed able overcome by implementing the reduction and separation of solid waste generated from the source, for example, the educational institution. These few years, educational institutions began to take proactive steps to work together in addressing this problem. However, most of them were focusing only on higher education institutions. Therefore, this research fills the gap by focusing on the *Pondok* institution. This research aimed 1) to determine the types of solid waste generated by *Pondok* institutions, and 2) to develop a sustainable solid waste management system at *Pondok* institutions using the Analytical Hierarchy Process (AHP) method. This research underlined three alternatives to solid waste management, which are composting, recycling, and both composting and recycling. This research utilized the convenience sampling method, where a constructive questionnaire was used as a research instrument. An online questionnaire with detailed descriptions was distributed to 15 *Pondok* institutions in Kelantan. After that, an empirical research using the AHP method was carried out to find the priority weights of alternatives to develop a sustainable solid waste management system in *Pondok* institution. There are two significant findings in this research. Firstly, this research revealed the types of solid waste generated by the community of *Pondok* institutions that are food waste/ farm waste, plastics, papers, metal & aluminium tin, also glass. The highest types of solid waste generated are organic waste, and the least is glass. Secondly, this research discovered the most appropriate sustainable solid waste management system alternative to be implemented in *Pondok* institutions, which is composting and recycling. Developing a sustainable solid waste management system will reduce excessive solid waste generation, reduce the use of space for dumping sites, and also overcome environmental problems caused by inefficient solid waste management system.

Pembangunan Sistem Pengurusan Sisa Pepejal Lestari Menggunakan Kaedah Proses Analisis Hierarki (AHP) di Institusi Pondok di Kelantan.

ABSTRAK

Di Malaysia, isu berkaitan pengurusan sisa pepejal bukanlah masalah baru. Kebanyakkan daripada pengurusan sisa pepejal di Malaysia melupuskan sisa pepejal mereka ke tapak pelupusan sampah tanpa menjalankan rawatan awal terlebih dahulu. Kaedah pengurusan yang tidak betul dan tidak efisien ini telah menyebabkan pelbagai impak negatif kepada ekosistem bumi. Isu ini dipercayai dapat diatasi dengan mengamalkan pengurangan dan pengasingan sisa pepejal daripada sumber, misalnya, daripada institusi pendidikan. Beberapa tahun kebelakangan ini, institusi-institusi pendidikan telah mula mengambil langkah proaktif untuk bekerjasama dalam menangani masalah ini. Namun, kebanyakannya hanya menumpukan pada institusi pengajian tinggi. Oleh itu, kajian ini memfokuskan pada institusi Pondok. Objektif kajian ini adalah untuk 1) menenentukan jenis sisa pepejal yang dihasilkan oleh komuniti Pondok, dan 2) menubuhkan sistem pengurusan sisa pepejal yang lestari di institusi Pondok menggunakan kaedah Proses Analisis Hierarki (AHP). Kajian ini telah mengariskan tiga alternatif utama untuk menguruskan sisa pepejal, iaitu kitar semula, kompos dan kitar semula berserta kompos. Kaedah persampelan yang digunakan dalam penyelidikan ini adalah kaedah persampelan kemudahan, di mana soal selidik konstruktif digunakan sebagai instrumen kajian. Soal selidik diatas talian dengan penerangan terperinci telah diedarkan ke 15 buah institusi Pondok di sekitar Kelantan. Setelah itu, kajian empirikal menggunakan kaedah AHP dilakukan untuk mencari berat prioriti dan keutamaan alternatif untuk pembangunan pengurusan sisa pepejal lestari di institusi Pondok. Terdapat dua penemuan utama dalam kajian ini. Pertama, jenis sisa pepejal yang dihasilkan oleh institusi Pondok dapat dikenal pasti, iaitu, terdiri daripada sisa makanan / sisa tanaman , kertas, plastik, logam / keluli / dan tin aluminium, dan kaca. Nilai sisa pepejal tertinggi adalah sisa organik, manakala, nilai terendah adalah gelas. Penemuan kedua bagi kajian ini menunjukkan kaedah alternatif yang paling sesuai bagi pengurusan sisa pepejal yang mampan untuk dilaksanakan di institusi Pondok iaitu kaedah kosmpos beserta kitar semula. Pembangunan sistem pengurusan sisa pepejal lestari di institusi Pondok akan menyumbang kepada pengurangan penghasilan sisa, memelihara sumber asli, pengurangan pembukaan kawasan untuk pelupusan sampah, serta dapat mengatasi masalah pencemaraan berpunca daripada sampah.

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LIST OF ABBREVIATIONS

ABC	Action Plan for a Beautiful and Clean Malaysia
AHP	Analytical Hierarchy Process
C	Composting
CI	Consistency Index
CR	Consistency Ratio
EI	Educational Institutions
GHSM	General Hierarchy Structural Model
IR	Index Random Consistency
MHLG	Ministry of Housing and Local Government
MSW	Municipal Solid Waste
NSP	National Strategic Plan
PI	*Pondok* Institutions
PPSPPA	Solid Waste Management and Public Cleansing Management Corporation
R	Recycle
SSWM	Sustainable Solid Waste Management
SSWMS	Sustainable Solid Waste Management System
SW	Solid Waste
SWM	Solid Waste Management
SWMS	Solid Waste Management System
Tonne/day	Tonne per day
UMK	University Malaysia of Kelantan
WH	Waste Hierarchy

LIST OF SYMBOLS

%	Percentage
°	Degree
ʻ	Minutes
λ	Lambda
×	Multiply
–	Subtract
∑	Sigma
n	Sample size
n	Matrix size
λmax	Eigenvector principles

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Human has been generating wastes since ancient times. Initially, the waste produced was just organic-based wastes which did not cause substantial environmental problems. However, with civilisation's progress, humans began to produce many non-environmentally friendly and toxic wastes, which has contributed to environmental impacts. The waste generated becomes more complex and diverse. The increase of solid waste (SW) generated has caused our environment degrading day by day. Moreover, rapid population growth, uncontrollable industrial development, and improper waste disposal techniques have made this situation worsen.

Malaysia's overall waste composition is delegated into 64% of municipal solid waste (MSW), 25% of industrial waste, 8% of commercial waste, and 3% of construction waste (Wahidah & Ghafar, 2020). Most of the wastes produced are biodegradable waste, such as food and paper (Anand, 2011). Furthermore, approximately 80% of the MSW is recyclables and disposed of in the landfill without any pre-treatment (Wahidah & Ghafar, 2020).

In 2006, the amount of municipal solid waste generated in the Kota Bharu, Kelantan is approximately 146.00 tonnes/day (Moh & Manaf, 2014). Meanwhile, in 2009, Kelantan has generated approximately 1423 tonnes/day of wastes, increasing by more than 90% every 10 years (Moh & Manaf, 2014). This waste was produced from various sources, namely, domestic, commercial, and private or public institutions. Moh & Manaf (2014), stated that primary sources of MSW are household, followed by the institutions and commercial area. The education institutions (EI) including the Islamic education institutions as known as the *Pondok* institution (PI), is part of the MSW contributors.

In the last few decades, education institutions, including PI, have faced challenges in executing sustainable solid waste management (SSWM) practices, where it has demanded environmentally friendly systems and practices (Anand, 2011). The implementation of SSWM practice is a daunting task because it encompasses all stakeholders, including students, staff, and surrounding people (Anand, 2011).

Various studies worldwide reported the implementation of the SSWM in EI. However, most of them were focusing on the execution of recycling and reducing resources programs. In addition, most of the studies conducted were focusing on the institution of higher education. Hence, the *Pondok* institutions has been focused on this research. This research's major aim is to develop a Sustainable Solid Waste Management System (SSWMS) in *Pondok* institutions in Kelantan. Therefore, an Analytical Hierarchy Process technique has been applied to select the best and appropriate SSWMS for *Pondok* institutions.

1.2 Problem Statement

The ineffective solid waste management (SWM) is inevitable because of improper systems that practiced on the ground. Most institutions send their waste directly to landfill without any pre-treatment and proper control (Wahidah & Ghafar, 2020). This has resulted in various negative impacts on the earth's ecosystem. In a developing country like Malaysia, the issues regarding SWM are crucial, since the solid waste (SW) generated continues to grow in line with the growth of the economy, human population, and development.

Present SWM in Kelantan is implemented in an unsustainable way. Kamaruddin et al., (2016) reported, 11 active dumping sites and no sanitary landfills currently operating in Kelantan. These dumping sites are considered non-engineered landfills and managed in a non-appropriate method (Kamaruddin et al., 2016).

The weak waste management institutional capacity with a lack of resources and funding resulting in huge quantities of waste is generated daily being managed inefficiently. Besides, the unsustainable SWM that is indirectly polluting the surrounding areas worsens these conditions. This issue has caused much pressure on the local authority and the community. The sustainable solid waste management system (SSWMS) that is time-consuming, requires a massive amount of energy and money, causing it to become the least choice among Malaysian. The inefficient system implemented has resulted in waste disposal in unauthorized places, and resulted in the presence of an unsightly and unsanitary environment in some areas.

Therefore, this research was conducted to overcome the inefficient SSWMS implemented, particularly in Kelantan. The reduction and separation of SW from the source can help in combating this issue. Consequently, a SSWMS will be developed in the *Pondok* Institutions, utilizing an Analytical Hierarchy Process (AHP) method. This method was utilized to select the best sustainable SWM alternatives that are effective, efficient, and appropriate for the education institutions' environment.

1.3 Objectives

The objectives of this research are designed as follows;

i. To determine the types of solid waste generated by the community of *Pondok* institutions.

ii. To develop a sustainable solid waste management system at *Pondok* institutions using Analytical Hierarchy Process method.

1.4 Scope of Study

This research was conducted to develop a sustainable solid waste management system at *Pondok* institutions in Kelantan. The technique adopted in this research was a multi-criteria technique, utilizing the convenience sampling technique. An online survey technique using Google form was used as the research instrument. The online questionnaire was distributed to 15 *Pondok* institutions in Kelantan thru online platforms such as email, Facebook, WhatsApp, websites, and Telegram.

The questionnaire was constructed utilizing an Analytical Hierarchy Process technique. The questionnaire is consists of four sections that is 1) respondent's demographics and types of solid waste generated in *Pondok* institution, 2) Pairwise Comparison between Criteria and Goal, 3) Pairwise Comparison between Criteria and Sub criteria, and 4) Pairwise Comparison between Alternatives and Criteria. The validity test utilizing the content validation test technique was conducted by expert lecturers from University Malaysia of Kelantan to ensure the questionnaire is unbiased and qualified to be used before distributed to the respondents. After that, the questionnaire was distributed to 15 *Pondok* institutions with an estimated population of 3000 persons and 341 sample size. However, the number of respondents obtained was less than the targeted amount which is 105 persons only. Nevertheless according to the rules of thumb it is still under acceptance values. Due to some limitations, the analysis of data has proceeded with 105 respondents.

The data were analysed using the Analytical Hierarchy Process method, utilizing the Microsoft Excel application. In this research, the respondents' demographics and types of solid waste generated in the *Pondok* institutions were determined. Furthermore, the comparison of the criteria has been done to analyse the best SWM method. Three types of alternatives used in this research that is composting, recycling, and both composting and recycling.

1.5 Significance of the Study

The development of a sustainable solid waste management system (SSWMS) in *Pondok* institutions will help the *Pondok* community to respond to the government's call for a more sustainable lifestyle. The idea of living a green lifestyle is a profitable living, where, people can gain money from the waste generated, reduce the generation of excessive solid waste, conserve the natural resources, reduce the use of space for dumping sites or waste treatment plants, and overcome the inefficient solid waste management system (SWMS) in that area.

Having said about sustainable living, it is known that environmental treatments require a high cost of money and investments. The disposal and management of waste is not a free process and the burden will be bared by the community and city municipalities. Thus, the development of a SSWMS in educational institutions will help reduce pollution and other environmental problems caused by the present inefficient SWMS implemented in the first place. Early prevention might help to reduce the percentage of pollution generated.

This research will help to reduce the generation of waste from sources. Knowing a proper method to manage SWM could help to prevent pollution issues in the environment as well as improve public health. Moreover, the reduction of waste will reduce amounts of waste to be sent to landfills, and it will help the government to reduce the opening of new waste disposal sites. Thus, the land can be used for other purposes such as for residential areas or agricultural areas, which are less risky and generate more benefits for the government and the community.

Besides, the development of proper waste management in the *Pondok* area may become one of the financial incomes to the *Pondok* institution, the agricultural sector also the recycling sector. Biodegradable waste could be turned into compost and sold to farmers, while non-biodegradable waste such as plastics, and papers could be sold to the recycling centre. The benefits of the development will be felt by all stakeholder.

In this research, the present SWMS implemented and types of waste generated by the PI were analysed. The information obtained will be beneficial for future studies on SWM in *Pondok* institution. This research can be one of the scientific references for researchers out there, as well as the educational institutions. The educational institutions can use the information as their guidelines to develop a SSWMS in their institution.

1.6 Limitation of the Study

This research has a few limitations due to uncontrollable circumstances. Firstly, the number of respondents obtained does not reach the expected number of the sample size. This happened due to almost half of the *Pondok* institutions (PI) approached were closed due to the spread of infectious disease, coronavirus disease (COVID-19). The COVID-19 issues have caused many of the PI to close. Besides, some of the PI that still operates, but nevertheless have limitations on the facilities and internet coverage, and requested for a face-to-face survey. However, the Movement Control Order (MCO) resulted from the COVID-19 issues has caused limited movement and no face-to-face survey was allowed to the *Pondok* institutions.

Apart from that, the limitation of time to run the survey also contributed to the limited number of respondents. There are also some limitations with the facilities from the *Pondok* community, where most of the students and staff there does not have enough access to the internet. Students are not allowed to bring smartphones, and some of the PI (especially those in rural areas) have limitations with the facilities and internet coverage, causing them unable to answer the questionnaire given. In addition, some of the *Pondok* people (especially the elderly) are technologically illiterate. Therefore, the above limitations have contributed to the total of respondents attained less than the minimum proposal for data analysis. Another limitation is that the respondents are not familiar with the online survey technique and the AHP methods. The application of the AHP method which resulted in long and repetitive types of questions causes the respondents unwilling to complete the survey.

CHAPTER 2

LITERATURE REVIEW

2.1 Solid Waste

Solid waste (SW) generally refers to waste that is neither liquid nor gas (Anuar, 2019), that is discharged or deposited in the environment. In urban areas, SW is consists of construction and demolition debris, commercial wastes, institutional wastes, industrial wastes, and clinical wastes (Tchobanoglous et al., 1993). The composition of SW may be different from one place to another. Many factors contributed to this, for example, the climatic conditions, waste collection and disposal method, also socio-economics of the residents (Tchobanoglous et al., 1993).

In developing countries like Malaysia, increasing living standards have enhanced the generation of SW. Most of the waste produced in developing countries is highly biodegradable waste compare to paper, metal, and glass (Anand, 2011). However, its compositions are different depending on the activities held in that particular area.

According to a research conducted by Kamaruddin et al. (2016), approximately 990 tonnes/day of SW, mainly Municipal Solid Waste (MSW) being disposed of at 11 Kelantan's actives dumping sites (**Table 2.1**). In Kelantan, the highest amount of

MSW disposed of is in the Kota Bharu district (capital district of Kelantan) with 350 tonnes/day and followed by Tumpat and Pasir Mas which are 120 tonnes/day (Kamaruddin et al., 2016). The population growth in Kota Bharu is 468,438, while for Tumpat is 104,234 followed by Pasir Mas with 86,189 persons (Kamaruddin et al., 2016). The waste generation is considered has a linear relationship with the growth of population since Kota Bharu is a developed city there.

Table 2.1 Dumping sites in Kelantan, Malaysia.

District	Dumping site	Area (ha)	Landfill classification	Daily incoming waste (Tonnes/day, TPD)
Pasir Puteh	Bukit Gedombak	9.70	Non-engineered	64
Bachok	Kg. Sungai Gali	4.49	Non-engineered	20
Kota Bharu	Telok Kitang	32.0	Non-engineered	280
	Panji	4.05		90
	Beris Lalang*	30.5		350
Jeli	Batu	0.5	Non-engineered	N.A
	Kg. Sungai Mekong	0.81		10
Kuala Krai	Damar	0.81	Non-engineered	5
	Bukit Akil*	4.05		20
Tanah Merah	Chat Rimau	4.90	Non-engineered	20
	Bukit Che Ros	5.00	Non-engineered	50
Dabong	Kg. Sungai Sam	4.50	Non-engineered	16
	Kemubu – Dabong	0.50	Non-engineered	5
	Jalan Kuala Krai – Gua Musang	0.20	Non-engineered	2
	Jalan Dabong - Sungai Sam	3.65		9
Ketereh	Bukit Pak Ajil	2.90	Non-engineered	70
Machang	Air Belaga	4.04	Non-engineered	100
Tumpat	Kg. Kok Bedollah	20.23	Non-engineered	120
Pasir Mas	Kg. Pusu	4.45	Non-engineered	120
Gua Musang	Renok*	32.0	Non-engineered	40

(Source: Kamaruddin et al., 2016)

In 2016, Kamaruddin et al. reported that the total amount of SW generated in Kelantan, particularly in Kota Bharu, Gua Musang, and Kuala Krai is comprised of 0.4 to 14.84 % of leather, rubber, wood, garden wastes, plastics (film and rigid), napkins, and textiles (**Figure 2.1**). Meanwhile, the major composition founded is organics, paper, and tetrapak, where, the range of the organic components was 28 % to 43 % of the total amount of SW generated and prevailed for all of the three research areas (Kamaruddin et al., 2016). In addition, Kamaruddin et al. (2016) also reported that Kota Bharu residents have produced the least amount of organic waste compared to Gua Musang and Kuala Krai, which is 33.13 %.

	Food/ Organic	paper	Tetrapak	Plastics film	Plastics rigid	Napkins	Textiles	Rubber	Leather	Wood Garden	Glass	Metal	House hold hazardous waste	Others
Beris Lalang	33.13	22.01	12.26	8.49	8.4	4.36	2.95	2.22	2.07	1.14	0.74	0.74	0.37	0
Bukit Akil	42.86	12.48	11.53	4.01	6.22	8.26	4.01	5.56	1.07	1.86	0.41	0.91	0	0.29
Renok	27.94	18.28	12.52	3.24	14.84	2.45	4.08	7.07	0.84	1.13	1.41	1.41	1.13	0

Beris Lalang Bukit Akil Renok

Figure 2.1 Waste composition for three landfills in Kelantan (Kota Bharu, Gua Musang, and Kuala Krai districts) in 2016.

(Source: Kamaruddin et al., 2016)

2.2 Solid Waste Management in Malaysia

Solid Waste Management (SWM) is a key component of sustainable managerial practices. Tchobanoglous et al. (1993) defined solid waste management as a discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid waste.

In Malaysia, solid waste management is under the administration of the Ministry of Housing and Local Government (MHLG). Malaysia's waste management is conceptualized under the Solid Waste and Public Cleansing Management Act 2007 (Act 672) (Anuar, 2019). This Act was established under Malaysia Solid Waste Management and Public Cleansing Management Corporation (PPSPPA), and functions as a guideline for solid waste management in Malaysia (Anuar, 2019; Sreenivasan et al., 2012). The policy and Act have been used as one of the tools to achieve efficient SWM in Malaysia (Sreenivasan et al., 2012).

The enforcement of Act 672 has been started on April 1 2011 in Peninsular Malaysia. However, this Act is still not wholly practiced by all states in Malaysia (Anuar, 2019). Among the states involves in practicing this Act are Perlis, Kedah, Kuala Lumpur, Putrajaya, Pahang, Negeri Sembilan, Melaka, and Johor.

According to the Ninth Malaysia Plan (2006-2010) report, total SW generated in Peninsular Malaysia has increased from 16,200 tonnes per day in 2001 to 19,100 tonnes per day in 2005 (Sreenivasan et al., 2012). In addition, in 2008, the MHLG has estimated that this amount will increase to 23,000 tonnes in 2010 and increase up to 30,000 tonnes a day by 2020. Apart from that, Wahidah and Ghafar (2020) stated in their research that the estimation of SW generated in 2020 will be more than 30,000 tonnes daily in Peninsular Malaysia.

On average, Malaysians generate approximately 0.8 kilograms of solid waste per day with an increase of 2.5% per annum (Anuar, 2019). These solid residues include domestic wastes, public wastes, institutional wastes, imported wastes, commercial waste also industrial wastes (Anuar, 2019). A statistic released by the PPSPPA in 2008 reported that approximately 1.8 million tonnes of domestic waste generated in Kuala Lumpur and Selangor, and it rose up to 1.9 million tonnes in 2009 (Anuar, 2019).

In 1993, Tchobanoglous et al. stated that SWM is one of the major global issues, especially in developing countries, including Malaysia. This is because, the rapid growth of the country which has improper utilization of energy, resources, and waste that does not manage efficiently (Tchobanoglous et al., 1993). Additionally, the implementation of landfilling without any pre-treatment method resulting in Malaysia to face various environmental problems. However, these years, the government has started to execute SWM initiatives to overcome these issues.

These few years, educational institutions also started practicing proper waste management (Smyth et al., 2010). Educational institutions, for instance, universities, pre-schools, child-care, primary-elementary, and secondary schools, are contemplated as part of the communities that impact surrounding areas (Taghizadeh et al., 2012). Implementing the sustainable solid waste management system (SSWMS) in these institutions can informally help educate the students to implement SSWM practices from the beginning (Armijo et al., 2008) and bring back this knowledge to their home. Indirectly, this method will help disseminate further information about SWM to local communities and students' families, particularly (Armijo et al., 2008).

Abas (2018) reported that various programs related to the SSWM have been executed in Malaysia's higher EI, and most of it is focusing on recycling and reducing resources programs. In addition, there are increasing numbers of EI that have adopted the zero-waste policy and recycling programs worldwide (Armijo et al., 2008).

A lot of research shows that educational institutions especially schools and universities plays a vital role in promoting sustainable practices in society (Zilahy and Huisingh, 2009; Ferrer et al., 2009). For instance, Elizabeth et al. (2016) have conducted a Waste Management Program at University Technological de Leon in Mexico. The program implemented has offered services to the whole university by collecting and separating the wastes. In 2008, Armijo et al. has conducted a research to evaluate the Recycling Potential at the Autonomous University of Baja California in Mexico. The research aimed to evaluate the generation of waste from three sources that are a community centre, buildings, and gardens. The research shows that the daily generation of waste was 1 tonne/day, which consists of 32% recyclable material, 34% potentially recyclable material, and 34% non-recyclable waste.

2.3 The Issues and Impacts of Inefficient Solid Waste Management System

Inefficient solid waste management system (SWMS) practices are one of the major issues worldwide. In 2016, Kamaruddin et al. reported that there are 11 active dumping sites currently operating in Kelantan, however, most of them were managed inappropriately. The management was impoverished, where there is no daily data on incoming waste for disposal, no proper environmental pollution control, where no daily cover materials, bed liner, and leachate drain for leachate collection (Kamaruddin et al., 2016).

This problem may contribute to major environmental risks, such as water, groundwater, and soil pollution (Kamaruddin et al., 2016). Numerous environmental problems occurred due to inefficient waste handling and lack of appropriate disposal facilities and equipment (Olukanni & Adeleke, 2016). Furthermore, the inadequate knowledge and expertise, lack of sufficient funds and labour, unorganized institutional functions, and low regulations and laws enforcement in solid waste management (SWM) also contribute to this issue (Olukanni & Adeleke, 2016).

Even though Malaysia has a good and growing economy, it is still backward in SWM (MHLG, 1988). Malaysia does facing inefficient systems issues, lack of expertise, financial difficulty, and non-compliance with the rules stated (MHLG, 1988). The SWMS implemented has caused the environment degraded and polluted, also contributed to global problems, such as climate change, degradation of natural resources, and habitat loss (Sreenivasan et al., 2012).

Oketola & Akpotu (2015) reported that the inefficient SWMS exposed to physical, chemical, and biological processes. These wastes have to degraded and accumulated huge amounts of xenobiotic organic compounds, metals, dissolved organics, inorganic salts, ammonia, and other toxicants in the soil and groundwater (Kanmani & Gandhimathi, 2013). The mixing of wastes in dumpsite has produced leachate and methane gas that are harmful to humans and the environment (Oketola & Akpotu, 2015). When these chemicals exceed the standard, it can pose a health risk to the ecosystem.

An inefficient SWMS also contributes to the outbreaks of infectious diseases caused by pests such as flies, cockroaches, and rats. Furthermore, it may also negatively affect the aesthetics values and socio-economic development of that area

(Zurbrügg & Ingegneria, 2013). An inefficient system is more likely to encounter degradation in natural resources, pollutions, fire hazards, odour issues, and harmful effects on human health (Olukanni & Adeleke, 2016).

2.4 Factors Influencing the Solid Waste Management System

In developing a sustainable solid waste management system (SSWMS), various factors will influence the development of the system. Five factors were considered in this research, that are the environmental aspect, social aspect, technical aspect, economic aspect, and administrative aspect (Armi et al., 2010; Zurbrügg & Ingegneria, 2013; Batagarawa et al., 2015; Aris, 2020).

2.4.1 Environmental Aspect

The environmental aspect (EAS) is the mechanism, operation, facilities, or goods that have an effect on the environment directly or indirectly (Zurbrügg et al., 2012). The entire cycle of operations, begin from the collection of raw materials on the generation of product will be included in recognising environmental aspects, and its effect on the ecosystem is a significant step to recognize (Zurbrügg et al., 2012). In order to determine the environmental aspect and impact, it is important to list the inventory of all activities and identify the release of the substance from each activity (Zurbrügg et al., 2012). The possible effects on the ecosystem and communities, pollution into the air, water, or ground, the infrastructure used, the use or production of chemicals, and natural resources, are generally included in this aspect.

The EAS indicator is the compliance with the environmental legislation, limitations of the waste generation and emissions (dependant on the size of the system), the efficiency of the natural resources, and energy consumption (Zurbrügg et al., 2012). When the emission generates surpass the limits, the actions taken by the owner are critical in this aspect, whether they reduce and carefully manage the waste produced or vice versa. In addition, evaluate the effects of health care programs and health security at the staff level is also crucial.

The EAS involves management and environmental preservation against emissions of pollution or residuals (Zurbrügg & Ingegneria, 2013). This factor involved in ensuring compliance with the pollution credited by the project and encourages pollution reductions by use of alternatives (Zurbrügg & Ingegneria, 2013).

2.4.2 Social Aspect

Social aspects (SA) are an essential aspect to be considered since waste generated and management systems are interrelated with resource consumption, socio-economic, and human lifestyle (Armi et al., 2010; Batagarawa et al., 2015; Aris, 2020). The SA is crucial in all phases of the SWM (Theses & Troschinetz, 2005). It plays a vital role in resulting in a positive or negative impact on the SSWM project (Theses & Troschinetz, 2005). SA can result in collaboration, motivation, acceptance, influence, and community interest in a project (Theses & Troschinetz, 2005).

Zurbrügg et al. (2012) stated that the indicators of the SA are the level of social commitment, level of social and institutional acceptance or support, level of social demand, level of social interaction, and the level of social inclusion. In addition, its elements include the stakeholder's involvement, social inclusion and acceptance, health, source quality, and social equity (Theses & Troschinetz, 2005; Zurbrügg & Ingegneria, 2013).

2.4.3 Technical Aspect

Technical aspect (TA) involves appropriate technology and facilities, physical conditions, technical infrastructure, availability of know-how, skill to handle the technology and operation, also management-related factors (IAEA, 1999; Theses & Troschinetz, 2005). Zurbrügg & Ingegneria (2013) stated that TA does not have a site-specific perspective yet it is dependent on the requirements of technology and facility on that place.

The local expertise for system design, installation, and level of skills for system management and maintenance is a predictor for this aspect (Zurbrügg et al., 2012). Technologies that have a long life, small-scale local development & low transportation dependency, robustness, reparability, replicability, and low lifetime costs are valuable elements in the TA (IAEA, 1999; Theses & Troschinetz, 2005; Zurbrügg & Ingegneria, 2013).

The technologies used to build a SSWMS should be consistent with the forms of waste and the requirements of the environment. Usage of environmentally sustainable technologies would minimize waste production (where it could reduce repair and disposal costs) and indirectly contribute to high productivity and efficiency of work. Zurbrügg & Ingegneria (2013), claimed that the characteristics of suitable technology are low investment costs per production device, organizational simplicity, high adaptability, and sparing use of the natural resources.

2.4.4 Economical Aspect

Economic aspects (EA) include human resources costs, inflation, also the overall cost which are, operational costs, repair costs, shipping costs, equipment costs, building costs, and early investment (Theses & Troschinetz, 2005; Zurbrügg & Ingegneria, 2013). EA includes potential job creation (human resources costs), markets, and prices. The overall cost of device implementation will require the cost of all procedures, from waste management to the final steps in the alternatives, inspection costs, mitigation costs (if any contamination happens), training costs for staff, and licensing costs (if necessary). The cost of human capital, is dependent on the types of work conducted, job scope, or expertise which may resulted in different costs.

Due to the lack of funding sources, the finances are seen as one of the main restrictions in the production of an SSWMS (Theses & Troschinetz, 2005). Therefore, financial assistance and investment may be a huge incentive to operate the SSWMS by direct financial support, elimination in taxes or bills, also facility improvement (Zurbrügg & Ingegneria, 2013).

2.4.5 Administrative Aspect

This aspect involves the groups responsible for maintaining and carrying out the system (Zurbrügg et al., 2012). In the process of developing a SSWMS, effective and efficient management, system supervision, mission accomplishment, program complementation, and implementation of rules and laws are vital (Theses & Troschinetz, 2005; Zurbrügg & Ingegneria, 2013). The excellent administration is key to ensuring the success of goals. A SWMS needs the strong policies and regulations that help to accomplish the goals (Sharifah et al., 2013; Abdullah & Jalil, 2016).

Effective administration is important and acts as one of the main foundations of SWM (Abdullah & Jalil, 2016). Good management would ensure the quality of waste generation, storage, recycling, and disposal. In addition, the site selection for systems should also consider few items such as it does not disturb main road traffic and readily accessible for waste collection (Abdullah & Jalil, 2016).

Besides, laws and regulations that will be established also help increase the efficacy of the SWMS (Abdullah & Jalil, 2016). For example, the ban of combining non-biodegradable waste with biodegradable waste, the proper categorization of waste, and the implementation of regulations should be strictly implemented, and a clear and straightforward system should be applied (Sharifah et al., 2013; Abdullah & Jalil, 2016). According to Abdullah & Jalil (2016), a scheme of a compound for individuals that break the laws and regulations shall be included in the legislation. For instance, any worker who combines non-biodegradable waste with biodegradable solid waste should be penalized. This action would improve the productivity of management and indirectly discourage them from repeating the error.

2.5 Sustainable Solid Waste Management System and Its Alternatives

In these few years, Malaysia has taken various initiatives to cope with the ineffective SWMS problems. In 1988, the Ministry of Housing and Local Government (MHLG) has established a National Action Plan known as Action Plan for a Beautiful and Clean Malaysia (ABC) (Sreenivasan et al., 2012). Furthermore, Malaysia has also initiated the National Recycling Program in 2000 and released the National Strategic Plan (NSP) for SWM in 2005 (Sreenivasan et al., 2012). The NSP was established in the Ninth Malaysia Plan and has been introduced based on the Waste Hierarchy which prioritizes waste reduction, transitional treatment, and final disposal by providing inclusive and systematized services (Sreenivasan et al., 2012).

Numerous effective SWM practices have been established to combat the inefficient solid waste management system (SWMS) issue. Diverse efforts have been done to reorient the SWMS towards sustainability, locally and globally. For example, in Asian regions, the 3Rs (reduce, reuse, and recycle) program is one of the initiatives methods that has been widely implemented (Sreenivasan et al., 2012). The implementation of appropriate techniques dependent on the waste characteristic, waste composition, types of waste, facilities, and infrastructure, location, land availability, economy, labour, the calorific value of waste, demand, environmental impact, also energy availability (Theses & Troschinetz, 2005; Armi et al., 2010).

The development of a SSWMS aimed to improve the present SWM towards more sustainable practices and indirectly will improve the economy, society, and environment (Abas, 2018). SSWMS will reduce poverty and environmental depletion, reducing mortality and percentage of disease, reduce the needs for landfilling, and reduce the emission of greenhouse gases which contributes to climate changes, also prevents the generation of waste from the first place (Armi et al., 2010; Kumar, 2011).

Studies by Sreenivasan et al. (2012) reported that there are various SWM concepts that have been established, for instance, the integrated solid waste management, waste minimization approach, zero waste concept, and waste hierarchy (WH). Therefore, this research focused on the WH concept, where it encourages a cyclical approach and no disposal of waste, and it has set waste reduction and separation as the most preferred elements (Sreenivasan et al., 2012). This concept also feasible to be implemented in the education institution sector (Abas, 2018). The WH was ranked in descending order as follows; elimination, reuse, recycling, composting, incineration, and disposal (Sreenivasan et al., 2012). In this research, there are three considered alternatives which are composting, recycling, and both composting and recycling.

2.5.1 Composting

Composting is a biological mechanism where food waste is converted into organic matter that is renewable and rich in nutrients (Barbara, 2008). Organic materials such as crop residues, animal waste, food waste, and other organic waste are ideal for composting (Barbara, 2008). Composting is a relatively slow process created by combining suitable volumes of organic material with carbon and nitrogen.

Composting is one of the highest potential alternatives for SSWM practices in educational institutions (EI) (Mbuligwe, 2002). Mbuligwe (2002) in his research reported that the composition of organic waste in the institutional sector is very high (especially in residential areas), where approximately 40% to 50% of the total waste produced comes from organic wastes. In his research, Mbuligwe (2002) has compared waste composition from three universities and all of them show the result for the amount of organic waste weight exceed 50%. Various benefits can be gained from implementation of composting, for instance, it helps improve the nutrients of the soil, generate money, save water use, and reduce run-off (McDough, 2005).

2.5.2 Recycling

Recycling is a waste gathered to create new goods that can support the community and the environment. The Jibril et al. (2012) and SLWP (2020) acknowledged that recycling leads to the saving of energy, protect natural resources, reduce waste disposed of by landfills, reduce the production of greenhouse gases and water contaminants, and also improves the productivity of manufacturing. It is an asset for both natural and economic purposes. It involves recycling unwanted goods, storing and refining recyclable products into raw materials, and remanufacturing them into new products (Jibril et al., 2012).

Recycling is one of the 6R's of sustainability which includes rethinking, refuse, reduce, reuse, repair, and recycle (Saara, 2013). Rethink or reinvent involves reconsidering and re-questions the consumption habits (Saara, 2013). This process causes people to become more aware of their actions and their effects on the environment. Next is refuse, where it involves refusing to consume processes (Saara, 2013). An individual may decide to choose an item that contributes higher benefits to humans and the environment rather than the items that contribute more wastes and harmful to the environment. Thirdly, reduce involves a process to reduce the amounts of waste generated by reducing the amounts of toxins, wastes, and materials to be sent to dumpsites (Saara, 2013). For instance, by reducing impulse shopping, buy refillable or reusable items, and avoid single-serving sizes product. Subsequently, the reuse and repair aim to expand the shelf-lives of the products (Saara, 2013). Finally is recycle, which involves the reclamation of raw materials.

In an educational institution, the generation of recyclable waste is very high (Mbuligwe, 2002). Approximately 50% to 60% of the waste generated in EI comes from bottles, papers, and tins (Mbuligwe, 2002). Thus, adopting recycling is very promising to reduce the percentage of waste generated in the educational institutions (Mbuligwe, 2002). Mbuligwe (2002) reported in his research that, the office and halls of residence produce significant quantities of paper in educational institutions, so the separation of waste from these areas for recycling or direct reuse are very important and profitable (Mbuligwe, 2002).

2.5.3 Composting and Recycling

SLWP (2020) stated that it is important to implement recycling and composting since both aims to minimize the flow of garbage to landfills or dumpsites. The implementation of both recycling and composting will help conserve raw materials, where recycling processes will reduce the consumption of natural resources, and composting will reduce the waste of natural resources (SLWP, 2020). This will helps to protect raw materials and natural habitats from being used uncontrollably. Besides, recycling and composting contribute to saving energy. The use of recycled materials in the manufacturing process uses less energy than that required for producing new products from raw materials, meanwhile, composting may generate energy by release methane gas during the decomposition process, this methane gas is also known as biogas which can be burned to produce energy (Sreenivasan et al., 2012; SLWP, 2020).

Composting and recycling also contribute to protecting the environment by reducing the need to extract, refining, and process raw materials (SLWP, 2020). Apart from that, it also reduces greenhouse gas emissions, which contributes greatly in tackle climate change (Sreenivasan et al., 2012). It also contributes to saving money and the reduction of waste from the sources (Sreenivasan et al., 2012; SLWP, 2020).

A research by Armi et al. (2010) reported that recycling and composting is the most suitable method for solid waste treatment processes in Sepang municipal solid waste treatment technology. In addition, Mbuligwe (2002) also reported that composting combined with recycling could theoretically reduce the amount of institutional solid waste by between 71% and 86% of institutional waste. This offers an appropriate future saving in landfill space as well as in the expense of collection and transportation (Mbuligwe, 2002).

CHAPTER 3

MATERIALS AND METHODS

3.1 Research Area

The research area for this research is Kelantan, which located in the northeast of Peninsular Malaysia (**Figure 3.1**). Kelantan is bordered by Terengganu, Pahang, and Perak. The geographical coordinates for the research area are latitudes 4° 30' - 6° 5' North and longitude 101° - 102°45' East. Kelantan is managed by ten administrative jurisdictions that are Kota Bharu, Pasir Mas, Tumpat, Pasir Puteh, Bachok, Kuala Krai, Machang, Tanah Merah, Jeli, and Gua Musang. Each district has at least one *Pondok* institution.

There is a lack of detailed statistics on the population of *Pondok* institutions due to a lack of systematic research on this organization. However, Fathil et al. (2017), have stated that in the state of Kedah, Kelantan, and Terengganu, there are approximately 250 to 300 *Pondok* institutions, and the total population of these institutions are approximately 15,000 students and 900 to 1000 teachers (Fathil et al., 2017). In this research, 15 *Pondok* institutions were involved. The establishment of *Pondok* institutions usually consists of mosques and residence areas (hostels and the warden houses) (Mohd & Osman, 2013; Fathil et al., 2017).

The *Pondok* education is split into two; modern education and the traditional system. The modern system is focusing on both religious education and secular subjects, such as, algebra, sciences, and languages (Fathil et al., 2017). This type of *Pondok* is growing nowadays and it has a more condensed teaching and learning atmosphere in terms of facilities for both students and staff (Fathil et al., 2017). Meanwhile, the traditional system focuses only on religious research and consists of various layers of generation starting from teenagers to the elderly (Fathil et al., 2017).

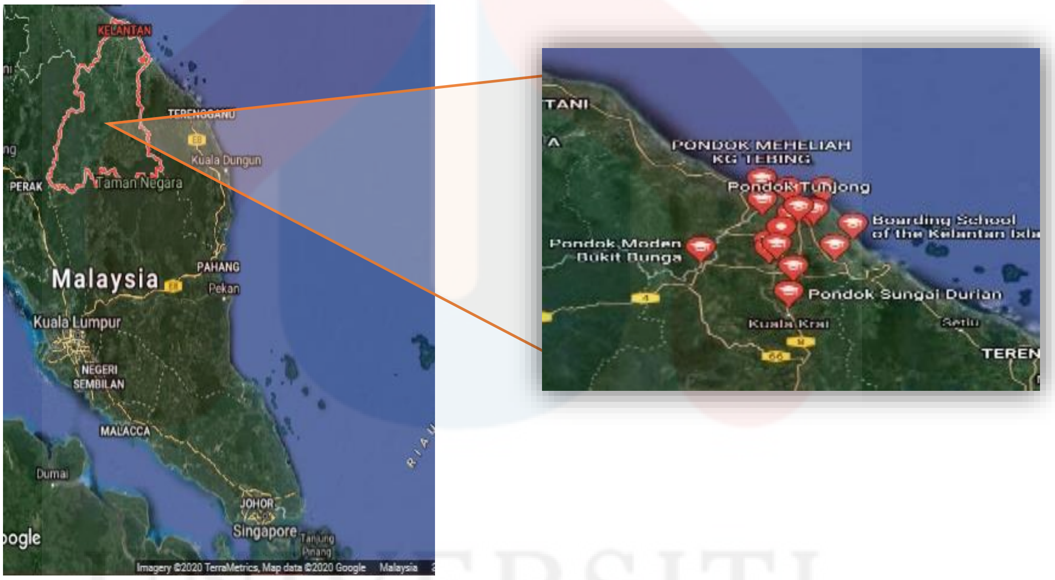

Figure 3.1 Maps of state of Kelantan in Peninsular Malaysia (Source: Google Maps, 2020)

Kelantan was chosen due to its wide area and encompassing different levels of society. It also recognized as a centre of excellence for Islamic studies, and the PI is one of the important educational institutions here. Having a vast area with a large population contributes to a large and varied generation of wastes. In Kelantan, *Pondok* institutions is very close to its surrounding community, the inappropriate SSWMS implemented will contribute a significant impact and risking the population in that area. Therefore, the selection of this research area is very suitable as a benchmark to determine the most SSWMS for *Pondok* institutions.

3.2 Research Instrument

A structured questionnaire was used as a research tool in this research. This research adopted a self-administered questionnaire, where respondents will complete the questionnaires themselves. Since the questionnaire was distributed to various layers of the community, the language used is the Malay language. This is because some of the respondents do not have a basis in English. Hence, simple Malay sentences were used in the questionnaire to help the respondents understand the question easily. For the types of questions, most of the questions created were in the close-ended questions, and some were in the open-ended questions. The questionnaire form was adapted and adopted from a few studies by Samah et al. (2011), and Aris (2020).

The questionnaire contained details on respondents' background and pairwise comparison from each phase of the General Hierarchy Structural Model. It is consists of four sections, that is Section A; Socio-economic profile of respondent and types of wastes generated daily, Section B; Pairwise Comparison between Criteria and Goal, and Section C; Pairwise Comparison between Criteria and Sub criteria, and lastly is Section D; Pairwise Comparison between Alternatives and Criteria.

Section A is consists of two segments that is the respondent's demographic, and the type of solid waste generated daily in the institution. Basic questions about types and amount of solid waste generated in the *Pondok* institutions were asked in the questionnaire. Section B is the pairwise comparison segments consist of the criteria to goal elements. Five criteria were considered for the development of a SSWMS.

Subsequently, Section C is a pairwise comparison between sub criteria and criteria, and eleven criteria have been included in this research. Finally is Section D, which includes a pairwise comparison between alternatives and sub criteria. Three alternatives were considered which are composting, recycling, and recycling and composting.

The scale ranges used for pairwise comparison values were referred to the Saaty's ratio scale (as shown in **Table 3.1**), which is between 1 to 9 (Saaty, 2008). The respondents were allowed to choose the preferred scale between 1 to 9 depends on their evaluation.

Table 3.1 The Saaty's ratio scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective.
3	Weak importance of one over another	Experience and judgment slightly favour one activity over another
5	Essential or strong importance	Experience and judgment strongly favour activity over another
7	Demonstrated importance	An activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent judgments	When compromise is needed

(Source: Saaty, 2008)

3.3 Validity Test

In order to ensure the questionnaire is representative and appropriate to use, a validity test was designed and conducted. These tests are important to evaluate the quality of the questionnaire, the agreement level of experts for the questionnaire contents, to avoid biases, to evaluate the difficulty of the content, also discriminate of the questionnaire (Ozer, 2014). These tests were conducted before the questionnaire was distributed to the *Pondok* institutions.

The validity analysis was conducted using the content validity analysis, where the items in the instrument reflect the entire content of the behaviour/ construct/ area of the instrument will be generalized (Taherdoost, 2016). The judgemental approach to establish content validity involved literature reviews and evaluation by expert judges (Taherdoost, 2016). Referring to Yusoff (2019), there are six important steps used to conduct this test, that is;

i. Preparing content validation form
ii. Selecting a review panel of experts
iii. Conducting content validation
iv. Reviewing domain and items
v. Providing the score of each item
vi. Calculating the Content Validation Index (CVI)

In this research, firstly, the content validation form was created referring to the previous studies and article journal. The rating scale of relevance applied in this research is as shown in **Table 3.2** which is from 1 to 4, referring to the scale used by Yusoff (2019). The preparation of the content validation form is vital to ensure a clear understanding from the panel of experts regarding the research.

Table 3.2 The rating scale of relevance for content validation

Degree of relevance	Definition
1	Item is not relevant to be measured domain
2	Item is somewhat relevant to be measured domain
3	Item is quite relevant to be measured domain
4	Item is highly relevant to be measured domain

(Source: Yusoff, 2019)

Next, two expert lecturers from the University Malaysia of Kelantan (UMK) Jeli Campus was selected to review the questionnaire. The content validation was conducted through a non-face-to-face approach. Thus, an electronic validation form with clear instructions was distributed to the experts. The lecturers were given a few days to review and properly analyse the questionnaire. After that, the response was collected. Lastly, the CVI was calculated and interpreted whether the questionnaire has met the criteria or not. Based on **Table 3.3** the acceptable CVI values for two experts are at least 0.80. The CVI values obtained in this research are 0.89, which is greater than 0.80. Thus the CVI values obtained are in an acceptable value. This indicates that the questionnaire is valid to be used for the survey.

Table 3.3 The number of experts and its implication on the acceptable cut-off score of CVI

Number of experts	Acceptable CVI values
Two experts	At least 0.80
Three to five experts	Should be 1
At least six experts	At least 0.83
Six to eight experts	At least 0.83
At least nine experts	At least 0.78

(Source: Yusoff, 2019)

3.4 Data Collection

3.4.1 Sampling Technique

The data used in this research are the primary data, collected from the survey in the *Pondok* institutions. The data were collected utilizing a non-probability or convenience sampling method, which involves a non-random selection of samples and dependant on the data collection from population members that are conveniently available to participate (Adam, 2018). An online questionnaire was created using Google form (online survey tools). After the questionnaire was validated, the Google form link was distributed to the sample population thru online platforms such as email and other social media like Facebook, WhatsApps, websites and Telegram.

3.4.2 Sample Size Determination

The respondents of this research are consist of staff, teachers, and students. Utilizing the stratified sampling method, the estimated total population of the *Pondok* community will be divided into small groups. A research conducted by Abidin et al. (2020) stated that the population of *Pondok* institution is approximately 200 persons. In this research, 15 *Pondok* institutions were involved, resulting in the estimated population become approximately 3000 persons. According to Krej (2008), the sample size for a 3000 population size is 341 respondents **(Table 3.4).**

Nevertheless, throughout the research, the number of respondents obtained is only 105, which is less than the targeted amount. According to the rules of thumb, the minimum sample size to ensure that the sample is representative is at least sample size; n = 30 (Abraín, 2014). Therefore, since the number of respondents obtained is exceeded by 30 persons, it is considered as under acceptable values.

Table 3.4 Krejcie and Morgan's table

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

(Source: Krej, 2008)

3.5 Data Analysis

The Analytical Hierarchy Process (AHP) method used as a technique for data analysis. According to Aris (2020), AHP is a suitable technique to select the most appropriate and efficient solid waste management system. It is designed to solve a multi-criteria in a number of application domains (Saaty, 1987). The AHP methodology has divided into four steps that are (i) structure the decision into objectives and alternatives; (ii) measure the objectives and alternatives utilizing pairwise comparison; (iii) synthesize of priority; and (iv) exploit subjective inputs to reach a prioritized list alternative (Bertolini, 2006; Aris, 2020).

In this research, firstly, a General Hierarchy Structural Model (GHSM) was developed to identify the issues, structure the objectives, criteria, and alternatives of the SSWMS. The GHSM model is comprised of four stages. The primary stage is the main goal of hierarchy which is the development of a sustainable solid waste management system. Meanwhile, the secondary and tertiary phases is the criteria and sub criteria needed to develop the system, and the quaternary stage includes the alternatives to the system.

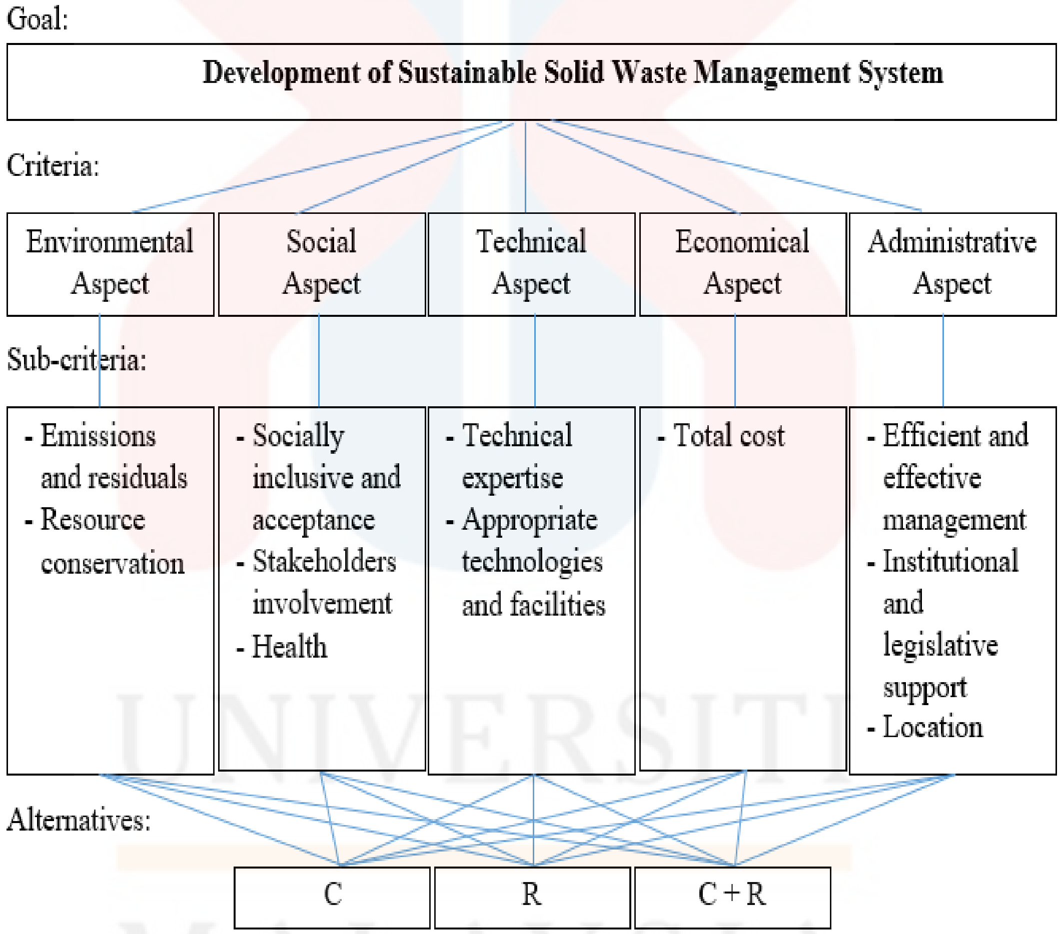

Figure 3.2 The General Hierarchy Structural Model (GHSM)

The development of GHSM is important to structure the problem specifically for decision-making purposes. **Figure 3.2** shows the GHSM for this research. Out of various alternatives mentioned in the literature review section, three alternatives were selected for this research which is composting (C), recycling (R), and both composting and recycling (C + R). The development of the GHSM has been done by revisions and references from various secondary sources, such as previous studies, journals, articles, and reading materials on waste management.

Secondly is to measure the pairwise comparative. Zahedi (1986) stated that the pairwise comparison will come out with a foundation to make choices by comparing two factors, elements, or criteria. The data regarding the criteria, sub criteria, and alternatives for the development of a SSWMS that was collected in data collection has been analysed at this level. The pairwise comparison of criteria from the second level of GHSM reflected the accomplishment of the first level. The same goes for level three, where sub criteria reflected the accomplishment of the second level, and level four which are the alternatives reflected the accomplishment of the third level.

In data analysis, a synthesis of priority involved the ranking process of the alternatives based on the criteria and sub criteria of relatives to the goal (Aris, 2020). The respondent's weights and scores were computed using Microsoft Excel. Initially, the data from the pairwise comparisons sections were inserted into the Pairwise Comparison Matrix, as shown in **Table 3.5**. This matrix was filled in to present the relative importance of one element to another.

Table 3.5 The Pairwise Comparison Matrix

Alternative	**Criteria 1**	**Criteria 2**	…….	**Criteria n**
Criteria 1	W_1/W_1	W_2/W_1	…….	W_n/W_1
Criteria 2	W_1/W_2	W_2/W_2	…….	W_n/W_2
…….	…….	…….	…….	…….
Criteria n	W_1/W_n	W_2/W_n	…….	W_n/W_n

Zahedi (1986) stated that a vector of composite weights is indicated as rankings to attain the decision problem's main goal. Therefore, the priority weights were calculated by averaging all the elements in the row and divided with the number of the criteria. After that, the consistency of the elements was calculated by multiply each value in the column with priority weights. Subsequently, the Eigenvector's value, consistency index (CI), and consistency ratio (CR) was calculated utilizing Eq. (3.1) to (3.3).

$$\text{Eigenvector principle } (\lambda\text{max}) = \frac{1}{n}\sum_{i=l}^{n}\left\{\frac{\sum_{j=l}^{n} a_{ij} \times wj}{Wt}\right\} \quad (3.1)$$

Where, λmax is the maximal or Eigenvector principle, n is matrix size, a_{ij} is pairwise comparison matrix, *wj* and *wi* is the *j* and *i* elements for values of eigenvector.

$$\text{Consistency Index (CI)} = \frac{\lambda\max - n}{n-1} \quad (3.2)$$

$$\text{Consistency Ratio (CR)} = \frac{\text{CI}}{\text{RI}} \quad (3.3)$$

For the CR, the CI value was calculated first using Eq. 3.2, whereas the index random consistency (RI) value has been referred to in **Table 3.6** below. After that, the CR values were calculated using Eq. 3.3. According to the rule of thumb, a CR value must not exceed 0.10 or 10% to obtain a consistent matrix and be considered as an acceptable value.

After the CR was calculated, each criterion, sub criteria, and alternatives have been rank according to the priority weights. Finally, the alternative score was calculated to determine which alternative are the most appropriate to be used in developing a SSWMS in the *Pondok* institution.

Table 3.6 The index random consistency (RI).

Number of elements (n)	**RI**
3	0.52
4	0.89
5	1.11
6	1.25
7	1.35
8	1.40
9	1.45
10	1.49
11	1.51
12	1.54
13	1.56
14	1.57
15	1.58

(Source: Saaty, 2008)

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 The Respondent's Demographic

From the survey, the total number of respondents obtained is 105 persons. The respondents obtained were from 15 *Pondok* institutions in Kelantan, such as *Pondok* Pasir Tumboh Kubang Kerian, Pondok Ar-Rahmaniah Tumpat, Pondok Aitam Al-Ghonna' Pasir Puteh, and Pondok al-Fununiah Al-Ghazaliah. The parameters used to determine the demographic data is gender, age group, residency area, position, and educational level. **Table 4.1** showed the respondents' demographic by all the *Pondok* institutions.

From the data obtained, 46 respondents (43.8%) are male while 59 respondents (56.2%) are female. This result showed that the percentage of females in *Pondok* institution is higher compared to the male. As stated by Ahmad (2009) in his research, this might happen due to the percentage of communities in educational institutions is monopolized by females compared to males (Ahmad, 2009). The result showed that 89 (84.8%) out of 105 respondents are single, meanwhile, 14 (13.3%) of the respondents are married, and 2 (1.9%) respondents are divorce. The majority of the respondents are single due to most of the respondents come from students.

Based on **Table 4.1**, the range of age for the *Pondok* community started from below 18 years old to above 36 years old. There are 45 respondents (42.86%) comes from below 18 years old, 40 respondents (38.10%) from 19 – 25 years old, 6 respondents (5.71%) from 31 – 35 years old, and 10 respondents (9.52%) are from above 36 years old. The result showed that the *Pondok* community comes from a broad range of age groups. The highest involvement of age group are below 18 years old group, followed by 19 – 25 years old age group, above 36 years old age group, 26 – 30 years old age group, and the least involvement are 31 to 35 years old group of respondents. This showed that the questionnaires were widely distributed to all layers of ages. However, the differences in values obtained is due to the majority of the population are students.

For the residency area, referring to **Table 4.1** and **Figure 4.1**, 39 respondents (37.1%) stayed in hostels, whereas 5 respondents (4.8%) and 61 respondents (58.1%) of the total respondents stayed in the warden's hostel and their personal/family home. The result showed that the majority of the respondents stayed in the personal/ family house. This happened due to the spread of infectious coronavirus disease (COVID-19) situation at that time which caused many of the *Pondok* institutions to close. This has resulted in the inaccuracy of the information on the actual residency areas of the *Pondok* institutions population. However, from the result, it is shown that approximately 37.1% of the respondents stayed in hostels, and 4.8% of them stayed in the wardens' hostel. Thus, it can be concluded that 41.8% of 105 respondents are known as contributors to the solid waste generation in the *Pondok* institutions.

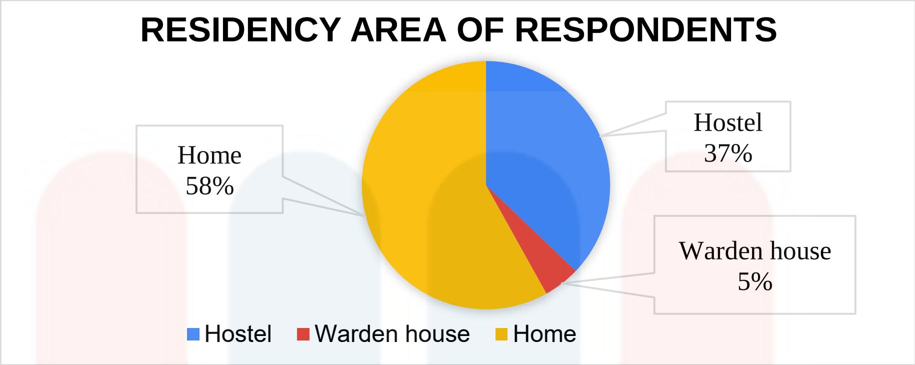

Figure 4.1 The residency areas of respondents from *Pondok* institutions

The result also shows that the involvement of the respondents came from 80 students (76.2%), 12 staff (9.5%), 10 teachers (11.4%), finally 3 persons (2.9%) from others which come from people who always visit the *Pondok*. **Table 4.1** also shows the education level of the *Pondok* population. Based on the result obtained, it is shown that this research managed to get the respondents from various educational levels. The educational level falls into six categories that are 2 respondents (1.9%) from primary schools, 53 respondents (50.5%) from secondary school, 2 respondents (1.9%) were from foundation or matriculation level, 16 respondents (15.2%) from diploma, 30 respondents (28.6%) from bachelor's degree, and finally 2 respondents (1.9%) from others. The result shows that the majority of the respondents came from secondary school students followed by the bachelor's degree educational levels. The differences in ages and educational background happened due the *Pondok* institutions came from two streams, which are a modern stream and a traditional stream (Fathil et al., 2017). The respondents with primary and secondary education levels might come from modern streams. Meanwhile, the respondents from Foundation or Matriculation, Diploma, Bachelor's degree, and Others might come from staff, teachers, and students from traditional streams.

Table 4.1 The Respondent's Demographic.

Demographic Features	Frequency (N)	Percentage (%)	Total (%)
Gender			
1) Male	46	43.8	46 (43.8)
2) Female	59	56.2	59 (56.2)
Marital status			
1) Single	89	84.8	89 (84.8)
2) Married	14	13.3	14 (13.3)
3) Divorce	2	1.90	2 (1.90)
Age group (years old)			
1) < 18	45	42.86	45 (42.86)
2) 19-25	40	38.10	40 (38.10)
3) 26-30	6	5.71	6 (5.71)
4) 31-35	4	3.81	4 (3.81)
5) >36	10	9.52	10 (9.52)
Residency area			
1) Hostel	39	37.1	39 (37.1)
2) Warden house	5	4.8	5 (4.8)
3) Home	61	58.1	61 (58.1)
Position			
1) Student	80	76.2	80 (76.2)
2) Teacher	12	11.4	12 (11.4)
3) Staff	10	9.5	10 (9.5)
4) Others	3	2.9	3 (2.9)
Education level			
1) Primary school	2	1.9	2 (1.9)
2) Secondary school	53	50.5	53 (50.5)
3) Foundation / Matriculation	2	1.9	2 (1.9)
4) Diploma	16	15.2	16 (15.2)
5) Bachelor's Degree	30	28.6	30 (28.6)
6) Others	2	1.9	2 (1.9)

4.2 The Types of Solid Waste Generated by *Pondok* Institutions

From the questionnaire distributed, the types and compositions of solid waste generated by *Pondok* institutions were observed. This research managed to determine the frequency of waste disposals, the types of solid waste generated by the respondents and the types of solid waste generated by *Pondok* institutions, as well and the waste management alternatives practiced by the *Pondok* institutions. This information is important in order to know the estimation of the amount of solid waste generated by the institutions. As been mentioned by Anand (2011), most of the waste produced is highly biodegradable waste compare to paper, metal, and glass, however, the compositions are different depending on the activities held in that particular area.

Table 4.2 shows the frequency of waste disposals by the respondents in a day. About 56 of the respondents (53.3%), which are half of the total respondents have disposed of two to three times of waste in a day. Meanwhile, the rest of them disposed of approximately a time (21.9%), five to eight times (17.1%), and more than 10 times (7.6%) in a day. The result indicates that the waste will be generated approximately twice to fourfold per day.

For the types of wastes generated by the respondents, the highest percentage of waste generated by the respondents are food wastes/farm wastes which are 40.50% of the total wastes (**Table 4.2**). These results followed by plastics (28.93%), papers (24.79%), glasses (3.31%), and the least are metal (2.48%). The three highest ranks for types of solid waste generated individually by the respondents is organic waste, plastics, and paper. Additionally, referring to **Table 4.2** and **Figure 4.2**, the alternatives that were considered are the 3Rs (reduce, reuse, and recycle), and composting. The reason these two alternatives was chosen is that it is a simple and well-known technique. In addition, these two techniques also covered the management of both organic and inorganic wastes. From the data obtained, approximately 48% of the respondents did not practice any alternatives waste management technique, 35.65% of the respondents practiced the 3Rs, and 16.52% of the respondents practiced composting. The result showed that the majority of the respondents did not implement any alternatives practices to reduce their wastes.

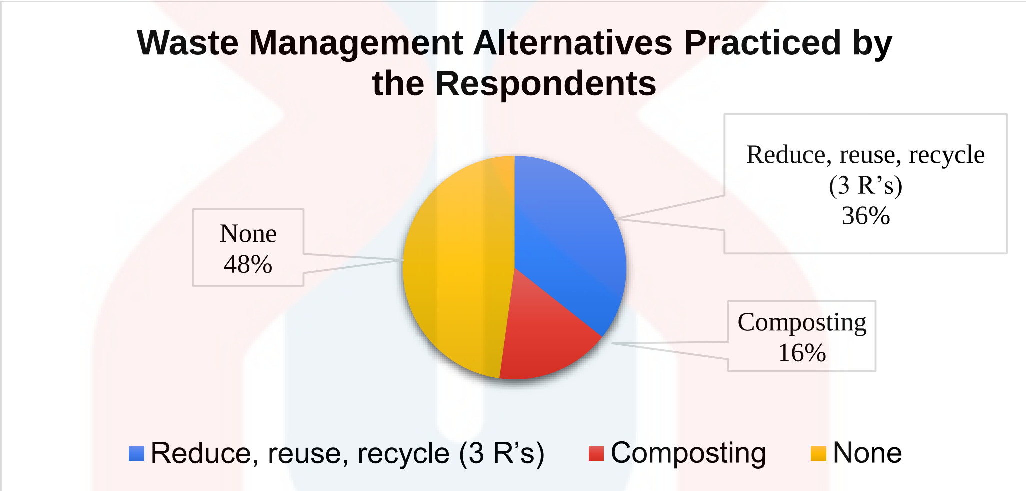

Figure 4.2 The waste management alternatives practiced by the respondents.

According to **Table 4.2** and **Figure 4.3**, the types of solid waste generated by *Pondok* institutions are consists of food waste/farm waste (33.20%), plastics (26.17%), papers (24.61%), metal/steel/aluminium tin (9.38%), also glass (6.64%). The result indicates that waste generated in *Pondok* institutions were dominated by organic compositions, that is food and kitchen waste, farm waste, and other organic wastes.

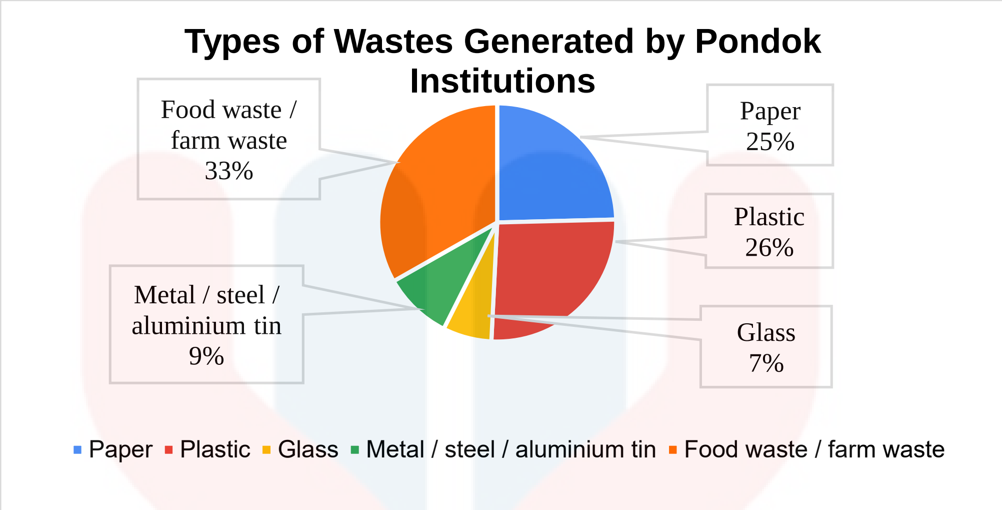

Figure 4.3 The types of solid waste generated by *Pondok* institutions.

For the opinion on present *Pondok* institutions solid waste management system, the question given is a five-point Likert Scale question, where the answer was categorized as 1) excellent, 2) good, 3) moderate, 4) bad, and finally, 5) very bad. Based on **Table 4.2**, the respondent's score shows that 45 respondents agreed that the present solid waste management system implemented in *Pondok* institutions is good. Meanwhile, 26 respondents (24.8%) agreed that the present solid waste management system implemented in *Pondok* institutions is excellent, and another 28 respondents (26.7%) agreed that the present solid waste management system implemented is excellent. Last but not least, 4 respondents (3.8%) agreed that the present solid waste management system implemented in *Pondok* institutions are bad and another 2 respondents (1.9%) are very bad.

Table 4.2 The types of solid waste generated by *Pondok* institutions.

Types of Solid Waste Generated by *Pondok* Institutions	Frequency (N)	Percentage (%)	Total (%)
Frequency of waste disposal in a day			
1) 1 time	23	21.9	23 (21.9)
2) 2 to 4 times	56	53.3	56 (53.3)
3) 5 to 8 times	18	17.1	18 (17.1)
4) More than 10 times	8	7.6	8 (7.6)
Types of wastes respondent's produced			
1) Paper	63	24.79	63 (24.79)
2) Plastic	72	28.93	72 (28.93)
3) Glass	9	3.31	9 (3.31)
4) Metal / steel / aluminium tin	7	2.48	7 (2.48)
5) Food waste / farm waste	97	40.50	97 (40.50)
Method implemented to reduce waste production			
1) Reduce, reuse, recycle (3 R's)	41	35.65	41 (35.65)
2) Composting	19	16.52	19 (16.52)
3) None of them	55	47.82	55 (47.82)
Types of wastes generated by *Pondoks*			
1) Paper	63	24.61	63 (24.61)
2) Plastic	67	26.17	67 (26.17)
3) Glass	17	6.64	17 (6.64)
4) Metal / steel / aluminium tin	24	9.38	24 (9.38)
5) Food waste / farm waste	85	33.20	85 (33.20)

Table 4.2 (Continued)

Opinion on present *Pondoks'* solid waste management system			
1) Excellent	26	24.8	26 (24.8)
2) Good	45	42.9	45 (42.9)
3) Moderate	28	26.7	28 (26.7)
4) Bad	4	3.8	4 (3.8)
5) Very bad	2	1.9	2 (1.9)

From the result above, the difference in the types of waste generated by educational institutions was proved by a few studies. Ioan et al. (2012), and Kamaruddin et al. (2016), agreed that waste generation is different from one institution to another institution. Ioan et al. (2012) revealed in their research that, some educational institution (EI) have paper as their highest percentage of waste generation, for instance, the Central University College, where the percentage of waste generated was 32.75% paper, 10.75% plastics, 7.25% of food waste and 12% residuals. Another EI that generated the highest percentage of paper is University Technology PETRONAS which is 40% of their total waste, and the University of Nairobi which is 54.22% of their waste (Ioan et al., 2012).

On the contrary, some of the EI generate food waste as their highest percentage of waste. Referring to the research conducted by Ioan et al. (2012), five over ten of the educational institutions that has been studied generated organic waste as their highest waste production. One of them is the campus of the University of Tabriz, where 45.3% of their waste generated comes from food waste and the rest are papers (14.45%), plastics (19.23%), residual wastes (10.84%), glass (8.87%), and demolitions and constructions (0.69%).

According to the result from the studies above, it is shown that every institution will generate different amounts and types of waste (Ioan et al., 2012). These differences might happen because of the different activities, perceptions, behaviour, and knowledge of the community (Kuun, 2017). Among the factors that influence the production of solid waste in *Pondok* institutions are cultural, educational, and microeconomic factors (McAllister, 2015). This happened due to the lack of education and awareness of effective waste management practices in *Pondok* institutions. Besides, lack of exposure to a proper SWM system may result in no participation from the community to carry out sustainable solid waste management practices (McAllister, 2015). No exposure to the appropriate infrastructure to manage solid waste sustainably is also one of the factors leading to biodegradable and non-biodegradable waste production. Finally, the policies, institutions, and macroeconomics (McAllister, 2015). *Pondok* management must first be exposed to the knowledge of solid waste management to understand better how the systems works and the benefit of the development of the system.

4.3 First Level Pairwise Comparison between Criteria and Goal

The first level of the pairwise comparison indicates the criteria that are significant in developing a sustainable solid waste management system. There are five criteria involved in this research, that is, Environmental Aspects (EAS), Social Aspects (SA), Technical Aspects (TE), Economical Aspects (EA), also Administrative Aspects (AA). Based on the result obtained in **Table 4.3**, the rank of priority weights for the criteria is as follows; Administrative Aspects (0.30), Economical Aspects (0.24), Technical Aspects (0.19), Social Aspects (0.15), and Environmental Aspects (0.12).

The result shows that the significant aspect in the first level of the pairwise comparison is the administrative aspects, whereas the least is the environmental aspects.

Table 4.3 The priority weight for Criteria

Num	Criteria	Weighted Sum Value	Priority Weight
1	EAS	0.13	0.12
2	SA	0.15	0.15
3	TA	0.18	0.19
4	EA	0.23	0.24
5	AA	0.32	0.30

Table 4.3 represents the lists of criteria and priorities weight of each criterion with respect to the goal. From the five criteria to be considered in the system, the administrative aspect (AA) considered being the most important dimension of the SSWMS with 0.30 weights. The AA is said to be the most important aspect since throughout the process of developing a SSWMS, effective and efficient management are vital to ensure the goal of the development, program complementation, and implementation of rules and laws (Theses & Troschinetz, 2005; Zurbrügg & Ingegneria, 2013) are going smoothly as planned. As been mentioned by Abdullah & Jalil (2016), in their research, the development of SWM requires the existence of policies and regulations that have contributed to the key purpose of growth being accomplished, resulting in effective management/ administration as the main foundations of SWM. The AA also includes the location or site selection of the system. The location indicates the land availability to build the systems and become the base for the system (Theses & Troschinetz, 2005). Poor land availability and site selection for systems might affect the systems, and surrounding activity, hence, the selection of site should be done properly. The AA is pivotal in ensuring the system developed being

managed in effective and efficient ways, the administrative aspects will ensure the institution follows the policy strictly.

The second most important criterion in developing a SSWMS is the economical aspects (EA). The cost of operation and cost of capital, reliable budgeting, and total cost are all important prerequisites for monitoring and evaluating the financial performance of the project (Zurbrugg et al., 2014). Moreover, since the respondents are aware that the finances of *Pondok* institution are dependent on donations and public contributions (Mohd & Osman, 2013), the EA has been chosen as one of the highest aspects to be considered.

The third successful criterion the technical aspects (TA), where it involves the use of appropriate technologies/ equipment. Zurbrügg & Ingegneria (2013) and Zurbrugg et al. (2014), reported that TA highlights the assessment of appropriate equipment that is locally produced and locally be well maintained or operated. In addition, the technology/equipment can be considered more sustainable, flexible, durable, robust, designed to operate under the local physical (e.g. climate, topography) or infrastructure conditions (Zurbrügg & Ingegneria, 2013; Zurbrugg et al., 2014). In *Pondok* institutions, the use of appropriate size and easy to handle equipment is vital, due to limited space and expertise in that particular area.

The fourth important criterion is the social aspects (SA), where it involves the stakeholders' involvement, development committees, as well as provide direct or indirect local employment opportunities (Zurbrugg et al., 2012; Zurbrügg & Ingegneria, 2013). The SA is very dynamic, however, it is important for the future development of the systems and communities.

Whereas the least important is the environmental aspect (EAS) with 0.12 weights. The EA is indeed an important criterion to be considered in the SWMS since it contributes a lot in providing a healthy and comfortable environment, prevent nuisances like a bad smell, dust, noise, and insects/animals, as well as safeguard workers' well-being and health from any consequences (Zurbrügg & Ingegneria, 2013; Zurbrugg et al., 2014). However, maybe lack of interest or exposure to environmental or solid waste management has results in fewer preferences from the community (McAllister, 2015) to prioritize this aspect from the first place.

4.4 Second Level Pairwise Comparison between Sub criteria and Criteria

The sub criteria for the development of sustainable solid waste management system this research were consists of eleven elements, that is Emissions and residuals (ER), Resource conservation (RC), Socially inclusive and acceptance (SIA), Stakeholders involvement (SI), Health (H), Technical expertise (TE), Appropriate technologies and facilities (ATF), Total cost (TC), Efficient and effective management (EE), Institutional and legislative support (ILS), as well as Location (L). The significant impacts of this stage are that all of the listed criteria will play important roles and might affect the criteria above. Based on the data in **Table 4.4**, the highest sub criteria elements based on the priority weight calculated for the sub criteria fall to L with the 0.15 priority weights. Whereas, the least important fall to the ER with the priority weights of 0.04. The order of rank for the sub criteria is ascending as follows; emissions and residuals (0.04), resource conservation (0.06), socially inclusive and acceptance (0.06), stakeholders involvement (0.07), health (0.08), technical expertise (0.09), appropriate technologies and facilities (0.10), total cost (0.11), efficient and effective management (0.11), institutional and legislative support (0.13), and finally the location (0.15).

Table 4.4 The priority weight for Sub criteria

Num	Sub criteria	Weighted Sum Value	Priority Weight
1	ER	0.05	0.04
2	RC	0.06	0.06
3	SIA	0.06	0.06
4	SI	0.07	0.07
5	H	0.07	0.08
6	TE	0.08	0.09
7	ATF	0.09	0.10
8	TC	0.11	0.11
9	EE	0.11	0.11
10	ILS	0.14	0.13
11	L	0.16	0.15

Table 4.5 shows the relative importance of the sub criteria under the elements of criteria from stage one of the pairwise comparison. Under the EA, the order rank of sub elements is RC (0.06), followed by the ER (0.04). Under the SA, the order rank of sub criteria is as follows; H (0.08), SI (0.07), and SIA (0.06). Under the criteria of TA, the order rank of the sub criteria are ATP (0.10), followed by TE (0.09). Under the EA, the order of rank of sub criteria is TC (0.11). Last but not least is under the criteria of AA, the order of rank of sub criteria is as follows; L (0.15), ILS (0.13), and EE (0.11). From the data analysed, it can be seen that the top five elements comparative to the goals are as follows; location, institutional and legislative support, efficient and effective management, total cost, and lastly appropriate technologies and facilities.

Table 4.5 The Consistency Ratio for Criteria and Sub criteria

Elements of criteria	Elements of sub criteria	Consistency ratio
Environmental Aspects (EA)	ER	
	RC	
Social Aspects (SA)	SIA	Criteria 0.041057
	SI	
	H	
Technical Aspects (TA)	TE	
	ATF	Sub criteria 0.031171696
Economical Aspects (EA)	TC	
Administrative Aspects (AA)	EE	
	ILS	
	L	

4.5 Third Level Pairwise Comparison between Alternative and Sub criteria

The third level of the pairwise comparison indicates the alternatives that are required in developing a sustainable solid waste management system. The alternatives to solid waste management that have been considered in this research were composting (A1), recycling (A2), and composting and recycling (A3). Based on the result in **Table 4.6,** the highest priority weights of the alternatives fall to A3 that is composting and recycling with 0.49 priority weight, followed by the A2 with 0.30 priority weights, and the least priority weights fall to A1 that is composting with 0.21 priority weights.

Table 4.6 The priority weight for Alternatives

Num	Alternative	Weighted Sum Value	Priority Weight
1	A1	0.21	0.21
2	A2	0.29	0.30
3	A3	0.50	0.49

According to a research by Sreenivasan et al. (2012), composting and recycling aim to minimize the flow of waste to landfills or dumpsites. Besides, SLWP (2020), has stated that it is important to implement both recycling and composting. The implementation of recycling and composting will helps in conserving natural resources, where recycling processes will reduce the consumption of natural resources, and composting will reduce the waste of natural resources (SLWP, 2020). Moreover, recycling and composting also contributes to the saving of energy, where using recycled materials required less energy than new raw materials, meanwhile, composting may generate energy by release methane gas during the decomposition process, this methane gas is also known as biogas which can be burned to produce energy (Sreenivasan et al., 2012; SLWP, 2020).

Sreenivasan et al. (2012) claimed that, in minimizing the generation of waste, the implementation of the waste minimization technique such as composting and recycling gives a positive effect. In addition, few studies from Malaysia educational institutions also proved that the implementation of recycling and composting gave a positive impact in reducing waste generation. In the meantime, the system carried out also brings positive side effects, such as fertile cultivation, reduced expenditure on chemical fertilizers, and income generation from recycling programs.

For example, in Universiti Kebangsaan Malaysia (UKM), the recycling activities held by Pusat Kitar Semula Universiti Kebangsaan Malaysia (PKS-UKM) has collected the recyclable composition up to 89.6% of paper products, 5.9% of plastic products, 3.0% of metal products, 0.9% of glass products, and 0.6% of e-waste (Tiew et al., 2019). Meanwhile, in Universiti Sains Malaysia (USM), there an application of a composting system named Simple Composting System as known as *Sistem Kompos Mudah* (SKM). This system is a basic decomposition method for organic waste, under the Eco-process Technology (ECOPRO) team, and it has resulted in a reduction of the huge amounts of organic wastes in USM (Irisha et al., 2017).

From the research above, it is shown that the implementation of both recycling and composting may result in a massive positive impact than the implementation of only one of them (either composting or recycling). Having said about profit and positive impacts, humans will tend to choose choices that will benefit them more (McAllister, 2015). Hence, due to more benefits will be gained from the combination of both techniques, it indirectly has influenced the respondents to choose that alternative. The implementation of these alternatives is highly profitable as it might generate income for the institutions and surrounding community if being handle carefully.

4.6 Development of Sustainable Solid Waste Management System at *Pondok* Institutions.

In order to analyse the best alternatives that will be used to develop a sustainable solid waste management system at *Pondok* institutions, the alternative score was calculated. Based on the alternative score in **Table 4.7**, the ascending order of rank for alternatives practices that can be used is A3 for both composting and recycling (0.50), A2 for recycling (0.30), and A1 for composting (0.21).

Table 4.7 The Alternatives Score

Alternatives Score		Ranking
A3	0.493938	**1**
A2	0.300387	**2**
A1	0.205676	**3**

Based on the graph of the alternatives score in **Figure 4.4**, it can be seen that there is a significant difference in respondent's preferences between composting and both recycling and composting, and less difference between recycling and both recycling and composting.

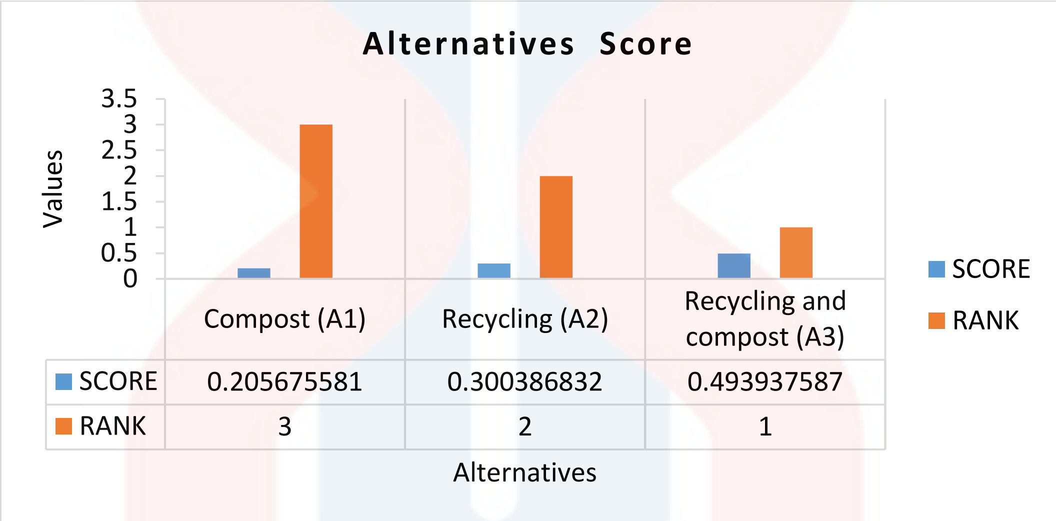

Figure 4.4 The alternatives score of the SSWMS.

The development of an administrative system, which is a sustainable solid waste management system for educational institutions function as a guideline for them to manage their solid waste properly. This system will ensure the smooth functioning of the organization and the solid waste management system, also enhance the use of appropriate techniques to manage the waste without contributing to other environmental issues.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

To conclude, this research has successfully determined the types of waste generated and analysed the types of alternatives that are suitable to be developed in the educational institutions, particularly *Pondok* institutions utilizing the Analytical Hierarchy Process (AHP) method.

In this research, almost half of the respondents generated organic wastes as their highest percentage of waste every day. In relation to this, approximately half of the total respondents revealed that they did not practice any alternatives waste management techniques to reduce their wastes. Most of the respondents are still not aware of the importance of waste management alternative practices to reduce the amount of waste generated. However, some of the respondents are aware of the importance of alternative waste management and practice it in their daily lives. Nevertheless, the majority of the respondents agreed that present *Pondok* institutions solid waste management system practiced are good.

The types of solid waste generated by the community of *Pondok* institutions were successfully determined. The result shows that the waste generated in *Pondok* institutions were dominated by organic compositions which are one-quarter of the total amounts of the total waste generated. The types of solid waste generated play an important role in choosing the appropriate alternatives for the sustainable solid waste management system.

The result of the analysis shows that the criteria and sub criteria of the waste management system that will be developed in the *Pondok* institutions were successfully analysed. From the analysis, the administrative aspect is the most important factor that will influence the development of the system. Most of the respondents believe that the top five elements for the sub criteria of the systems were located, institutional and legislative support, efficient and effective management, total cost, and lastly appropriate technologies and facilities. In relation to this, the priority weights for composting and recycling are the highest. The analysis of the system is correlated between the goal, criteria, sub criteria, and alternatives. This shows that the respondents believe that this alternative is the most appropriate practices to be adopted in the systems. The development of a sustainable solid waste management system in *Pondok* institutions will contribute to the reduction of waste generation, conserve natural resources, reduce the use of space for dumping sites or waste treatment plants, as well as overcome the pollution issues related to waste management.

5.2 Recommendations

As for the recommendation, educational institutions can use this research finding as a guideline to develop their waste management system in their institution. The development of the sustainable solid waste management system in *Pondok* institutions will reduce the excessive solid waste production and overcome the inefficient solid waste management system in that area. It will also help to reduce pollution generation and other environmental problems caused by the feeble and weak solid waste management system.

The implementation of the system may also help in reducing the amount of money invested to manage the waste generated in the institution. Besides, it can also become one of the financial resources for the institution, generated from the reduction of waste produced, and from the composting and recycling practices. Educational institutions can earn money by selling the recyclables waste from the recycling practices and selling the fertilizer from the composting activities. On the other hand, the information obtained can also be used as a scientific reference for future research on sustainable solid waste management system in the educational institution sector.

Based on this research, there are several improvements that can be made in analysing the appropriateness of solid waste management systems in that particular area. Firstly, it is really recommended to analyse the composition of waste generated in that area to get precise amounts and types of waste generated by the community. Finally, it is highly recommended to conduct a face-to-face survey (especially for the AHP method survey), to better understand, and to get accurate also precise results. This improvement is especially important for studies related to rural areas.

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APPENDIX A *Borang Soal Selidik*

Membangunkan Sistem Pengurusan Sisa Pepejal Lestari Menggunakan Kaedah Analisis Hierarki (AHP) di Institusi Pondok di Kelantan.

Tujuan: Penyelidikan ini bertujuan untuk membangunkan sistem pengurusan sisa pepejal lestari yang terbaik untuk dibangunkan di institusi pendidikan. Segala maklumat yang dikumpulkan melalui soal selidik ini akan digunakan sebagai sebahagian daripada data kajian. Penyelidikan ini mensasarkan responden dari komuniti Pondok di Kelantan.

Kerahsiaan: Untuk makluman responden, segala maklumat peribadi yang diberikan akan dirahsiakan. Penyelidik mempunyai hak milik penuh atas soal selidik yang telah dilengkapkan dan ia akan dimusnahkan setelah selesai penyelidikan. Semua respon yang diberikan akan digunakan untuk penyelidikan akademik ini.

Sebarang pertanyaan lanjut boleh diajukan kepada;

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BAHAGIAN A (1): LATAR BELAKANG RESPONDEN

Arahan: Bahagian ini merupakan soal selidik mengenai latar belakang anda. Sila tandakan pilihan jawapan anda pada ruang yang disediakan.

1) Jantina : ☐ Lelaki ☐ Perempuan

2) Status : ☐ Bujang ☐ Berkahwin ☐ Lain-lain : _____

3) Umur : _______ tahun

4) Tempat tinggal : ☐ Asrama ☐ Rumah warden ☐ Rumah sendiri

5) Pekerjaan : ☐ Pelajar ☐ Guru ☐ Staff ☐ Lain-lain : _____

6) Tahap Pendidikan : ☐ Sekolah Rendah ☐ Sekolah Menengah ☐ Diploma ☐ Sijil/ Asasi/ Matrikulasi ☐ Ijazah ☐ Lain-lain : ________

BAHAGIAN A (2): JENIS-JENIS SISA PEPEJAL YANG DIHASILKAN

Arahan: Bahagian ini merupakan soal selidik mengenai jenis-jenis dan jumlah sisa pepejal yang dihasilkan di institusi pendidikan. Bagi menjawab soalan di bahagian ini, sila tandakan pilihan jawapan anda pada ruang yang disediakan dan/atau isi tempat kosong yang disediakan. Sila pastikan anda mengisis kesemua persoalan yang diberikan.

7) Kekerapan anda membuang sampah dalam masa sehari?

Sekali ☐ 2 ke 4 kali ☐ 5 ke 8 kali ☐ Lebih daripada 10 kali ☐

8) Apakah jenis-jenis sisa pepejal yang anda hasilkan setiap hari?

Kertas ☐ Plastik ☐ Kaca ☐ Besi/ Keluli/ Tin ☐ Sisa makanan/taman ☐

9) Adakah anda mengamalkan amalan alternatif untuk melupuskan sisa pepejal anda? (Contohnya; Kitar semula, Guna semula, Kompos sisa makanan, dan sebagainya)

Ya ☐ Jika ya, sila nyatakan: ____

Tidak ☐

10) Pada pendapat anda, apakah jenis-jenis sisa pepejal yang dihasilkan oleh institusi Pondok setiap bulan?

Kertas ☐ Plastik ☐ Kaca ☐ Besi/ keluli/ Tin ☐ Sisa makanan/taman ☐

11) Apakah pandangan anda tentang pengurusan sisa pepejal yang sedang dilaksanakan di institusi Pondok?

Sangat baik ☐ Kurang baik ☐

Baik ☐ Sangat kurang baik ☐

Sederhana baik ☐

Arahan: Bagi **Bahagian B, Bahagian C,** dan **Bahagian D,** soalan perlulah dijawab merujuk kepada Jadual Skala penilaian dibawah.

Jadual Skala Penilaian

Tahap kepentingan	**Definisi**	**Penjelasan**
1	Sama penting	Kedua-dua aktiviti menyumbang objektif yang sama
3	Sederhana penting	Pengalaman dan pertimbangan lebih berat kepada satu aktiviti berbanding yang lain
5	Penting	Pengalaman dan pertimbangan sangat menggemari aktiviti berbanding yang lain
7	Sangat penting	Pengalaman dan pertimbangan sangat menggemari aktiviti berbanding yang lain
9	Kepentingan mutlak	Aktiviti sangat digemari dan penguasaannya ditunjukkan dalam amalan
2, 4, 6, 8	Nilai pertengahan diantara dua penilaian	Apabila memerlukan kompromi

Penjelasan terperinci mengenai cara untuk menjawab soalan pada Bahagian B, C, dan D iaitu perbandingan berpasangan:

Untuk **Bahagian B**, **Bahagian C**, dan **Bahagian D**, tahap kepentingan perlu dipilih diantara angka 1 sehingga 9, mengikut pilihan anda.

Jika tahap kepentingan bagi perbandingan berpasangan adalah pada di sebelah kanan kotak, maka pilihan jawapan adalah daripada angka 9 hingga 2 disebelah kanan. Manakala, jika pilihan jawapan adalah pada sebelah kiri kotak, maka pilihan jawapan perlulah dibulat diantara angka 2 hingga 9 disebelah kiri. Jika intensiti kepentingan adalah sama, maka jawapan perlulah dibulat pada angka 1.

Contohnya;

Bagi soalan dibawah, iaitu tahap kepentingan bagi kriteria-kriteria yang perlu ada untuk membina sistem pengurusan sisa pepejal yang lestari. Bagi kriteria Aspek Alam Sekitar dan Aspek Sosial, jika anda berpendapat bahawa kriteria Aspek Alam Sekitar adalah kriteria yang sangat penting berbanding Aspek sosial, maka anda perlulah membulatkan jawapan anda pada nombor 5, dibahagian kiri kotak.

Kriteria	**Tahap kepentingan**																	**Kriteria**
Aspek Alam Sekitar	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Sosial

Jawapan menunjukkan Aspek Alam Sekitar lebih penting berbanding Aspek Sosial pada skala 5

BAHAGIAN B : PERBANDINGAN BERPASANGAN TAHAP PERTAMA DIANTARA KRITERIA DAN MATLAMAT

Arahan: Bahagian ini merupakan soal selidik mengenai tahap pertama dalam perbandingan berpasangan yang melibatkan **kriteria-kriteria yang penting** didalam **pembinaan sebuah sistem pengurusan sisa pepejal lestari**.

Terdapat 5 kriteria yang diperlukan iaitu;

1. Aspek Alam Sekitar : Merangkumi pemeliharaan dan pemuliharaan sumber dan perlindungan alam sekitar daripada pelepasan sisa pencemaran. Ianya memastikan projek yang dijalankan mematuhi jumlah pelepasan yang dikreditkan dan mempromosikan pengurangan pelepasan sisa secara lestari.
2. Aspek Sosial : Merangkumi penglibatan semua pihak (yang terdiri daripada institusi, masyarakat, dan individu), pengetahuan dan penerimaan masyarakat terhadap kaedah pengurusan sisa pepejal yang lestari, komitmen dan kesedaran sivik daripada semua pihak.
3. Aspek Teknikal : Melibatkan kemudahan teknologi yang sesuai, keadaan fizikal, infrastruktur teknikal, pengetahuan serta kemahiran untuk mengendalikan teknologi dan operasi.
4. Aspek Ekonomi : Melibatkan jumlah perbelanjaan daripada awal pembinaan sistem sehingga penyelenggaran bulanan. Aspek ekonomi memainkan peranan penting dalam memastikan kelancaran sistem yang dibangunkan.
5. Aspek Pentadbiran : Aspek pentadbiran melibatkan pengurusan dan pelaksanaan sistem, memastikan objektif penubuhan dapat dicapai, dan melibatkan penguatkuasaan peraturan dan undang-undang yang sistematik, telus, dan efisien.

Diantara aspek-aspek tersebut, ada perlulah membuat perbandingan dan menilai tahap kepentingannya merujuk Jadual Skala Penilaian.

Kriteria	Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari																	Kriteria
Aspek Alam Sekitar	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Sosial
Aspek Alam Sekitar	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Teknikal
Aspek Alam Sekitar	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Ekonomi
Aspek Alam Sekitar	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Pentadbiran
Aspek Sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Teknikal
Aspek Sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Ekonomi
Aspek Sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Pentadbiran
Aspek Teknikal	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Ekonomi
Aspek Teknikal	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Pentadbiran
Aspek Ekonomi	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspek Pentadbiran

BAHAGIAN C : PERBANDINGAN BERPASANGAN TAHAP KEDUA DIANTARA SUB-KRITERIA DAN KRITERIA

Arahan: Bahagian ini merupakan soal selidik mengenai tahap kedua dalam perbandingan berpasangan yang melibatkan **sub-kriteria** yang perlu ada dibawah kriteria pembinaan sebuah sistem pengurusan sisa pepejal lestari.

Diantara sub-kriteria yang telah disenaraikan, ada perlulah membuat perbandingan dan menilai tahap kepentingannya. Anda perlulah memilih salah satu daripada sub-kriteria yang dirasakan penting, dan bulatkan tahap kepentingan tersebut mengikut skala kepentingan pada Jadual Skala Penilaian.

Penerangan bagi setiap Sub-kriteria:

1. Pelepasan bahan pencemar dan sisa : Pengawalan berterusan terhadap pelepasan bahan pencemar dan sisa ke udara, tanah, dan air, mengurangkan pembuangan bahan yang boleh dikitar semula, dan mengurangkan jumlah sisa pepejal untuk dilupuskan.
2. Pemuliharaan sumber : Amalan pengurusan sisa pepejal yang lestari mampu mengurangkan kadar penggunaan sumber asli dan memastikan sumber flora dan fauna sedia ada tidak diganggu dan dijaga rapi.
3. Inklusif dan penerimaan secara sosial : Memberikan pendedahan yang jelas, mengambil kira permasalahan, idea, serta penerimaan semua lapisan masyarakat.
4. Penglibatan pihak berkepentingan : Semua pihak sama-sama melibatkan diri dalam menjayakan penubuhan sistem.
5. Kesihatan : Penubuhan sistem tidak memberikan impak buruk terhadap kesihatan dan keselamatan masyarakat setempat. Misalnya, masalah bau yang boleh menyebabkan kehadiran serangga perosak menyebabkan ketidakselesaan kepada orang sekeliling serta penularan penyakit.
6. Pakar teknikal : Mempunyai tenaga mahir yang mampu mengendalikan sistem dengan baik.
7. Teknologi dan kemudahan yang sesuai : Pengunaan teknologi dan infrastruktur yang bersesuaian dengan kawasan pembinaan serta boleh menampung jumlah sisa yang akan dihasilkan, dan boleh digunakan dalam masa yang panjang.
8. Jumlah perbelanjaan : Kos pembinaan, kos pengangkutan dan pengurusan yang rendah, dan institusi mempunyai dana yang mencukupi untuk menampung keseluruhan kos.

9. Pengurusan yang cekap dan berkesan : Pengurusan Pondok yang tersusun, dan sentiasa mengemaskini maklumat dan mengaplikasikan kawalan pencemanran alam sekitar yang betul sepanjang sistem ditubuhkan.
10. Sokongan institusi dan perundangan : Pondok memberikan sokongan penuh terhadap penubuhan sistem pengurusan sisa pepejal, menguatkuasakan peraturan dan undang-undang yang bersesuaian untuk memastikan semua pihak patuh dan ambil kisah dengan penubuhan sistem tersebut.
11. Lokasi : Penempatan sistem di kawasan yang bersesuaian (misalnya; di kanti dan mudah diakses.

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pemuliharaan sumber
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Inklusif dan penerimaan secara sosial
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Penglibatan pihak berkepentingan
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kesihatan
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pakar teknikal

Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teknologi dan kemudahan yang sesuai
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Jumlah perbelanjaan
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Pelepasan bahan pencemar dan sisa	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Inklusif dan penerimaan secara sosial
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Penglibatan pihak berkepentingan
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kesihatan

Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pakar teknikal
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teknologi dan kemudahan yang sesuai
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Jumlah perbelanjaan
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Pemuliharaan sumber	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Penglibatan pihak berkepentingan
Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kesihatan
Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pakar teknikal
Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teknologi dan kemudahan yang sesuai

Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Jumlah perbelanjaan
Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan
Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Inklusif dan penerimaan secara sosial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Penglibatan pihak berkepentingan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kesihatan
Penglibatan pihak berkepentingan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pakar teknikal
Penglibatan pihak berkepentingan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teknologi dan kemudahan yang sesuai
Penglibatan pihak berkepentingan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Jumlah perbelanjaan
Penglibatan pihak berkepentingan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan

Penglibatan pihak berkepentingan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Penglibatan pihak berkepentingan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Kesihatan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pakar teknikal
Kesihatan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teknologi dan kemudahan yang sesuai
Kesihatan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Jumlah perbelanjaan
Kesihatan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan
Kesihatan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Kesihatan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Pakar teknikal	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teknologi dan kemudahan yang sesuai

Pakar teknikal	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Jumlah perbelanjaan
Pakar teknikal	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan
Pakar teknikal	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Pakar teknikal	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Teknologi dan kemudahan yang sesuai	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Jumlah perbelanjaan
Teknologi dan kemudahan yang sesuai	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan
Teknologi dan kemudahan yang sesuai	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Teknologi dan kemudahan yang sesuai	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Jumlah perbelanjaan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pengurusan yang cekap dan berkesan

Jumlah perbelanjaan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Jumlah perbelanjaan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Pengurusan yang cekap dan berkesan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sokongan institusi dan perundangan
Pengurusan yang cekap dan berkesan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

Sub-kriteria	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Sub-kriteria**
Sokongan institusi dan perundangan	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lokasi

BAHAGIAN D : PERBANDINGAN BERPASANGAN TAHAP KETIGA DIANTARA ALTERNATIF DAN SUB-KRITERIA

Arahan: Bahagian ini merupakan soal selidik mengenai tahap ketiga dalam perbandingan berpasangan yang **melibatkan alternatif bagi pembinaan sebuah sistem pengurusan sisa pepejal lestari.** Diantara pilihan alternatif yang dinyatakan dibawah, adalah perlulah memilih alternatif yang dirasakan relevan untuk dilaksanakan di Pondok, berpandukan penilaian kriteria dan sub-kriteria diatas. Bandingkan alternatif-alternatif tersebut mengikut tahap kepentingan pada Jadual Skala Penilaian.

Bagi menjawab soalan di bahagian ini, sila bulatkan jawapan anda mengikut tahap kepentingan daripada 1 hingga 9 pada alternatif yang dinyatakan. Sila pastikan anda menjawab kesemua bahagian soalan yang diberikan.

Alternatif	**Tahap kepentingan dalam pembangunan Sistem Pengurusan Sisa Pepejal lestari**																	**Alternatif**
Kompos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kitar Semula
Kompos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kompos dan Kitar Semula
Kitar Semula	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kompos dan Kitar Semula

- Soalan tamat , terima kasih -

APPENDIX B Result Calculation

The result of Validity test

Item	Expert 1	Expert 2	Experts in Agreements	I-CVI	UA
Q1	1	1	2	1	1
Q2	1	1	2	1	1
Q3	1	1	2	1	1
Q4	1	1	2	1	1
Q5	1	1	2	1	1
Q6	1	1	2	1	1
Q7	1	1	2	1	1
Q8	1	1	2	1	1
Q9	1	1	2	1	1
Q10	1	1	2	1	1
Q11	0	0	0	0	0
Q12	1	1	2	1	1
Q13	1	1	2	1	1
Q14	1	1	2	1	1
Q15	1	1	2	1	1
Q16	1	1	2	1	1
Q17	1	1	2	1	1
Q18	0	0	0	0	0
Q19	1	1	2	1	1
Q20	1	1	2	1	1
Q21	1	1	2	1	1
Q22	1	1	2	1	1
Q23	1	1	2	1	1
Q24	1	1	2	1	1
Q25	0	0	0	0	0
Q26	1	1	2	1	1
Q27	1	1	2	1	1
Q28	1	1	2	1	1
			S-CVI/Ave	**0.8929**	
Proportion Relevance	25	25	**S-CVI/UA**		**0.8929**
Average Proportion of Items Judged As Relevance Across The Six Experts					**25**

The result of Pairwise Comparison

Step 1: Calculating Pairwise Comparison Matrix for each level

Pairwise Comparison Matrix for Criteria

	EAS	SA	TA	EA	AA
EAS	**1**	0.64	0.53	0.57	0.56
SA	1.56	**1**	0.50	0.58	0.58
TA	1.90	2.01	**1**	0.51	0.49
EA	1.76	1.72	1.95	**1**	0.57
AA	1.80	1.73	2.06	1.76	**1**
SUM	**8.02**	**7.10**	**6.04**	**4.43**	**3.19**

Pairwise Comparison Matrix for Sub criteria

	ER	RC	SIA	SI	H	TE	ATF	TC	EE	ILS	L
ER	**1**	0.49	0.45	0.44	0.41	0.45	0.45	0.52	0.46	0.44	0.50
RC	2.03	**1**	0.56	0.57	0.56	0.54	0.55	0.51	0.53	0.51	0.58
SIA	2.21	1.79	**1**	0.60	0.45	0.53	0.53	0.47	0.48	0.52	0.51
SI	2.26	1.74	1.68	**1**	0.50	0.56	0.55	0.47	0.58	0.53	0.55
H	2.44	1.78	2.24	2.01	**1**	0.50	0.54	0.47	0.51	0.49	0.54
TE	2.24	1.86	1.90	1.77	1.99	**1**	0.54	0.54	0.54	0.54	0.50
ATF	2.23	1.80	1.88	1.82	1.87	1.86	**1**	0.50	0.53	0.56	0.56
TC	1.93	1.97	2.11	2.11	2.14	1.86	2.01	**1**	0.58	0.59	0.57
EE	2.18	1.87	2.06	1.73	1.97	0.54	1.89	1.72	**1**	0.63	0.62
ILS	2.27	1.98	1.93	1.87	2.05	1.86	1.79	1.70	1.59	**1**	0.56
L	2.00	1.72	1.97	1.81	1.85	2.00	1.78	1.76	1.62	1.78	**1**
SUM	**22.77**	**18.00**	**17.77**	**15.74**	**14.78**	**11.69**	**11.63**	**9.65**	**8.43**	**7.58**	**6.49**

Pairwise Comparison Matrix for Alternative

	A1	A2	A3
A1	**1**	0.58	0.49
A2	1.73	**1**	0.51
A3	2.05	1.96	**1**
SUM	**4.78**	**3.53**	**2.00**

Step 2: Second step is the Normalized/ Standardized Pairwise Comparison Matrix. All of the elements in the column are divided by the sum of the column. The priority weights was calculated by averaging all the elements in the row and divided with the number of the criteria.

Normalized/ Standardized Pairwise Comparison Matrix for Criteria

	EAS	SA	TA	EA	AA	**Priority Weight**
EAS	0.12	0.09	0.09	0.13	0.17	**0.12**
SA	0.19	0.14	0.08	0.13	0.18	**0.15**
TA	0.24	0.28	0.17	0.12	0.15	**0.19**
EA	0.22	0.24	0.32	0.23	0.18	**0.24**
AA	0.22	0.24	0.34	0.40	0.31	**0.30**
SUM	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	1.00

Normalized/ Standardized Pairwise Comparison Matrix for Sub criteria

	ER	RC	SIA	SI	H	TE	ATF	TC	EE	**Priority Weight**
ER	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	**0.04**
RC	0.09	0.06	0.03	0.04	0.04	0.05	0.05	0.05	0.06	**0.06**
SIA	0.10	0.10	0.06	0.04	0.03	0.05	0.05	0.05	0.06	**0.06**
SI	0.10	0.10	0.09	0.06	0.03	0.05	0.05	0.05	0.07	**0.07**
H	0.11	0.10	0.13	0.13	0.07	0.04	0.05	0.05	0.06	**0.08**
TE	0.10	0.10	0.11	0.11	0.13	0.09	0.05	0.06	0.06	**0.09**
ATF	0.10	0.10	0.11	0.12	0.13	0.16	0.09	0.05	0.06	**0.10**
TC	0.10	0.10	0.12	0.11	0.13	0.05	0.16	0.18	0.12	**0.11**
EE	0.10	0.10	0.12	0.11	0.13	0.05	0.16	0.18	0.12	**0.11**
ILS	0.10	0.11	0.11	0.12	0.14	0.16	0.15	0.18	0.19	**0.13**
L	0.09	0.10	0.11	0.12	0.13	0.17	0.15	0.18	0.19	**0.15**
SUM	**1.01**	**0.99**	**1.00**	**0.98**	**0.99**	**0.89**	**0.99**	**1.07**	**1.05**	**1.00**

Normalized/ Standardized Pairwise Comparison Matrix for Alternative

	A1	A2	A3	**Priority Weight**
A1	0.21	0.16	0.24	**0.21**
A2	0.36	0.28	0.26	**0.30**
A3	0.43	0.55	0.50	**0.49**
SUM	**1.00**	**1.00**	**1.00**	**1.00**

Step 3: The calculation of Consistency Ratio (CR), where the value must not exceed 0.10 or 10%.

The consistency of the elements was calculated by multiply the each value in the column with priority weights. Then, the weighted sum value is calculated by taking sum of each value in a row.

Consistency of elements for Criteria

Priority Weight	**0.12**	**0.15**	**0.19**	**0.24**	**0.30**	
	EAS	SA	TA	EA	AA	**Weighted Sum Value**
EAS	0.02	0.01	0.02	0.03	0.05	**0.13**
SA	0.02	0.02	0.02	0.03	0.06	**0.15**
TA	0.03	0.04	0.03	0.03	0.05	**0.18**
EA	0.03	0.04	0.06	0.05	0.05	**0.23**
AA	0.03	0.04	0.07	0.09	0.10	**0.32**
SUM	0.12	0.15	0.19	0.24	0.30	**1.00**

Consistency of elements for Sub criteria

Priority Weight	**0.04**	**0.06**	**0.06**	**0.07**	**0.08**	**0.09**	**0.10**	**0.11**	**0.13**	**0.15**	
	ER	RC	SIA	SI	H	TE	ATF	TC	ILS	L	**Weighted Sum Value**
ER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	**0.05**
RC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	**0.06**
SIA	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	**0.06**
SI	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	**0.07**
H	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	**0.07**
TE	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	**0.08**
ATF	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	**0.09**
TC	0.00	0.01	0.01	0.01	0.01	0.00	0.02	0.02	0.01	0.01	**0.11**
EE	0.00	0.01	0.01	0.01	0.01	0.00	0.02	0.02	0.01	0.01	**0.11**
ILS	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	**0.14**
L	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	**0.16**
SUM	0.04	0.06	0.06	0.07	0.08	0.08	0.10	0.12	0.13	0.15	**1.00**

Consistency of elements for Alternative

Priority Weight	**0.21**	**0.30**	**0.49**	
	A1	A2	A3	**Weighted Sum Value**
A1	0.04	0.05	0.12	**0.21**
A2	0.07	0.09	0.13	**0.29**
A3	0.09	0.17	0.25	**0.50**
SUM	0.21	0.30	0.49	**1.00**

After that, the consistency ratio is calculated by dividing the weighted sum value with priority weights.

The **λ max** is calculated by sum up the total values for sum of pairwise comparison for each elements multiply by priority weight of each elements.

Sesequently, the consistency index are calculated based on the formula given below.

Consistency Index (C.I.) = (λ max – n) / (n – 1)

Finally, the **Consistency Ratio (CR)** was calculated by dividing the Consistency Index (CI) with Random Index (RI).

The RI value were referred by using the RI table below

Number of elements (n)	**RI**
3	0.52
4	0.89
5	1.11
6	1.25
7	1.35
8	1.40
9	1.45
10	1.49
11	1.51
12	1.54
13	1.56
14	1.57
15	1.58

Consistency Ratio for Criteria

	EAS	SA	TA	EA	AA	**Weighted Sum Value**	**Priority Weight**	**Consistency Ratio**
EAS	0.02	0.01	0.02	0.03	0.05	0.13	0.12	1.06
SA	0.02	0.02	0.02	0.03	0.06	0.15	0.15	1.00
TA	0.03	0.04	0.03	0.03	0.05	0.18	0.19	0.92
EA	0.03	0.04	0.06	0.05	0.05	0.23	0.24	0.97
AA	0.03	0.04	0.07	0.09	0.10	0.32	0.30	1.05
SUM	0.12	0.15	0.19	0.24	0.30	1.00	1.00	5.00
λ max						**5.18**		
CI						**0.045573**		
CR						**0.041057**		

Consistency Ratio for Sub criteria

	ER	RC	SIA	SI	H	TE	ATF	TC	EE	**Weighted Sum Value**	**Priority Weights**	**Consistency Ratio**
ER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.05	0.04	1.11
RC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.06	0.06	1.04
SIA	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.06	0.06	0.98
SI	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.07	0.07	0.07	0.97
H	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.06	0.07	0.08	0.92
TE	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.06	0.08	0.09	0.93
ATF	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.09	0.10	0.95
TC	0.00	0.01	0.01	0.01	0.01	0.00	0.02	0.02	0.12	0.11	0.11	1.00
EE	0.00	0.01	0.01	0.01	0.01	0.00	0.02	0.02	0.12	0.11	0.11	1.00
ILS	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.19	0.14	0.13	1.02
L	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.19	0.16	0.15	1.08
SUM	0.04	0.06	0.06	0.07	0.08	0.08	0.10	0.12	1.05	1.00	1.00	11.01
λ max										**11.47**		
CI										**0.047069262**		
CR										**0.031171696**		

Consistency Ratio for Alternative

	A1	A2	A3	**Weighted Sum Value**	**Priority Weight**	**Consistency Ratio**
A1	0.04	0.05	0.12	0.21	0.21	1.03
A2	0.07	0.09	0.13	0.29	0.30	0.95
A3	0.09	0.17	0.25	0.50	0.49	1.02
SUM	0.21	0.30	0.49	1.00	1.00	3.00
λ max				**3.03**		
CI				**0.015782504**		
CR				**0.030350969**		

Step 4: Choose the Best Alternatives for the Development of A Sustainable Solid Waste Management System At Pondok Institutions Using Analytical Hierarchy Process (AHP) Method.

The best alternatives was calculated by multiply the priority weights of all criterias by the priority weight of the alternative. After that, calculate the alternative score (total sum of criterias priority weights x alternative priority weight).

After the alternative score calculated, rank the alternatives.

Priority weights of all criteria

Criteria	Priority Weight
EAS	**0.12**
SA	**0.15**
TA	**0.19**
EA	**0.24**
AA	**0.30**

Priority weight of the alternative

Alternatives	Priority Weight
A1	**0.21**
A2	**0.30**
A3	**0.49**

Alternative Score

Alternatives	Score	Rank
A1	0.205676	**3**
A2	0.300387	**2**
A3	0.493938	**1**