University of Southampton

Faculty of Engineering and The Environment

Centre for Environmental Science

FACTORS THAT IMPACTED THE DEVELOPMENT OF MUNICIPAL SOLID WASTE MANAGEMENT: AN ANALYSIS OF VISIBILITY AND INFLUENCE

by

Erni Mariana Mukhtar

Thesis for the degree of Doctor of Philosophy

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Abstract

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Despite a remarkable progress in economic status of countries around the world, there are significant negative implications on the environment resulted from the escalation and complexity of solid waste generated. The development of common strategy to understand the interactions of solid waste management factors has become increasingly challenging due to the differences of city's realities and local waste circumstances.

There are many factors that influenced such differences, how the systems evolved overtime and shaped the future systems. Although various factors of solid waste management are applicable at a basic level in every country, the strength of each factor and depth of interaction with other factors are unique in each local context.

The overall study aims to identify sets of fundamental factors and their interactions between one to another that are impacted the development of solid waste management in terms of their visibility and influence. Visible factors are commonly considered in the development of ~~SWM~~solid waste management which are measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes, published for awareness and available for relevant access by public. Influence of factors refers to the impact of each factor on the development of ~~SWM~~solid waste management.

This study employs a two rounds Delphi to seek global experts' views from developed and developing countries. This study has identified 43 fundamental factors with regard to the development of ~~SWM~~solid waste management systems and classified them via a PESTLE (political, environment, social, technology, legal and economic) system. ~~Global experts classified these factors in terms of their visibility and influence.~~ The analysis of influence and visibility of fundamental factors in ~~SWM~~ solid waste management shows the different interactions of factors ~~that impacted the development of SWM~~ in developed and developing countries.

A conceptual models on waste management status are employed to provide insights on how the ideal combination of fundamental factors can impacted in different conditions. Findings highlights on the need to adopt new perspectives in the selection of factors considered in regard to local waste management systems. Recognising and making use of selected invisible factors within a local context may hasten the implementation and effectiveness of initiatives taken

towards the development of SWM systems. Factors in waste management may vary in influence and change dynamically alongside urbanization; this dynamic varies from one country to another and so factors need to be re-evaluated periodically. Alongside the use of a reliable evidence-base, addressing the factors in terms of their visibility and influence is crucial if municipalities in developed and developing countries are to move towards more effective and locally optimised sustainable waste management systems.

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Declaration of Authorship

I, Erni Mariana Mukhtar declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research titles "Fundamental Factors That Impacted The Development of Solid Waste Management: An Analysis of Visibility and Influence"

I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University;
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- Where I have consulted the published work of others, this is always clearly attributed;
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- Parts of this work have been published as:
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    2. Mukhtar, E., Williams, I., Shaw, P., Ongondo, F., 2016. A tale of two cities: The emergence of urban waste systems in a developed and a developing city. Recycling 1, 254–270. doi:10.3390/recycling1020254
    3. Mukhtar, E.M., Williams, I.D., Shaw, P.J., 2017. Visible and invisible factors of solid waste management in developing countries, in: Cossu, R., He, P., Kjeldsen, P., Matsufuji, Y., Reinhart, D., Stegmann, R. (Eds.), 16th International Waste Management and Landfill Symposium. CISA Publisher, Sardinia, Italy, October 2-6 2015, Paper 439.
    4. Mukhtar, E.M., Williams, I.D., Shaw, P.J., 2018. Visibility of fundamental solid waste management factors in developing countries. Detritus 1, 162-173.

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TERIMA KASIH (Thank you)

Chapter 1: Introduction

1.1 Introduction to solid waste management

All human activities generate waste. Principally, the terms used in defining solid waste describe the intention of the holder to eliminate waste from visibility and has to be complemented with the concept of waste and how waste is perceived by the holders (Pongrácz and Pohjola, 2004; Turner, 2016). Solid waste can be in the form of solid, liquid (in the form of sludge), semi-liquid or in a free chemical phase (Turner, 2016). Generation of solid waste is an inevitable consequence of all processes where materials are used (Shekdar, 2009; Williams, 2015a). The rate of material use today is escalating, both with regard to the total amounts and calculated as an average on *per capita generation*, that the waste generated will impact on the environmental quality and human health globally if it is not managed properly (Lagerkvist and Dahlén, 2012).

A phenomenal growth in the amounts of waste generated has been observed in various regions of the world (Afroz et al., 2011; Ramachandra et al., 2018; Taweesan et al., 2017), drawing various countries and environmental organisations attention (Maddox et al., 2011; Muchangos et al., 2015). With approximately 2.01 billion tonnes on waste generated globally and estimated average of waste generated per person per day ranges from 0.11 to 4.54 kilograms (Kaza et al., 2018), poor management of solid waste can lead to public health risks, adverse environmental impacts and leads to depreciate the water quality and other socio-economic problems (Ramachandra et al., 2018). The development of common strategy to understand the influence of solid waste management factors has become increasingly challenging due to the differences of city's realities and local waste circumstances (Contreras et al., 2010; Wilson, 2007).

1.2 The importance of solid waste management

Solid waste management refers to the supervised handling of waste material from generation at the source through the recovery processes and finally to disposal (Sreenivasan et al., 2012) , in a manner that is in accordance with the best principles of health, economics, engineering, conservation, aesthetics, and other environmental considerations, and that is also responsive to public attitudes (Hwa, 2007). Solid waste collection process includes not only the gathering of waste from the source, but also the transportation of these waste to common collection sites (Chaudhary et al.,

2019). A number of global issues make the management of solid waste a priority environmental stream. These are briefly discussed in the following section.

1.2.1 Resource depletion

The extraction and consumption of resources has an impact on the quality of life and well-being of both current and future generations (Bruckner et al., 2012). The mass consumption of resources resulted from the industrialization had caused threat of massive waste generations and material depletion. The values of materials had gradually increased alongside with the increase rate of material consumption (Marshall and Farahbakhsh, 2013). The per capita level of resource consumption had changed dramatically whereby per capita waste generated across sectors varies evident from 0.54 kg/cap/day in household, 0.018 kg/m2/day in commercial, 0.015 kg/m2/day institutional and 0.47 kg/m2/day in small and medium scale industries (Ramachandra et al., 2018). With world population at 7,750 million people in 2019 (United Nations, 2019), it is expected that greater demand on resources will continue to escalate in the near future in relations to the increase of waste generation (Moh and Abd Manaf, 2014).

The link between urbanization and increased generation of waste has been well-known, however the impact of resource consumption intensity has yet been fully explored and understood (Gharfalkar et al., 2015; Lehmann, 2011). Waste was seen as threat to human health and environment, however, shifting perception of materials scarcity and dire need to conserve natural resources, waste is identified as valuable resources (Demirbas, 2011). In today's consumption-dominated society, resource use has outstripped population growth significantly. Depletion of natural resources has lead to the implementation of more effective waste management practices and solutions (Romero-Hernández and Romero, 2018). Recycling, reuse and materials recovery has emerged as philosophical shift towards waste as resource, rather than burden to the environment (Paz et al., 2013).

A circular economy has been introduced as a sustainable alternative to our current linear economic system. Resources are kept in use for as long as possible to extract the maximum value from them, then produce new products at the end of resources's life (Williams, 2015a). Some of the factors that triggers the promotion of circular economy ambitions are the lack of resources, insufficient use of recycled materials, and poor national strategy on mitigating the resource depletion, accompanied by the desire for sustainable economic growth (Sakai et al., 2011). Key challenges are to go beyond the perception of waste as problem to waste as valuable resources (Williams, 2015a). Circular economy

principles emphasize on the improved design and production practices as a means to enhance resource efficiency through resource recovery from products at the end of their life cycle (Romero-Hernández and Romero, 2018). Figure 1.1 illustrate the transition from linear to circular economy concept. Creating a circular economy helps to increase revenue using by-products previously discarded.

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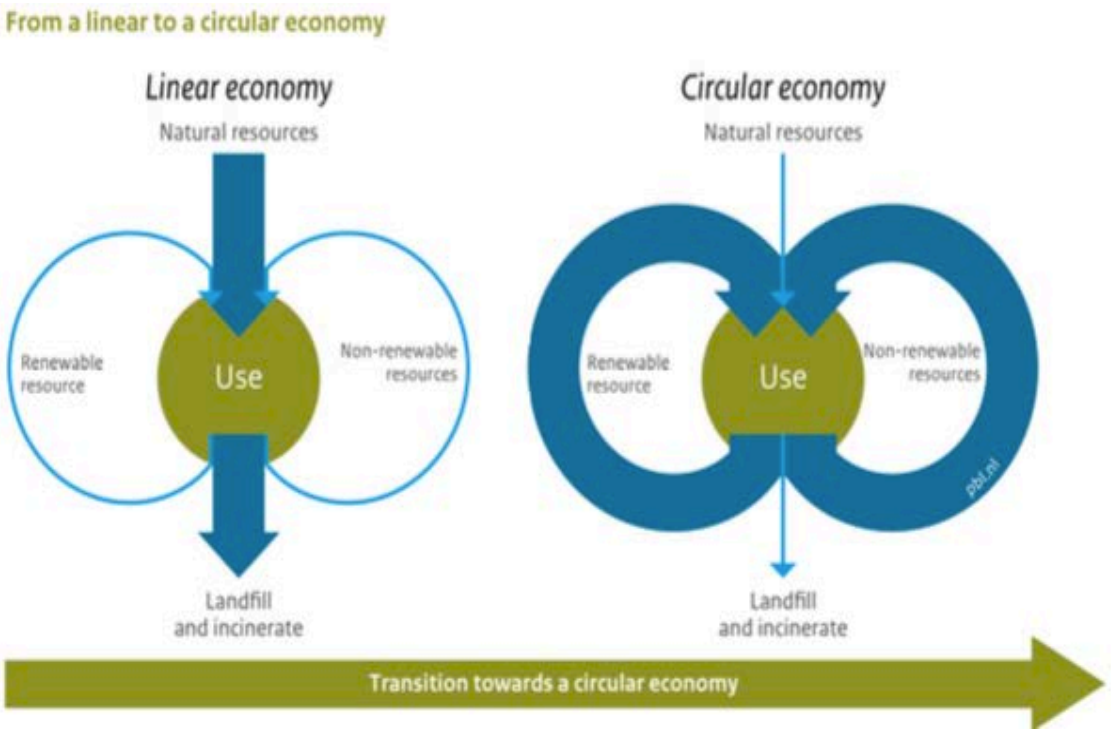


Figure 1.1: Transition from linear to a circular economy (Potting et al., 2017)

1.2.2 Health impact

Human activity generates waste and improper waste management poses threats to human health (H. Yang et al., 2018). Historical evidence of disease and epidemics caused by improper waste disposal and treatment (Louis, 2004), which proved the potential adverse impact of waste onto human health (Albanna, 2012; Giusti, 2009; Melosi, 1981). The impact are non-specific and there are variations in resistance and sensitivity of individual towards waste-related contamination or pollution (Saffron et al., 2003). The increase concerns of human health has initially sparked the objectives of the waste management development (Periathamby et al., 2009b). Uncontrolled burning of solid waste, improper incineration as well as decomposition of organic waste at landfills contributes significantly to urban air pollution (Sandhu, 2014). For example, gases emitted from landfill sites, consist of methane and carbon dioxide, with other gases, such as hydrogen sulphide

and mercury vapour being emitted with a mixture of volatile organic compounds (Rushton, 2003). Solid waste can pollute air, water and soil, lead to various environmental impacts and cause health hazards as a result of poor storage, spillage during transportation and improper disposal method. In order to reduce the impacts to human health resulted from the inappropriate waste disposal and treatment, huge investment is much needed to develop more highly technological waste treatment facilities that have minimal impact on the environment and human health (Giusti, 2009). Residence or employment near the source of pollution caused by waste (e.g. landfill sites, incinerators or any waste disposal facilities), lead to concern regarding links between waste management practices and health outcomes (Saffron et al., 2003). A summary of health hazards, exposure routes and health impacts is shown in Figure 1.2.

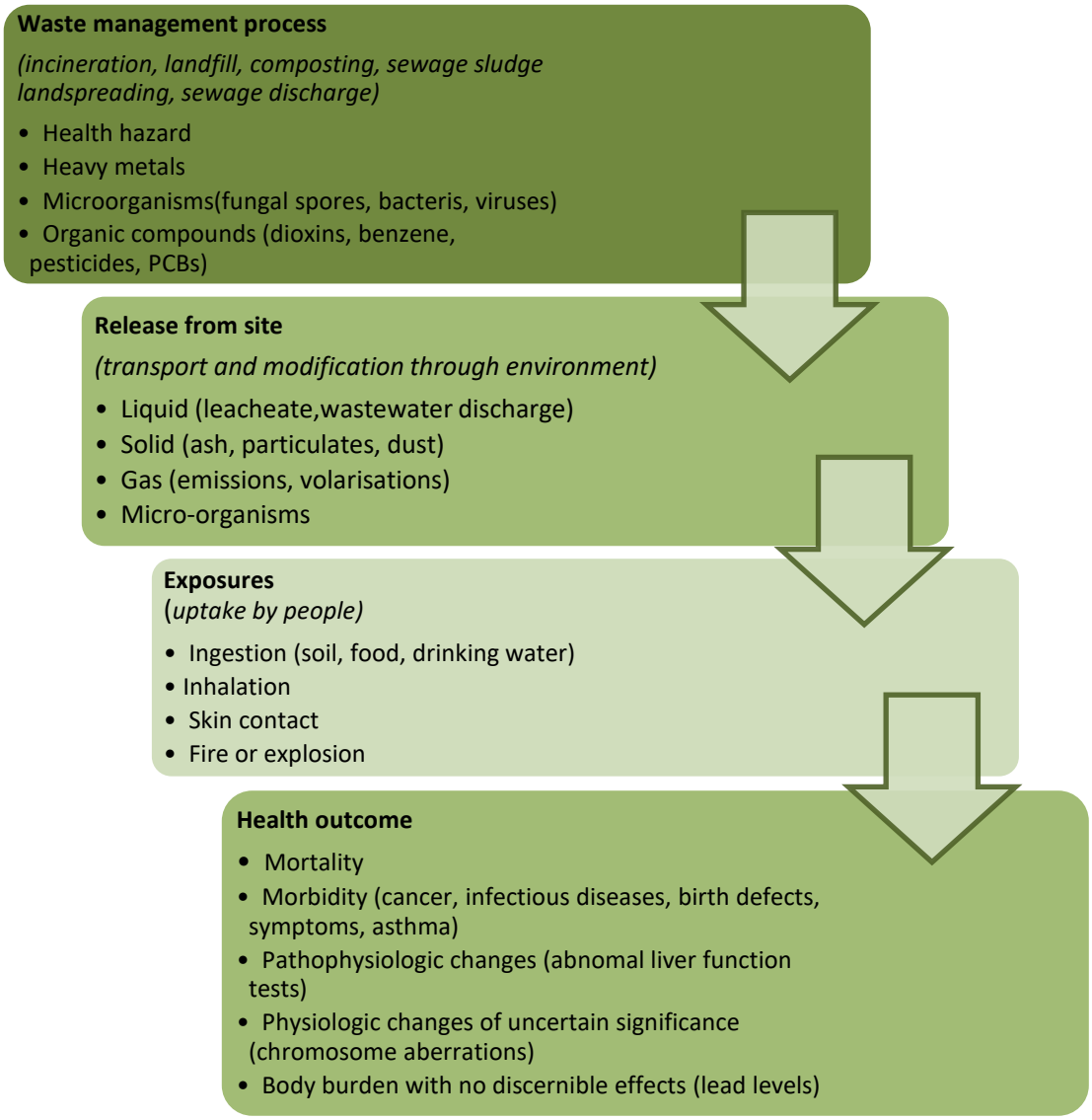


Figure 1.2: Pathways from health hazards to health impacts (Saffron et al., 2003)

1.2.3 Environmental impacts

Poor waste management can affect the environment at different scales as well as being detrimental towards human health and safety (Gupta et al., 2015). For example, leachate seepage into the ground resulted from open dumping of wastes can contaminate nearby water bodies with organic and inorganic pollutants (Albanna, 2012). As the waste generation increased rapidly and waste is disposed of untreated into the environment, the capacity of the natural environment to absorb and process these materials has increasingly burdened. Figure 1.3 shows the potential contribution of emissions from different stages of waste treatment and disposal.

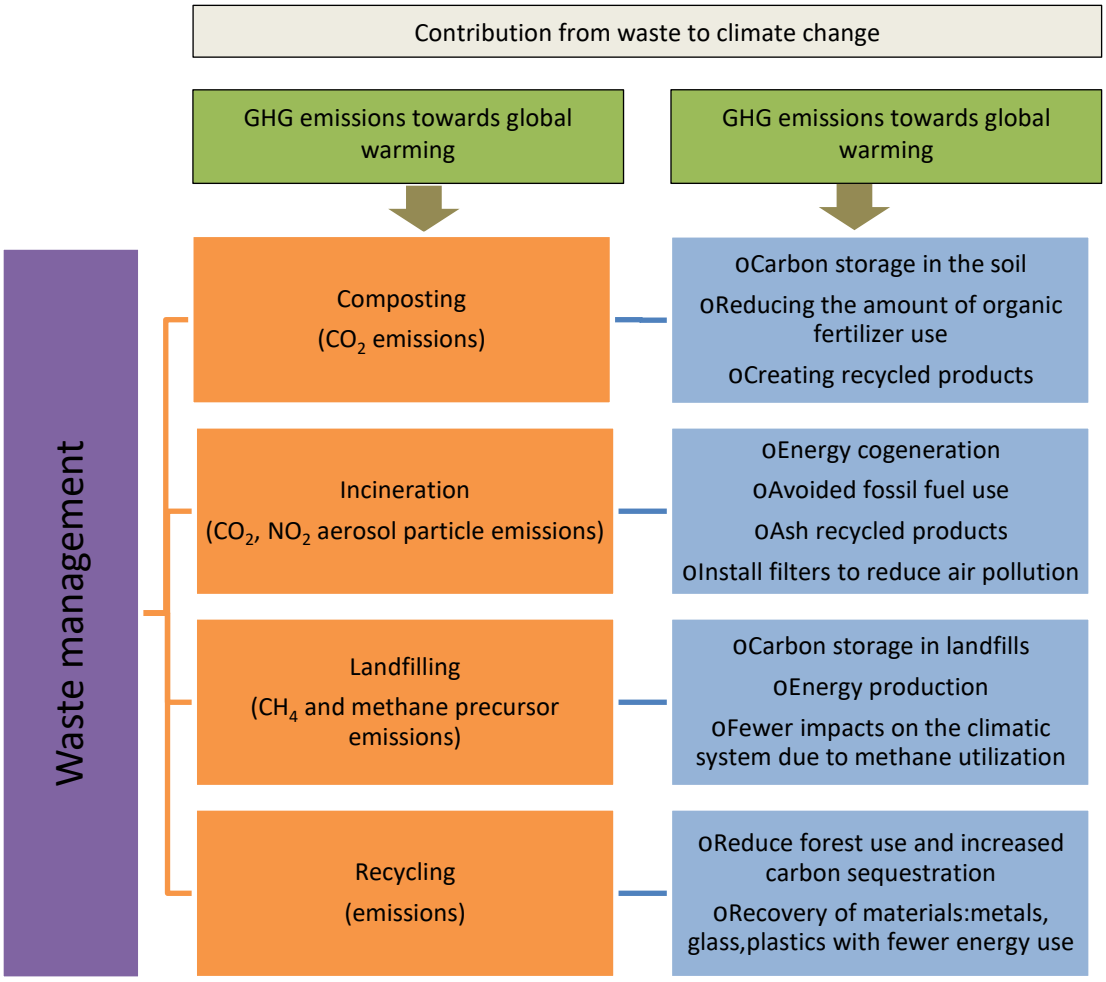


Figure 1.3: Contribution from waste to climate change (United Nations Environment Programme, 2004)

The disposal and treatment of waste can produce emissions of greenhouse gas (GHG), which contribute to global climate change (Turner, 2016; Vergara and Tchobanoglous, 2012). The most significant GHG produced from waste is methane which is released during the breakdown of organic matter. Other forms of waste disposal also produce GHG but these are mainly in the form of carbon

dioxide (CO_2), which considered as a less harmful GHG (Ramachandra et al., 2018). The benefits of waste prevention can outweigh the benefits derived from any other waste management practices. For example, prevention of waste avoids GHG emissions from treatment and disposal of the waste, whilst and recycling and reuse can reduce GHG emissions by reducing the need for raw resource extraction and manufacturing, respectively (United Nations Environment Programme, 2010).

1.3 Current and emerging issues in solid waste management

1.3.1 Differences in solid waste management development between developed and developing countries

The conditions, issues and problems of solid waste management in the developed and developing countries are different (Mmereki et al., 2016) (see Table 1.1). Wilson (2007) and McDougall et al. (2001), for example, highlighted that waste management practises in developed countries focus on optimization of strategies for resource conservation and urban mining. Approaches to waste management in developing cities are often characterised as highly underdeveloped (Badgie et al., 2012; Di Maria et al., 2018a), operationally inefficient, and inadequately managed with limited knowledge and expertise (Guerrero et al., 2013; Zurbrügg and Schertenleib, 1998). These distinct gaps have led to an urgent need for developing countries to seek guidance and advice to shaping waste management systems that are workable and acceptable in the local waste management system (Di Maria et al., 2018a). Solid waste management in developing countries serves basic priorities; to protect public health and environment by eliminating uncontrolled disposal (Wilson and Velis, 2014). Many of the developing countries had faced greater challenges in managing their rapidly-increasing waste generations alongside rapid urbanization and economic growth, limited resources and insufficient financial allocations (Sukholthaman and Shirahada, 2015; Vij, 2012). Developing countries had historically looked to developed cities as exemplary models for rapid solutions of their waste management problems; straight adaptation of the system may lead to disastrous consequences due to the differences in the systems and background (Mukhtar et al., 2015). Alas, the adaptation requires high capital investments in terms of financial funding, developing expertise and skills transfer from developed countries as well facilities and technological application (Badgie et al., 2012; Valencia-Vázquez et al., 2014). Adopting best practices from others experiences may not address local characteristics, customs, peculiarities or waste composition (Periathamby et al., 2009b).

Table 1.1. Summary of performance of solid waste management systems in developed, developing and lesser developing countries

Issues	Developed countries	Developing countries	Lesser developing countries
Governance	Systematic transformation and multifaceted approach	Fragmented organizations and governing bodies	Weak organizational structures
Legal	Systematically implemented and overarching strategic development guidelines Promotion of integrated initiatives in waste management	Broadly implemented SWM policies	Scarce policies and ad hoc approaches
Leaders' interest in solid waste	Policy-makers have developed policies and identified gaps and trends Have diverse interests towards achieving targets	Limited interest to stimulate sustainable approaches	Not embraced optimum reuse, recycling and recovery programmes
Technologies available	Designed and applied integrated methods and techniques as well as sophisticated technologies	Mass burning and landfilling: limited technology	Inefficient SWM technologies and environmentally polluting solutions such as mass burning and landfilling. Shortages of sanitary landfills and landfill sites in urban areas forcing authorities to look for alternative waste management systems
Public awareness	Promotion of community awareness and capacity building as well as community consultation	Limited public awareness	Limited public awareness
Suitable infrastructure	Adequate disposal and treatment infrastructure	Limited availability of treatment and disposal facilities	No readily available disposal and treatment facilities

Source : Mmereki et al. (2016)

The potential sustainable solution to manage the escalating amount of waste generated and complexities of waste characteristics are very much dependent on the local circumstances (Badgie et al., 2012). Understanding how the local waste management operates and the factors that underpin the changes may become fundamental to strategizing towards the sustainable waste management (Periathamby et al., 2009b; Wilson, 2007). Integrating the local elements and global factors that influence the development of waste management could possibly produce holistic solutions to the

problem as well as reducing the gap in efficiency of waste services and knowledge between developed and developing countries.

1.3.2 More bigger cities and population expansion

The size of individual cities is increasing rapidly; which creates bigger cities or megacities. Megacities are the cities that have more than 10 million of people (Ziv and Cox, 2007). There were 4 megacities in 1975, 17 megacities in 2000 and likely to be 39 megacities by 2025 (Mavropoulos et al., 2012). Only 30 percent of the world's population living in urban areas in 1950; this proportion had increased to 55% in 2018 and expected to reach 66 percent in 2050 (United Nations, 2018; Wilson and Velis, 2014). The increased size and numbers of large cities are significantly correlated with economic growth and income level of a country, so is the generation of solid waste within urban areas. Waste management is required to be effective, transparent manner and must work well with communities (Mavropoulos et al., 2012). Rapid population expansion had caused exhaustive consumption of resources and lead to severe damage to the environment (Sakai et al., 2011). Globally, an average of 120 - 130 billion tons of natural resources are consumed every year and around 3.4 - 4 billion tons of municipal solid waste are produced (Song et al., 2015). Decoupling of raw material usage from economic growth is considered a necessary step towards achieving sustainable development and a low carbon economy (Sustainable Europe Research Institute (SERI), 2009). With continued growth of resource consumption, increasing complexity of waste characteristics is anticipated, hence a need for more innovative and rapid solutions.

1.3.3 Application of waste hierarchy

Waste hierarchy is a tool used to evaluate processes intended to protect the environment alongside resource and energy consumption, ranked from the most favourable to the least favourable actions (Van Ewijk and Stegemann, 2016). Ideal waste management means following the waste hierarchy (Figure 1.4), i.e with preference for the prevention of waste, followed by its preparation for reuse, recycling, energy use and finally disposal (Polanec et al., 2013; Williams, 2015b). The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste (Williams, 2014). Application of the waste hierarchy can help to prevent emissions of greenhouse gases, reduces pollutants, save energy, conserves resources, create jobs and stimulate the development of green technologies. Following the waste hierarchy will generally lead to the most resource efficient and environmentally sound choice but refining decisions within the hierarchy or departing from it can lead to better environmental outcomes (Farmer et al., 2015). For instance, life-cycle thinking and assessment can be used to support decision-making and to

identify the best environmental options that suits local circumstances (Turner, 2016). Life-cycle thinking can be applied to the five stages of the waste management hierarchy. It involves looking at all stages of a product's life to find where improvements can be made to reduce environmental impacts and improve the use, reuse and recovery of resource.

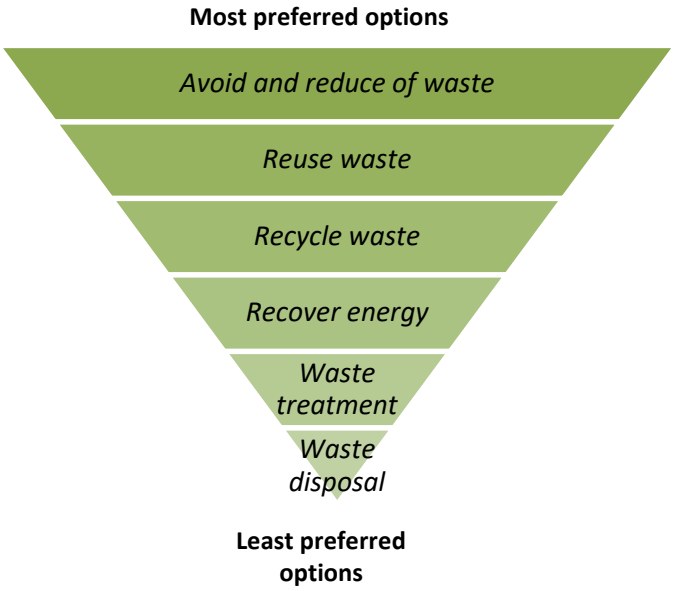


Figure 1.4 : Waste hierarchy (Cole et al., 2014)

Whilst ultimately striving to optimize the waste reduction (Figure 1.4), the benefits of circular economy concept are actually more multidimensional. As discussed in Section 1.2.1, circular economy concept extends the resource use in the cycle to optimize its value in the resource stream. Van Ewijk and Stegemann (2016) argued that waste hierarchy is insufficient foundation for waste and resource policy to achieve absolute reductions in material amount. The adoption of the waste hierarchy can be further emphasized through stringent policies and regulation on the least preferred options of disposal and adaptation of value-based concept of waste practices.

1.3.4 Appropriate decision making tools for solid waste management

The key of waste management plan is to establish an acceptable cost whilst balancing environmental, economic, technical, regulatory, and other social factors (Allesch and Brunner, 2014).

Table 1.2. Description of the assessment methods in solid waste management

Assessment method	Description
Life cycle assessment (LCA)	LCA addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle, from raw material acquisition through production, use, end-of-life treatment, recycling, and final disposal (ISO 2006)
Cost benefit analysis (CBA)	The essential theoretical foundations of CBA are defining benefits as increases in human wellbeing (utility) and costs as reductions in human wellbeing. All benefits are converted to monetary units. The cost component is the other part of the basic CBA equation
Multi-criteria-decision-making (MCDM)	MCDM is a decision-making tool that facilitates choosing the best alternative among several alternatives. This tool evaluates a problem by comparing and ranking different options and by evaluating their consequences according to the criteria established
Benchmarking	Benchmarking is a continual comparison of products, services, methods, or processes to identify performance gaps, with the goals to learn from the best and to note out possible improvements
Cost effectiveness analysis (CEA)	CEA evaluates alternatives according to both their cost and their effect concerning producing some outcome (Levin and McEwan, 2000). CEA allows the consideration of intangible effects.
Eco-efficiency analysis (Eco-Eff)	Eco-efficiency analysis (Eco-Eff) denotes the ecological optimisation of overall systems while not disregarding economic factors. The Eco-Eff analysis by BASF quantifies the sustainability of products and processes, considering the environmental impacts and economic data concerning a business or national economic level (Saling et al., 2002)
Emergy analysis (EA)	Emergy is the amount of available energy that is used up in transformations, directly and indirectly for a service or product. The EA is an evaluation method that considers both environmental and economic values
Environmental impact assessment (EIA)	EIA is a method that has to be performed before consent is given to a project. Significant effects on the environment by virtue, inter alia, of their nature, size, or location are made subject to a requirement for development consent and for an assessment concerning their effects (Directive 2011/92/EC).
Exergy analysis	The exergy method evaluates the qualitative change from the available energy to the unusable one in the form of work
Life cycle costing (LCC)	LCC is an economic analysis method in combination with LCA. This method is a tool for accounting the total costs of a product or service over a long life span
Risk assessment (RA)	RA is an integral part of the overall organisation's performance assessment and measurement system for departments and for individuals. The goal is to provide a comprehensive, fully defined, and fully accepted accountability for risks (ISO 2009).
Statistical entropy analysis	The statistical entropy analysis is a method that quantifies the power of a system to concentrate or to dilute substances
Strategic environmental assessment (SEA)	SEA is a method to provide a high level of protection to the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes, with an aim to promote sustainable development by ensuring that an environmental assessment of certain plans and programmes, which are likely to have significant effects on the environment, is performed (Directive 2001/42/EC)

*Adapted from Allesch and Brunner (2014)

Assessment tools and methods are able to support decision-making in solid waste management by identifying weaknesses or strengths of existing systems in a structured way (Zurbrügg et al., 2014). Hence, for evaluation of the system, economic boundary, local circumstances and sustainability aspects (social, technological, environmental) need to take into consideration. Decision makers are often in a dilemma to choose the most appropriate and cost effective method for reaching the goal and targets of solid waste management (Li, 2007). The most popular sustainable decision making models are life-cycle assessment, cost–benefit analysis and multicriteria analysis. Life cycle analysis calculates the environmental impact of all processes of the waste treatment from "cradle to grave"; cost–benefit analysis considers the monetary dimension, while multicriteria decision analysis compares social, economic, and environmental criteria (Morrissey and Browne, 2004; Tsydenova et al., 2018). Ultimately, considerations of all relevant factors in solid waste management within local circumstances is vitally important to determine the success or failure of the selected assessment methods for decision making (Zurbrügg et al., 2014). In developing countries, where problems associated with solid waste management are more challenging than in developed countries (Badgie et al., 2012; Gupta et al., 2015), existing tools should be more flexible to make them simpler and cheaper to apply. Limitations and gap of knowledge are identified in developing countries; adaptation of existing system or technology from developed countries that could lead to disastrous consequences without detailed preparatory research (Wilson and Velis, 2014). Assessment methods are not only required for the development of a new solid waste management system or plant, but also to evaluate existing situations. Several tools are available, with several applications to waste management (Table 1.2). However, some limitations and gaps of knowledge are identified, requiring a serious work of researchers and practitioners to overcome challenges and to facilitate a positive application in low- and middle-income countries.

The issues highlighted in this section indicate that there are increasingly complex chellenges related to solid waste management that require attention to further avoid its negative consequences to the environment and public health. Nevertheless, the sector also offers great opportunities for private sector participation and for revenue-making businesses. It is important to understand the historical and evolution of solid waste management system, focusing on the factors and their interactions that drive such changes. This is vital for decision making regarding the design of strategies and systems to manage solid waste that would maximise the recovery of resources with minimal impacts on public health and environmental quality.

1.4 Research framework

1.4.1 Research problem

The acceleration of industrialization on a global scale during the last century, the population expansion and the resulting intensification of urbanization, have transformed the relationships between the environment and society (Guerrero et al., 2013). Despite remarkable progress in economic status of countries around the world, there are significant negative implications on the environment resulted from the escalation and complexity of solid waste generated. The challenges of sustainable solid waste management are well knbown (e.g Ai, 2011; Cohen, 2006; Guerrero et al., 2013; Gutberlet, 2017; Khatib, 2011; Le Courtois, 2012; Vij, 2012; Wilson and Velis, 2015). However, Mwanza and Mbohwa (2017) stated studies that analyze the drivers of solid waste management literally are relatively few. Enhancement of the solid waste management system can be amplified by identifying and interpreting the drivers and barriers (Mwanza and Mbohwa, 2017; Periathamby et al., 2009b; Wilson et al., 2001). In developing countries, the management of waste is becoming more complex as a result of rapid urbanization and the increasingly heterogeneous nature of consumer products. Expansion of global population, rapid urbanization, increasing economic activity and an uprise in society's living standards, particularly in major cities in developing countries have led to substantial growth in waste generation (Di Maria et al., 2018b; Khatib, 2011). On the contrary, waste management in developed countries are often described as systems with efficient policy frameworks, well-organised, facilitated with well-engineered infrastructures and technology, experts and funding (Mmereki et al., 2016).

There are many factors that influenced such differences, how the systems evolved overtime and shaped the future systems. Most of the reviewed studies have focused on the contribution of factors in isolation. Past studies have listed factors into different classification and unique in each waste management scenario, for example, within the context of a municipality, city or entire country. Although various factors of solid waste management are applicable at a basic level in every country, the strength of each factor and strength of interaction with other factors will be unique to each local context. Thus, the main aim of this study is to identify the factors in different localities that serves as the starting point to design waste management strategy or policies based on tangible local trends or evidence. There is a need to design a framework where combinations of various factors that works efficiently in different set of waste management system can be identified. In this study, the commonly-highlighted factors, which are quantifiable and measurable, are identified as "visible". Whilst most attention has been paid to measurable factors in solid waste management, there are

also factors that influenced the system but receive little attention. These factors can only be identified through the historical evidence or waste managers' experiences that provide different perspectives of the development of the system. In this study, we identified the non-measurable and non-quantifiable factors as "invisible".

1.4.2 Aims and objectives

In order to address the research problem outlined in previous section, the overall study aims to identify sets of fundamental factors and their interactions between one to another that are impacted the development of solid waste management in terms of their visibility and influence.

Aim 1:
Identify and critically review the fundamental factors that are visible, and influence, the development of SWM system in developed and developing countries.

Objectives:

1.1 Identify and characterize the fundamental factors that are relevant in the development of solid waste management.

Aim 2:
Analyse the visibility and influence of the fundamental factors to demonstrate a conceptual framework illustrating the interactions of factors that influence the solid waste management.

Objectives:

2.1 Classify and critically review the visible and invisible factors in solid waste management in developed and developing countries.

2.2 Investigate the interactions of visibility and influence of factors to establish the ideal combinations of factors that works best in the development of solid waste management.

1.4.3 Research questions

The research questions provide the main themes and direction of this study. An exploration of the experiences of respondents highlights the influence of various factors on the development of solid waste management system within each local context. The research questions are developed based on the literature and as elucidated below:

RQ1. What are the important factors in the development of solid waste management system?

RQ2. How these factors interact with each other and how intense the connections are?

RQ3. What are the ideal combinations of factors that efficiently drive the waste systems towards sustainability?

There is a need for planners and decision-makers to understand their current waste management status and identify what are the important and influential factors that were excluded from being considered in the local waste management policy and strategy. Knowledge about the visible and invisible factors might help planners in identifying factors within its areas of responsibility and addressed the issues more precisely and effectively. The analysis of visibility and influence of the factors may be able to provide better understanding on the ideal combination of factors that works best within a local circumstances.

Key aspects of the research scope include:

a) This thesis is concerned with the management of solid waste, principally municipal solid waste (MSW), hence, the management of wastewater and electrical/electronic waste are not considered.

b) This thesis addresses factors that impacted the development of municipal solid waste according to PESTLE (political, environment, social, technology, legal and economic) analysis. It is necessary to concentrate and focus on selected classification method for more thorough investigation and discourse on those topics.

c) This thesis explores the interactions of factors in terms of their visibility and influence in order to identify the important factors that impacted the development of solid waste management in developed and developing countries.

d) The analytical framework and supporting information are intended to be used to support decision making by different factors, including private companies and entrepreneurs, local governments and national governments.

1.5 Structure of thesis report

This thesis conveys together the fundamental parts of the research conducted in order to fulfil the study aims and objectives. This thesis is presented in seven chapters and is structured as follows:

- Chapter 1 comprises a brief introduction to the research field and defines the primary research aims and scope of this thesis. Section 1.1 and 1.2 provides the introduction and importance of solid waste management. In Section 1.3, a brief explaination on the current and emerging issues of solid waste management that builds the fundamental design of the research problem and questions as outlined in section 1.4. Section 1.5 oulined the structure of the thesis.
- Chapter 2 presents the literature review that provides the broad context of the research. Section 2.1 briefly explained the historical evidence of solid waste management in selected cities/countries. Section 2.2 provides the variety definitions of solid waste management around the world with examples from selected cities. The different classification of solid waste are explained in Section 2.3 while Section 2.4 focusing on the municipal solid waste management, which is the main subject matter in this study. In Section 2.5, the past literature on factors that are important in the development of solid waste management which builds the list of factors employs in this study were discussed.
- Chapter 3 describes the methods employed in the study, which includes the data collection, statistical analysis and the justification of the selected methods. The discussions include the assessment and justifications of the selected methods in conducting the survey and data analysis.
- Chapter 4 presents the partial results from Delphi study which focusing on the analysis of visibility of factors in the development of solid waste management. This chapter was partially presented and published in the *Proceedings of the Sixteenth International Waste Management and Landfill Symposium, Sardinia Italy, October 2-6 2017* under the title "Visible and invisible factors of solid waste management in developing countries". This chapter fullfilled requirement of aim 1 (objective 1.1) by establishing a comprehensive list of factors from the literature and classify these according to the PESTLE (political, environmental, social, technological, legal and economic) system. It also partially fulfilled aim 2 (objective 2.1) by identifying and classifying the factors as "visible" or "invisible" in practice through a Delphi study.The partial work from this chapter also has been peer-reviewed and published as:

Mukhtar, E.M., Williams, I.D., Shaw, P.J., 2018. Visibility of fundamental solid waste management factors in developing countries. *Detritus* 1, 162-173, doi.org/10.26403/detritus/2018.16

- Chapter 5 presents the partial results from the Delphi study on the factors that influence the development of solid waste management. The work presented in this chapter fulfilled the aim 2 (objective 2.2) by investigating the interactions of visibility and influence of factors. This chapter had first quantifies the influence of fundamental factors in solid waste management through a Delphi study. It also assessed the factors that are influential in consideration of its visibility in relation to the demonstrate the interactions of factors.
- Chapter 6 discusses and evaluates the overall findings of Chapter 4 and 5 within the context of conceptual model and its relation to the main study aims. It also demonstrates the application and consideration of the identified factors in selected case studies.
- Chapter 7 presents the overall summary and recommendations from the research project as a whole are presented, along with suggestions for further research.

Chapter 2: Literature review

2.1 History of global solid waste management development

A profound examination of solid waste management can reveal the development of solid waste management through its historical evolution (Louis, 2004). Scholars viewed that early waste management in the United States has received systematic attention (Barles, 2010; Louis, 2004; Melosi, 1981; Wilson, 1976), but limited number of research on other regions (Velis et al., 2009). Evaluation of historical evidence provides insights on some of the important factors that have influenced the development of solid waste management in different cities around the world.

2.1.1 From the emergence of ancient cities to Pre Industrial Revolution (1000-1800)

From the earliest civilizations, burial of wastes has always been considerably easy in rural areas, whilst in larger cities, disposal problems become difficult with increase of population density (Wilson, 1976). In the early period of human development, streets were covered with organic waste, household waste, animal and human manure, that mixed with stagnant water, and hence caused foul-smelling mud (Barles, 2010; Louis, 2004). The needs to create an organize solid waste management came alongside with the development of the new cities and town with the concentration of population and increase of land use (Louis, 2004; Melosi, 1981). For example, the Greeks organized its first municipal dumps by 500 B.C with a basic waste collection using wagons (Wilson, 1976) and disposal to dump pits located at rural areas (Melosi, 1981). The Chinese cities were reported to have ‘‘disposal police’’ responsible for enforcing disposal laws by 200 BC (Marshall and Farahbakhsh, 2013).

Initiatives to clean the streets were taken; streets pickers were assigned by the authorities to clean the streets (Melosi, 1981). In England, for instance, wastes were collected from property owners, which were mainly rich people who paid for the services (Wilson, 2007). Residual and organic waste were sent to the farmers for use as fertilizers or as animal feeds, whilst ‘consumer’ and any resellable items were either repaired, reused and sold to provide a source of income to the pickers (Velis et al., 2009; Wilson, 2007). In small communities, the wastes were treated individually by the generators, either being disposed into water bodies or simply buried (Marshall and Farahbakhsh, 2013). However, as the urban areas expanded and developed into

towns and cities, unsafe and improper waste disposal started to cause significant public health problems as well as creating odours and attracting rodents and pests (Louis, 2004; Seadon, 2006). Poor sanitation and improper waste disposal caused the plagues that affected most of the Europe between the 14th to 16th centuries (Wilson, 2007). The Black Death[1] was partially caused by streets littering and waste dumping into waterbodies that caused contamination and indiscriminately claimed lives more than 2000 people a day at its peak (Gottfried, 2010; Marshall and Farahbakhsh, 2013). Sir Edwin Chadwick, through his publication, *Enquiry into the Sanitary Condition of the Labouring Population of Great Britain* in 1842, linked the public health with degraded, unsanitary environmental conditions and believed that organized and improved waterworks, sewers, clean paved streets, and ventilated buildings were necessary to control the epidemics that had plagued London throughout the late 18th and early 19th centuries (Chadwick, 1965). Chadwick's work has influenced researchers in the America to emphasized on the importance of public health through good sanitation and controlled littering (Louis, 2004). Epidemics were reported; the yellow fever outbreak in Philadelphia in 1793 that claimed more than 5600 lives and also cholera outbreaks in New York in 1832 and 1849 that caused more than 100,000 deaths (Louis, 2004; Sandhu, 2014). The primary causes of these diseases were believed to be associated with poor sanitation, littering and improper disposal of waste (Hezri, 2010; Velis et al., 2009).

2.1.2 Early Industrial Revolution (1800-1900)

In the late of 18th century, the development of solid waste management systems appeared to be more aggressive with emerging concern on public health, resource value and recovery (Velis et al., 2009) that resulted from the Industrial Revolution in the late 18th and early 19th century (Williams, 2015a). Before the beginning of Industrial Revolution, the quantity of waste were generally small with unsatisfactory collection methods and disposal, which caused disturbance towards public comfort (Barles, 2010). The Industrial Revolution and rapid urbanization in most part of the Western world led to the high demand of material and expansion of the waste management services in the cities (Wilson, 2007). Velis et al. (2009) and (Herbert, 2007) claimed that London dust-yard was the first large scale of zero waste system and set example of a semi-formal and organised method to waste management (Figure 2.1). Residual waste, which was largely composed of coal ash from domestic fires, was generated and was in demand for both

[1] Black Death was the greatest natural disaster in European history. The plague was caused by a combination oif bubonic, pneumonic and septicaemic plague strains. It devastated the Western countries from 1347 to 1351 by killing almost 60% of Europe's population (Gottfried, 2010).

brick making and soil conditioner (Herbert, 2007). Soil from the dust yard were sent to the farmers to be used as fertilizers while other household items were repaired and later sold (Velis et al., 2009). These collection networks were mainly carried out by the informal pickers that efficiently removed the major components of waste from the cities. According to (Herbert, 2007), calls for the establishment of a municipal authority with waste removal powers were inititied as early as 1751 by Corbyn Moris, who proposed to standardize the cleaning of London under one public management as a move towards efficiency. The dust-yard system had been working successfully up to middle 1850s, when the market value of 'dust' collapsed coincide with the emergence of the sanitation movement. (Velis et al., 2009). Waste was then collected by the municipality, hence, many controversional and different types of contractual agreements existed between the private and public sector (Velis et al., 2009). During the late 18th and early 19th centuries, technological advancements in waste collection and disposal methods included the development of "destructors" (incinerators) and crude sanitary landfills started to replace the traditional practice of open dumping (Herbert, 2007; McAllister, 2015). The first incinerator was built in England in 1874 which later expanded to other countries such as Germany and America (Wilson, 1976).

Figure 2.1. The sifting process of ashes at a dust yard in London in 19th century (Velis et al.,2009).

2.1.3 Urbanization and Industrialization Era (1900-1970)

The Industrial Revolution brought large increases in population in cities around United States of America; in 1790, city dwellers in 24 cities accounted for 5.1% of total population and in 100

years later, the number had increased to 10.8% of total population who resided in 131 cities (Louis, 2004). The escalation of urban population was mainly due to the technology expansion and industrialization which has bloomed rapidly in the late of 19th century, when 50% of the countries' goods were manufactured in urban areas hence contributed to the increased of industrial and domestic waste (Louis, 2004). From the 1830s onwards, technological optimism was obvious in the west, which had implications for natural resource management. However, after 1945, in most part of the Europe, awareness of environmental problems emerged along with the "sustainable development" movement (Kollikkathara et al., 2009).

The development of proper sanitation infrastructure and institutional arrangement on waste management were implemented on regional scale in the 1870s (Melosi, 1981). However, due to high investment on water sanitation infrastructure, waste were managed at local level; the similar system that still persists today in most of the American cities (Louis, 2004). In some parts of the world, systems for waste management developed at different rates. In Japan, prior to the World War II, the initiatives started with providing public sanitation and then proper solid waste management and disposal were developed. Incineration of solid waste was implemented as early as 1930 when the Waste Cleansing Law enforced compulsory incineration of solid waste as a result of limited areas for landfills (Williams, 2015a). The World War II had destroyed all infrastructure and facilities,hence rapid changes had occurred since then. Japan now has one of the most modern and technologically advanced systems for waste management in the world. Other Asian countries (India, China and Indo- nesia) have responded to the challenges of waste management as their populations have grown, become richer and more urbanized. However, large parts of the world still have little or no effective systems for safely collecting, treating and disposing of waste from anthropogenic activities, with open dumping and uncontrolled burning and composting widespread.

2.2 Definitions of solid waste

Defining solid waste can be simple and often negligible, but addressing it within the local context is important (Pongrácz and Pohjola, 2004). The definition has to be sufficiently wide to cover all relevant activities with regard to waste but not be too wide to avoid over-regulation (Cheyne and Purdue, 1995). Definition is said to be the only adequate method of characterising a scientific concept (Hempel, 1966).

Table 2.1. Definitions of solid waste according to selected world organisations and countries

Organisations	Definitions
European Union	Any substance or object which the holder discards or intends or is required to discard (European Commisssion, 2008)
Organisation for Economic Co-operation	Materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose (OECD, 2014)
United Nations Environment Program	Substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law (United Nations Environment Programs, 1994)
Countries	**Definitions**
United Kingdom	Any substance or object which the holder discards or intends or is required to discard (Department of Environment Food and Affairs (DEFRA), 2012)
Malaysia	Any scrap material or other unwanted surplus substance or rejected products arising from the application of any process; any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled; or any other material that according to this Act or any other written law is required by the authority to be disposed of (Malaysia Government, 2005)
China	Any solid, semisolid, or contained gaseous substance or material resulting from production, daily life and other activities, which lose its original utilization value, or which does not lose utilization value but is discarded, and substance or material regulated as solid waste by laws and regulations (Ministry of Commerce of the People's Republic of China Department of Foreign Investment Administration, n.d.)
United States of America	Any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, oe air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining and agricultural operations, and from community activities (US EPA, 2013)
Switzerland	Any moveable material disposed of by its holder or the disposal of which is required in the public interest (The Federal Council, 2019)
Singapore	A substance or object that is proposed to be disposed of; or disposed of; or required by any written law to be disposed of (Singapore Government, 2019)
South Africa	Any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act; or any other substance, material or object that is not included in Schedule 3 that may be defined as a waste by the Minister by notice in the Gazette, but any waste or portion of waste, referred to in paragraphs (a) and (b), ceases to be a waste— (i) once an application for its re-use, recycling or recovery has been approved or, after such approval, once it is, or has been re-used, recycled or recovered; (ii) where approval is not required, once a waste is, or has been re-used, recycled or recovered; (iii) where the Minister has, in terms of section 74, exempted any waste or a portion of waste generated by a particular process from the definition of waste; or (iv) where the Minister has, in the prescribed manner, excluded any waste stream or a portion of a waste stream from the definition of waste (South African Government, 2014)

There are various definition of solid waste, based on various perceptions (Amasuomo and Baird, 2016; Zaman and Lehmann, 2011); it can be categorized according to type of generator and source (Ai, 2011), substances and composition (Boer et al., 2010), territorial limits and economic activities that generates waste (Buenrostro et al., 2001) and type of collectors or service provider (United Nations Human Settlement Programme, 2010). The variation in definitions of solid waste creates confusion and leads to different interpretations. Therefore it is important to understand local definition in order to address the relevant issues precisely. Table 2.1 provide the list of definitions of solid waste according to the selected world organisations and countries.Waste can be considered the useless by-product of human activities which physically contains the same substance that are available in the useful product (White et al., 1995). Wastes are not only defined as any product or material which is useless to the producer, but also as by-products that were generated from inefficient production processes which lead to the loss of resources (Amasuomo and Baird, 2016). Principally, the terms used in defining solid waste describe the intention of the holder to eliminate waste from visibility and has to be complemented with the concept of waste and how waste is perceived by the holder(s). The term 'waste' is often subjective, with the designation of a material or substance as being waste dependent on the situation and the value recognized to the material or substance by its owner in that situation, i.e. what may be waste to one person may not be waste to another.

Despite of all broad variations in defining waste, certain limits has to be set on how far the definition can be stretched and suitable to its purpose (Cheyne and Purdue, 1995). Nevertheless, to hypothetically describe waste is not the main purpose of these definitions. The label 'waste' does not necessarily mean that something is an ultimate waste, rather, it means that it will be treated as waste. It appears that it is not possible to create or identify a comprehensive definition that explicitly categorises every discarded object as either waste or resource (Pongrácz and Pohjola, 2004).

2.3 Classifications of solid waste

Solid waste is commonly described as solid state of the waste (Turner, 2016). According to Turner (2016) and Periathamby (2001), the classification of solid waste depending on schemes as follows:

a) physical form (solid, gaseous, liquid, etc.)
b) source of generators (household, commercial, industries, etc.)
c) original use (packaging, garden waste, food waste, etc.)

d) material type (glass, paper, plastic, etc)

e) physical properties (biodegradable, combustable, recyclable, etc)

f) safety parameters (hazardous, non-hazardous or radioactive)

Table 2.2. Sources, generators and type of solid waste generated

Source	Waste generators	Types of solid wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes (e.g., paints, aerosols, gas tanks, waste containing mercury, motor oil, cleaning agents), e-wastes (e.g., computers, phones, TVs)
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants (excluding specific process wastes if the municipality does not oversee their collection)	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, e-wastes
Institutional	Schools, hospitals (non-medical waste), prisons, government buildings, airports	Same as commercial
Construction and Demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, bricks, tiles
	Street	
Municipal Services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas, sludge
All of the above should be included as municipal solid waste. Industrial, commercial, and institutional (ICI) wastes are often grouped together and usually represent more than 50% of MSW. Construction and demoliation waste is often treated separately: if well managed it can be disposed separately. The items below are usually considered MSW if the municipality oversees their collection and disposal.		
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off-specification products, slag, tailings
Medical	Hospitals, nursing homes, clinics	Infectious wastes (bandages, gloves, cultures, swabs, blood and body fluids), hazardous wastes (sharps, instruments, chemicals), radioactive waste from cancer therapies, pharmaceutical waste
Agricultural	Crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food wastes, agricultural wastes (e.g., rice husks, cotton stalks, coconut shells, coffee waste), hazardous wastes (e.g., pesticides)

Source : Hoornweg and Bhada-Tata (2012)

Each of these aspects has the effect of the type of waste management that is required, favored, or legally prohibited for a given waste flow (Turner, 2016). The focus of this study is on municipal solid waste (MSW), which comprises waste from households and other waste that are similar in nature to household waste. MSW is conceptualized as the solid waste generated within the territorial limits of a municipality, independently of its source of generation (Buenrostro et al., 2001). Table 2.2 shows the sources, generators and types of waste generated to further explain the source of generators considered in MSW. As mentioned above, solid waste can be classified as being either hazardous or non-hazardous. Whilst MSW may contain small amounts of hazardous wastes, it is predominantly non-hazardous (Hoornweg and Bhada-Tata, 2012). Waste may be classified hazardous if it is potentially harmful to human health, living organisms, or the environment (Turner, 2016).

Examples of hazardous waste includes:

- asbestos, batteries, electrical equipment containing ozone depleting substances (e.g. fridges and freezer and cathode ray tubes), fluorescent tubes, oils and oil filters, paints, inks, and resins, pesticides and solvents (Turner, 2016)
- form of paints, vehicle maintenance products, mercury-containing waste, pharmaceuticals, batteries and many other diffuse products (Mmereki, 2015; Slack et al., 2005)

These hazardous substances in household waste are not strictly controlled under hazardous waste regulations and commonly disposed of to landfill along with other household waste (Slack et al., 2005). The risk of disposal at landfill are often negligible due to insignificant amount of hazardous substances in the waste stream (Mmereki, 2015). According to (Pitchel, 2005), MSW are classified as hazardous if they consists one or more of the following characteristics: ignitability, corrosivity, reactivity and toxicity. In this study, MSW includes waste generated from residential, industrial, commercial, institutional and municipal sources.

2.4 Municipal solid waste management

In the European Union, solid waste management (SWM) is defined under Article 1 of the Council Directive on waste (75/442/EEC) that modified by Directive (91/156/EEC) on waste as "….collection, transport, recovery and disposal of waste, including the supervision of such operations and after-care of disposal sites and including actions taken as a dealer or broker" (European Union Law, 2013). SWM includes elements associated with control of waste generation, storage, collection, transport or transfer, processing and disposal of solid waste

materials (see Figure 2.2) in a way that best addresses the range of public health, conservation, economics, aesthetic, engineering and other environmental considerations (Kreith and Tchobanoglous, 2002; Pitchel, 2005). It involves multidisciplinary approach in order to reduce the adverse impacts of waste materials on human health and environment as well as supporting the economic development and superior quality of life (McAllister, 2015).

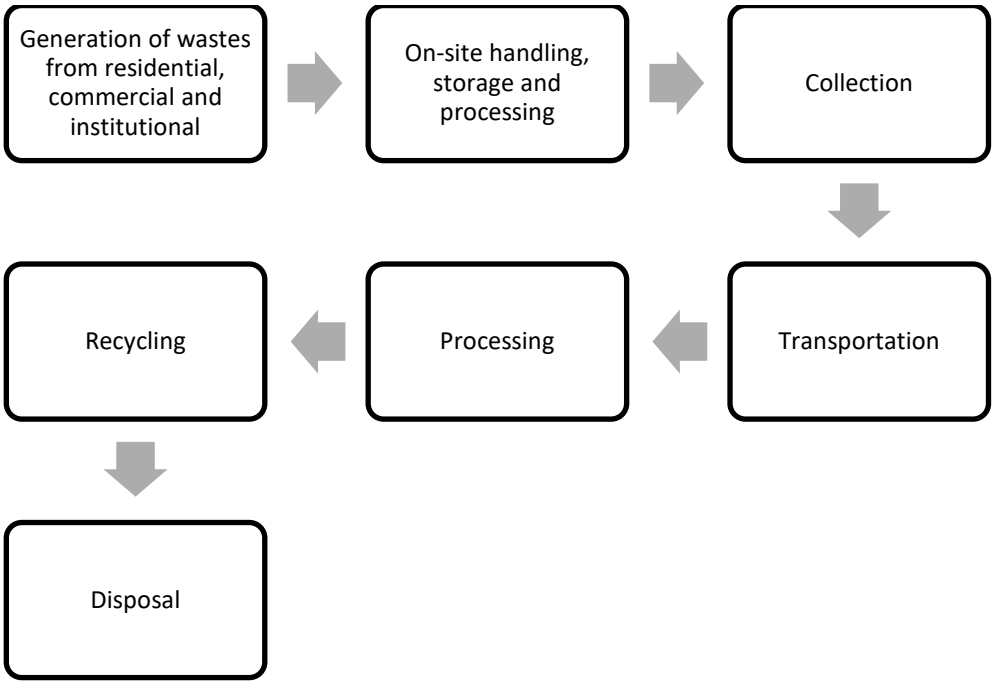


Figure 2.2. Functional activities in solid waste management (Khan and Samadder, 2014)

Municipal solid waste management (MSWM) is known to be an important contributor to environmental and public health problems (Dinie et al., 2013; Li et al., 2009). The objectives of MSWM are to consider human safety, resource conservation and the reduction of the environmental burdens of MSWM (Q. Yang et al., 2018). White, Franke and Hindle (1995) argued that collection, treatment and disposal of MSW is considered as an important service by politicians and local government. MSW is wastes collected for local authorities from domestic, commercial and household sources (Amasuomo and Baird, 2016). MSW also reflects the lifestyles and customs of the people that produces it, which has negative impact on the well-being of the public and the environment if not properly managed (Vergara and Tchobanoglous, 2012).

According to Demirbas (2011), a MSWM concept including the following goals:

1. Reduction of total amount of waste by reduction and recycling of refuse.
2. Recycling and re-introduction of suitable groups of substances into production cycles as secondary raw material or energy carrier.
3. Re-introduction of biological waste into the natural cycle.
4. Best-possible reduction of residual waste quantities, which are to be disposed on ‘‘suitable” landfills.
5. Flexible concept concerning fluctuations in waste quantities and the composition of domestic waste. New developments in the field of waste management must be included into the system.

Various factors that determine the characteristics of municipal waste generated includes the socio-economic background of the generators (Zen et al., 2014), type of dwellings (Timlett, 2010), geographical location as well as habits of the population such as cultural practices (Martin et al., 2006), religion (Mohamad et al., 2012) and consumerism patterns (Vij, 2012). Identification of general characteristics and composition of waste generated is essential to determine the further steps of managing the waste including collection frequency, manpower, type of collection vehicle fleet, storage capacity at transfer stations, treatment and disposal methods (Dinie et al., 2013). Knowledge on waste characteristics, generation patterns, composition and type of waste sources are vitally important as a baseline of planning purposes and systems operations to progress towards efficient management of the waste (Mmereki et al., 2016). Integrating MSW with other external elements are essentially relevant in managing the complexity and enourmous amount of waste generated. This requires a modern and systematic approach to waste management with aims towards achieving sustainable waste management in economically viable, socially accepted and environmentally friendly manner (Asefi and Lim, 2017).

It is important to understand the factors that influence the development of MSW, variables that influence its generation, collection and disposal methods in order to help avoid the negative impacts associated with MSW. Even more important is an understanding of how these factors interact to affect decisions that would maximise the recovery of resources with minimal ethical malpractices, health and environmental impacts. A review of literature reveals a number of factors that influence the decision makers in selecting the best assessment method to ensure the selection or decision is optimal. It is impossible to list all possible factors as factors are

differently categorised by researchers, based on different circumstances. Factors that influence the MSW development in past literature are discussed in section below.

2.5 Factors that are important in the development of solid waste management

The increasing global population has resulted in an increase of daily consumption of resources and raw materials (Troschinetz and Mihelcic, 2009). The better standards of living lead to greater resource consumption, hence, one can expect greater demand on resources in the near future (Balatsky et al., 2015). The accumulation of waste and the 'throw-away-philosophy' has resulted in several environmental problems, health issues and safety hazards hence, preventing sustainable development in terms of resource recovery and recycling of waste (Lehmann, 2011; Seik, 1997). Primary responsibilities to manage solid waste generated safely are mainly under the jurisdiction of local authorities (Ezeah, 2010). Proritization is often on the effective removal of waste from neighbourhood residences and disposal of the waste outside the cities' boundaries (Kaza et al., 2018; Taherzadeh and Rajendran, 2014). Resulting from the Industrial Revolution, there was a significant increase in the consumption patterns and huge disposal of waste that went beyond the social acceptability and the absorption capacity of local and global sinks (Marxsen, 2001). Hence, initiatives and perspectives are aimed at and focusing on the sustainable development in the use of resources which directly influence the management of solid waste, which has been gradually implemented through policy guidelines and directives at national levels (Taherzadeh and Rajendran, 2014).

Past studies indicated significant interest in evaluating factors in solid waste management. Some scholar have addressed the factors that influence the elements of MSW systems. According to Liu et al. (2019), the generation of waste is influenced by family size, their education level and the monthly income. Barr (2007) has commented upon the sets of situational and psychological variables that influence the household attitudes and behaviour related to waste reduction, reuse and recycling. Collection, transfer and transport practices are affected by improper bin collection systems and location, poor route planning, lack of information about collection schedule (Olukanni et al., 2016). Waste collection systems can be effectively improved by integrating the informal sectors with other service providers as suggested by Wilson et al. (2006) and Guerrero et al. (2013).

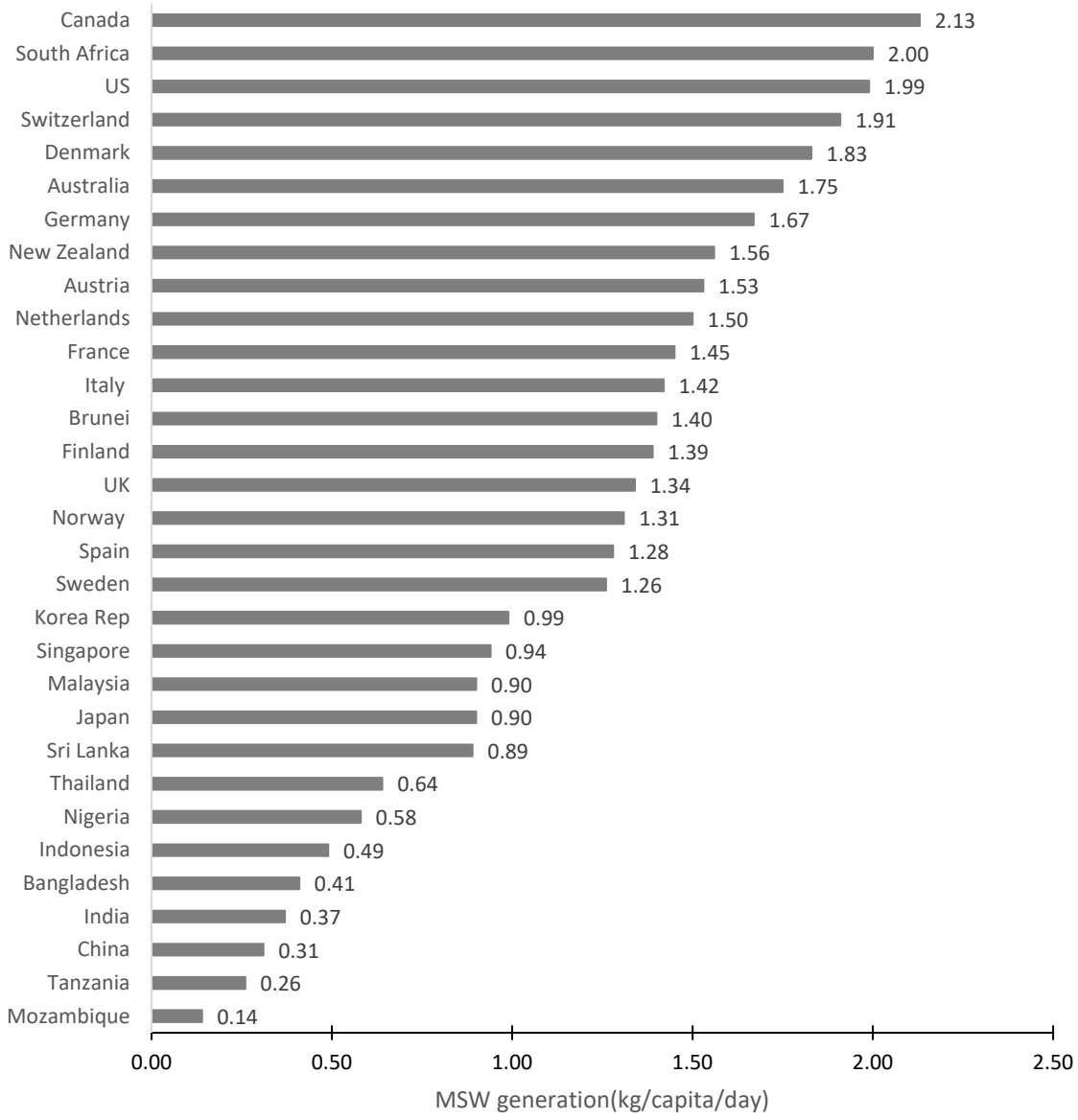


Figure 2.3. MSW generations rate in selected countries, in kg per capita per day

In relation to recycling and waste reduction, Troschinetz and Mihelcic (2009) identified twelve factors that influence the sustainable recycling of MSW management in developing countries: government policy, government finances, waste characterization, waste collection and segregation, household education, household economics, administration, personnel education, MSWM plan, local recycled-material market, technological and human resources, and land availability. Minghua et al. (2009) concluded that the government is responsible to establish good markets for recycled materials and increasing professionalism in recycling companies to increase recycling rates. In Figure 2.3, most of the developed countries produce more wastes than developing countries, which connected to the socio-economic status of the countries (Liu et

al., 2019). Economic development of a country is positively related to the per capita generation rate of SW, the rate of consumption of commercial goods and levels and patterns of growth (Bovea et al., 2010).

Improper waste management and limited public awareness, especially in developing countries are linked to the fragmentation of MSW management, such as limited corporation and coordination of stakeholders function, weak governance, redundancy of jobscope as well as institutional management structures and capabilities (Mmereki et al., 2016). Challenges faced by the developing countries in managing their solid waste as reported in past studies include the primitive treatment technologies and disposal methods, low coverage of collection services, lack of governmental commitment and low public participation in waste management (Guerrero et al., 2013). As reported by Badgie et al. (2012), most of the developing countries are still struggling with the initial steps of MSW management such as waste quantities and characterization, treatment and disposal, whilst developed countries have generally implemented effective and well-functioning systems to effectively manage the waste. In developed countries, waste management systems are focused on the integrated and sustainable approaches to resource management rather than ad hoc approaches in developing countries (Guerrero et al., 2013).

The terms “factors” in MSW management are also known as “drivers”, which refers to factors that positively (facilitators) or negatively (constraints) alter an existing waste management system (Periathamby et al., 2009b; Wilson, 2007). Past studies have identified and classified factors into different categories. For instance, Wilson (2007) studied sustainable waste management in several European cities and then classified the factors into six broad categories of MSW drivers in developed and developing country contexts. Wilson (2007) also pointed out that it is important to understand the past development of solid waste management which can provide much needed context and insight for how best to move forward in the future. The six factors that influence sustainable waste management includes: public health, environmental protection, resource value of waste, closing the loop, institutional and responsibility issues, public awareness. Periathamby et al.(2009b) re-organized the six categories from Wilson (2007) into four, which were human, economic, institutional and environmental and expanded on them, from the Asian perspective. It was concluded that in Asia, especially in the developing countries, the economic driver has the highest impact. However, recent environmental and

political trends have increased the impact of the environment driver, which now motivates sustainable waste management.

The legislative infrastructure and its enforcement which is linked to the effectiveness, enforcement and practicality of laws related to sustainable waste management, often has different impacts on the MSW system (Periathamby et al., 2009b). The drivers have to be interpreted in the local context to be effective, especially in decision making process. MSW management factors are inter-connected and dynamic in nature; therefore, the actual influence of an individual factor may not be seen in dynamic waste management development trends (Zaman, 2013). For example, social acceptance and willingness to participate on the national solid waste management plan can influence the success of waste minimisation program (Han et al., 2019). Policy of the government and fund allocations for waste management activities are important towards achieving the sustainable waste management (Mmereki et al., 2016; Periathamby et al., 2009b). Developed countries such as Denmark, Sweden, United Kingdom and Japan have moved away from landfilling as method for disposal, mainly due to the sufficient allocations of fund as well as changes in the national policy with regards to the environmental protection and preservation (Taherzadeh and Rajendran, 2014). On contrary, developing countries such as India, Bangladesh and Malaysia are still depending on landfills for waste disposals (Johari et al., 2014; Kumar et al., 2017); limitations are not only on the funding and government support, but are also influenced other factors such as low acceptance of the public, inefficient collection coverage and political conflict (Nunn, 2012). Social behaviour in following the new laws and plans with regards to the MSW management is important, however the level of acceptance is different between localities (Razali et al., 2017). For instance, acceptance on the separation of waste at source may be influence by the socio-economic factors, awareness and education, availability of facilities as well as willingness of society to follow such regulations (Storey et al., 2015). Introducing new concept or changes in the current systems can spark resistance among the public. Economic motivation is needed to change public perception and behaviour, while, commercial sector need to be forced through legislation (Taherzadeh and Rajendran, 2014).

Mismanagement in the municipalites as the authorized institutions to manage effectively the solid waste management also captured the interest of researchers (Guerrero et al., 2013). Local authorities can have an inadequate institutional structures capacity, which are leaders' interest, insufficient budget, accountability, poor policy performance, transparency, management

structures and commitment Mmereki et al. (2016). However, there is very limited information on this issues, therefore, it is extremely difficult to gain an insight into the complex problem which remains to be solved.

Understanding the factors and their interactions with other factors that influenced the development in waste management in the past, and how dynamic the changes are in the present system are important in understanding how best to move forward in developing sustainable waste management systems globally. There is no single factor that can be seen as a 'principal factor'; rather, all factors are potentially important and the balance between them will vary between countries and depend on local circumstances. The next appropriate steps towards developing an integrated and sustainable waste management system will still need to be determined for each local situation.

Chapter 3: Methodology

3.1 Overall methodology

This study used a quantitative and positivist approach. It was decided at the early stages of the study to generate data and findings with hard evidence which provides factual and descriptive information. Hence, a quantitative research design was deemed appropriate for several reasons. One, the approach would enable the collection and analysis of extensive sources of data. Secondly, the approach allows for the generation of empirically-testable data whose nature facilitates the investigation and analysis of the associations between factors. Thirdly, a quantitative approach would permit replication of the study in different circumstances. Finally, a quantitative approach enhances the generalisation of the results to the whole study population and facilitates comparisons of the variables both spatially and temporally (see Albers (2017) and De Vaus (2002)).

3.2 Reliability and validity

Reliability and validity are two important factors to consider when developing and testing a questionnaire. Reliability and validity are the measurement of adequacy and accuracy of indicators used in a social study. A measure can be reliable but not valid, if it is measuring something very consistently but in the wrong construct. Likewise, a measure can be valid but not reliable if it is measuring the right construct, but not consistent (De Vaus, 2002; Ongondo, 2011). Using the analogy of a shooting target, where the center of target representing the aim of the study, Figure 3.1 shows graphical presentation of possible combinations of validity and reliability.

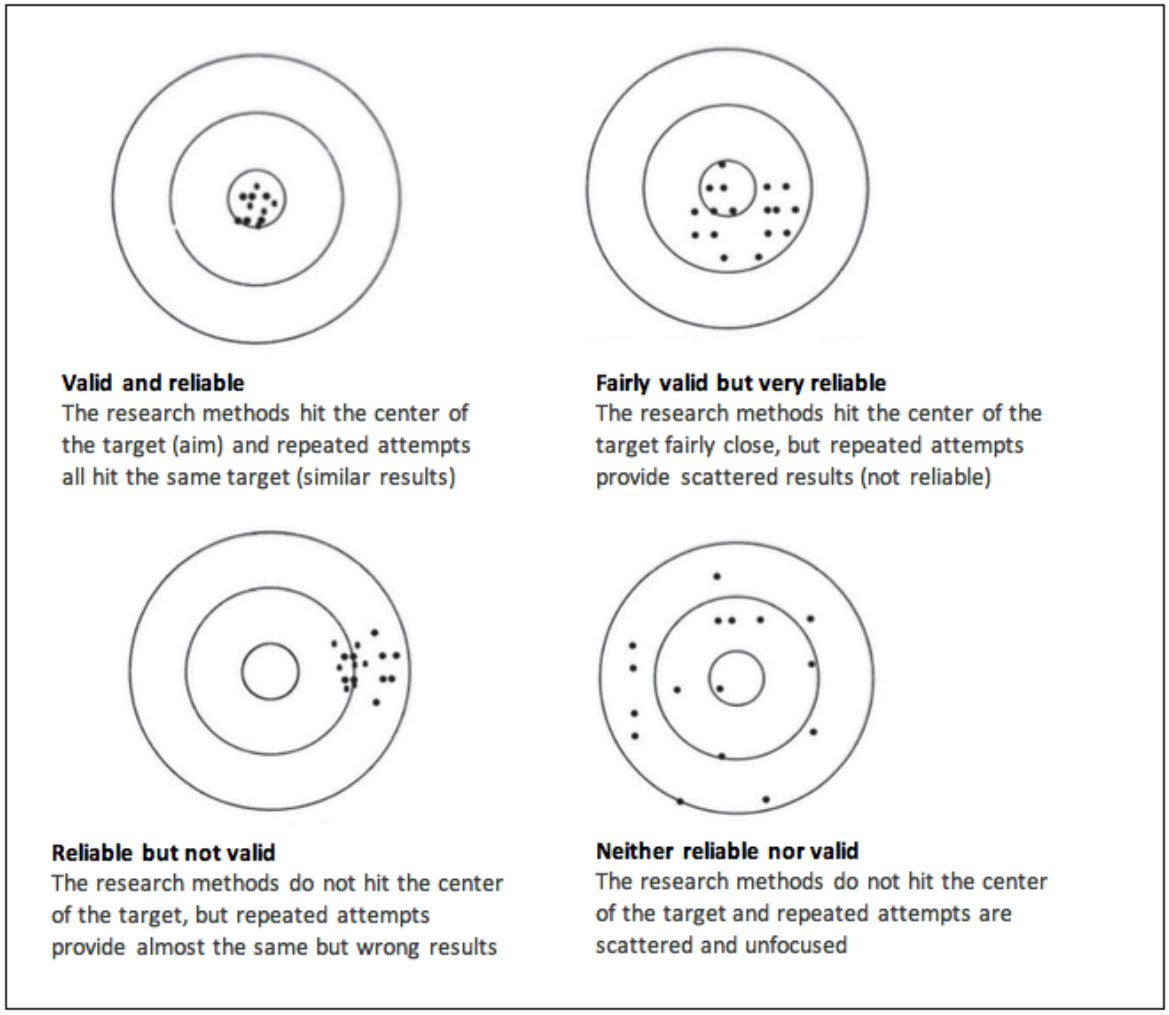


Figure 3.1. Graphical presentation of possible combinations of reliability and validity (Bolarinwa, 2015)

3.2.1 Reliability

Reliability is where we obtain the same result under the same conditions on different occasions. It is the expectation that there will not be any different findings each time the measure is used assuming that nothing has changed in what is being measured (Carmines and Zeller, 1979; De Vaus, 2002). It is most commonly used to determine the reliability of multiple Likert questions in a questionnaire that form a scale (Bhattacherjee, 2012). Reliability implies consistency but not accuracy (Ongondo, 2011). Reliability of the questionnaire is usually carried out using a pilot test. The best methods of testing the reliability of indicators is to measure the concept rather than single-item indicators (De Vaus, 2002). Reliability could be assessed in three major forms; test-retest reliability, alternate-form reliability and internal consistency reliability.

a) Test-retest reliability

Test- retest method is the only way to check the reliability of single questions by asking the same questions at the lapse of two to four weeks. For example, people might be asked about their opinion on how social factors had influenced the development of the waste management and were asked the same questions two weeks later in which the correlation of both answers on both occasions were calculated. If the correlation is high (typically an r value of 0.7 or above), it is assumed that the question is reliable (Bolarinwa, 2015; De Vaus, 2002; Ongondo, 2011). Test-retest correlation provides an indication of stability over time (Bolarinwa, 2015). However, this method is often considered as poor and not relevant as the respondent is expected to provide the same answers, potentially leading to artificial reliability of the questionnaire (De Vaus, 2002; Okoli and Pawlowski, 2004).

In this study, it was not deemed necessary to use the test-retest procedure(see Section 3.3 for full justification and explanation of adopted Delphi methodology). The complex issue requires knowledge from people who understand the factors that impacted MSW from different perspectives which are political, environmental, social, technology, legal and economic. Thus, a Delphi study answers the study questions more appropriately.

b) Alternate-form reliability

The alternate-form reliability is measured by administering at least two equivalent tests (e.g. a questionnaire) to one group of people on different occasions. The respondents can be either the same group or different group. It uses differently-worded or differently-order questions to measure the same attribute or construct (Bolarinwa, 2015; De Vaus, 2002). A high degree of correlation between both sets of test indicate the measure is deemed to be reliable. Preparing two equivalent tests to measure can be difficult, thus, this method is seldom implemented (Ongondo, 2011).

This method was ruled out due to the types of data that the questionnaires utilised aimed to capture; there was no perceived value in asking the same respondents the same questions in two different ways.

c) Internal consistency reliability

Internal consistency is a test or instrument that measures the same thing and is considered to be the most commonly-used statistical method to estimate reliability. For example, when measuring the respondent's attitudes towards a particular issue, it is expected that the answers are consistent across all the items measuring that same construct (item-item correlations). This test is applied to groups of items that are regarded as measurements of different aspects of the same concept.

Hence, it is an indicator of how well the various items measure the same issue (Ongondo, 2011; Ursachi et al., 2015). Internal consistency is measured by Cronbach's alpha index and in some research, split-half reliability index and Kuder–Richardson formula 20 (KR-20) index was used (Bolarinwa, 2015; Ursachi et al., 2015). The reliability of a measure concerns the extent to which it yields the same result on repeated trials.

The split/half reliability index estimate requires dividing up the test into two parts (e.g. odd/even items or first half of the items/second half of the items), administering the two forms to the same group of individuals and determining the correlation of the responses. Coefficient alpha and KR-20 both represent the average of all possible split/half estimates. The difference between the two is when they would be used to assess reliability. Specifically, coefficient alpha is typically used during scale development with items that have several response options (i.e., 1 = strongly disagree to 5 = strongly agree) whereas KR-20 is used to estimate reliability for dichotomous (i.e., yes/no; true/false) response scales (Bhattacherjee, 2012).

Using several statistical analysis software, KR-20 and Cronbach alpha can easily be estimated. The Cronbach's alpha value of more than 0.70 is deemed to be reliable, although it may decrease to 0.60 in an exploratory research (Hair et al., 2016). The more items included in a scale to measure the construct of interest, the more reliable the scale will become. However, the problem with simply increasing the number of scale items when performing applied research is that respondents are less likely to participate and answer completely when confronted with the prospect of replying to a lengthy questionnaire (Bolarinwa, 2015). It is important to develop a scale that completely measures the construct of interest which may lead to the higher levels of respondent participation and comprehensiveness of responses to produce a rich pool of data that answer the research questions (Ongondo et al., 2011).

Internal consistency reliability was not applied in this research work since the questionnaire items were not of the multi-item type nor did they have to be; it was not the aim of the various case studies in the research to measure any single or group of constructs regarding a particular issue.

3.2.2 Validity

Validity refers to the ability of an instrument to measure what it is aimed to measure and how accurate the measurement is. It is not the measure that is valid or invalid but the use to which the measure is put. In other words, an instrument that is invalid on one construct may be valid on another construct (De Vaus, 2002; Ongondo, 2011). For example, measuring age of respondents to

reflects their behaviour on waste management might not be valid, conversely, it is more suitable to measure the educational background may influence how they manage their waste at home.

Validity of a questionnaires usually divided into several types. It can be measures either by establishing a panel of experts (theoretical construct) or the use of another survey in the form of field test (empirical construct). Two subtypes of validity under theoretical construct are face validity and content validity, while the commonly used empirical construct are criterion-related validity and construct validity (De Vaus, 2002). These four most common validity types are briefly discussed below. Measuring the validity of an instrument is difficult and none are entirely satisfactory. The method chosen are vary by situation (Bolarinwa, 2015; Ongondo, 2011)

a) Face validity

Face validity involves the expert on the research subject reviewing the items in the questionnaire and concludes that the test is a valid measure of the concept (characteristics or trait of interest). This form is often said to simple and least scientific; many researchers do not consider this as an active measure of validity. Hence, it is subjective and is not a very scientific way of assessing validity (Bolarinwa, 2015; Gravetter and Forzano, 2011).

Despite its shortcomings, face validity was confirmed through the review questionnaires used in the study by selected academic and non-academic experts with previous experience in designing and administering survey questionnaires.

b) Content validity

Content validity is another subjective method to understand how well a set of items is measuring the different aspects of the concept. it is assessed by careful assessment of the measurement method against the conceptual definition of the construct (Bolarinwa, 2015). Inclusion of at least five experts in the relevant field would be useful to judge the content domains of a scale through use of rating scales (Yaghmaie, 2003).

Similar to face validity, content validity was ensured by assessment of questionnaires used in the study by various academic and non-academic experts knowledgeable in the subject area under study, and with previous experience in designing and administering survey questionnaires.

c) Criterion-related validity

Criterion-related validity is assessed when one is interested in determining the relationship of scores on a test to a specific criterion or well-accepted measures of the concept. In other words, this test is

about comparing one's own test with well-establish and similar test; the new measure is valid when both new and the established measures are highly correlated (Ongondo, 2011). However, there are problems related to this approach. The validity of old measures need to be assumed beforehand. It may appear that the old measures are not valid, and when comparing with the new measures, the correlation might now represents the validity of the new measures. Commonly, new measures are developed because the old measures are unsatisfying, thus, it is self-defeating to compare the old to the new ones (De Vaus, 2002). If the other measures are available at the same time (concurrent) as the new measures, then concurrent validity is established. Also, predictive validity is the ability of a test to measure some event or outcome in the future (Bolarinwa, 2015). Unfortunately, for many concepts, finding well-establshed and similar study might be challenging.

Criterion-related validity was assured in this study by thoroughly reviewing the literature to identify factors that would eventually answers this study's research questions (see Chapter 4).

d) Construct validity

Construct validity estimates how well a measures conforms to theoretical expectations. This approach may be difficult; first, finding a well-established theory and conforms with the new measures can be either prove that the the theory is wrong or that the new measures are invalid. Second, there is no benefit of validating a new measures if the theory is not well supported and later, use the new measures to confoms the theory (Ongondo, 2011).

By employing a Delphi method, construct validation is ensured by asking experts to validate the researcher's interpretation and categorization of the variables. As Delphi is not anonymous thus allows validation to be conducted among experts.

3.3 Data collection, analysis and reporting

3.3.1 Selection of Delphi method

The Delphi method is a popular technique for forecasting and an aid in decision-making based on the opinions of experts. It was first developed by Dalkey and Helmer (1963) at the Rand Corporation in the 1950 (Hsu and Sandford, 2007). This method was conceived as a group technique aimed to obtain the most reliable consensus of opinion of a group of experts through series of intensive questionnaires with controlled feedback to deal with a complex problem (Hsu and Sandford, 2007; Landeta, 2006; Linstone and Turoff., 1975). The questionnaires are designed to focus on problems,

opportunities, solutions, or forecasts. According to Landeta (2006), the main characteristics of Delphi study are as follows:

a) It is a repetitive process, so the experts must be consulted at least twice on the same question. This will allow them to reconsider their answer with information provided by other experts.
b) It keeps the anonymity of either the participants' details or their answers. The group coordinator will process the answers and communicate accordingly to selected experts whenever necessary.
c) This method provides controlled feedback, where group coordinator will carry out the communication and exchange of information between experts.
d) The results are processed quantitatively and statistically.

Although we could conduct a traditional survey to gather input from experts, we judged the Delphi method to be a stronger methodology for a rigorous query of experts and stakeholders. In this study, the Delphi method was employed due to following reasons:

a) This study explores the fundamental factors that are impacted in the development of solid waste management, where experts with related knowledge and experience are required to answers complex questions related to the topic.
b) This study involves global experts who were scatteredly across the world. Delphi is selected as it does not require the experts to meet physically, which could be impractical for international experts. The survey was conducted fully on online basis where experts were contacted via emails.
c) Experts have sufficient time to complete the survey at their convienience.
d) There is no agreement on the panel size for Delphi studies, nor recommendation or standand definition of small or large samples (Hsu and Sandford, 2007; Paliwoda, 1983). Delphi panel size requirements are modest, and it would be practical to solicit up to four panels from 10 to 18 members in size (Okoli and Pawlowski, 2004).
e) The Delphi study is flexible in its design, and amenable to follow-up interviews in several rounds. This permits the collection of richer data leading to a deeper understanding of the fundamental research questions.

The comparison between traditional survey and Delphi method are listed in Table 3.1.

Table 3.1. Summary of comparison between traditional survey and Delphi method

Evaluation	Traditional survey	Delphi method
Summary of procedure	The researchers design a questionnaire with questions relevant to the issue of study. There are numerous issues concerning validity of the questions they must consider to develop a good survey. The questionnaire can include questions that solicit quantitative or qualitative data, or both. The researchers decide on the population that the hypotheses apply to, and selects a random sample of this population on whom to administer the survey. The respondents (who are a fraction of the selected random sample due to non-response by some) fill out the survey and return it. The researchers then analyze the usable responses to investigate the research questions.	All the questionnaire design issues of a survey also apply to a Delphi study. After the researchers design the questionnaire, they select an appropriate group of experts who are qualified to answer the questions. The researchers then administer the survey and analyze the responses. Next, they design another survey based on the responses to the first one and readministers it, asking respondents to revise their original responses and/or answer other questions based on group feedback from the first survey. The researchers reiterate this process until the respondents reach a satisfactory degree of consensus. The respondents are kept anonymous to each other (though not to the researcher) throughout the process.
Representativeness of sample	Using statistical sampling techniques, the researchers randomly select a sample that is representative of the population of interest.	The questions that a Delphi study investigates are those of high uncertainty and speculation. Thus, a general population, or even a narrow subset of a general population, might not be sufficiently knowledgeable to answer the questions accurately. A Delphi study is a virtual panel of experts gathered to arrive at an answer to a difficult question. Thus, a Delphi study could be considered a type of virtual meeting or as a group decision technique, though it appears to be a complicated survey.
Sample size for statistical power and significant findings	Because the goal is to generalize results to a larger population, the researchers need to select a sample size that is large enough to detect statistically significant effects in the population. Power analysis is required to determine an appropriate sample size	The Delphi group size does not depend on statistical power, but rather on group dynamics for arriving at consensus among experts. Thus, the literature recommends 10–18 experts on a Delphi panel.
Individual vs. group response	The researchers average out individuals' responses to determine the average response for the sample, which they generalize to the relevant population.	Studies have consistently shown that for questions requiring expert judgment, the average of individual responses is inferior to the averages produced by group decision processes; research has explicitly shown that the Delphi method bears this out. Pretesting
Reliability and response revision	An important criterion for evaluating surveys is the reliability of the measures. Researchers typically assure this by pretesting and by retesting to assure test-retest reliability	Pretesting is also an important reliability assurance for the Delphi method. However, test-retest reliability is not relevant, since researchers expect respondents to revise their responses.

(Continued Table 3.1)

Evaluation	Traditional survey	Delphi method
Construct validity	Construct validity is assured by careful survey design and by pretesting.	In addition to what is required of a survey, the Delphi method can employ further construct validation by asking experts to validate the researcher's interpretation and categorization of the variables. The fact that Delphi is not anonymous (to the researcher) permits this validation step, unlike many surveys.
Anonymity	Respondents are almost always anonymous to each other, and often anonymous to the researcher.	Respondents are always anonymous to each other, but never anonymous to the researcher. This gives the researchers more opportunity to follow up for clarifications and further qualitative data. Non-response
Non-response issues	Researchers need to investigate the possibility of non-response bias to ensure that the sample remains representative of the population.	Non-response is typically very low in Delphi surveys, since most researchers have personally obtained assurances of participation.
Attrition effects	For single surveys, attrition (participant drop-out) is a non-issue. For multi-step repeated survey studies, researchers should investigate attrition to assure that it is random and non-systematic.	Similar to non-response, attrition tends to be low in Delphi studies, and the researchers usually can easily ascertain the cause by talking with the dropouts.
Richness of data	The richness of data depends on the form and depth of the questions, and on the possibility of follow-up, such as interviews. Follow-up is often limited when the researchers are unable to track respondents.	In addition to the richness issues of traditional surveys, Delphi studies inherently provide richer data because of their multiple iterations and their response revision due to feedback. Moreover, Delphi participants tend to be open to follow-up interviews

Source : Okoli and Pawlowski (2004)

The Delphi method involves multiple steps and are briefly explain as follows:

a) Selection of experts

As mentioned above, a Delphi is a group decision mechanism requiring qualified experts who have experiences and knowledge of the selected topic. Therefore, it is critical to carefully select the qualified experts. The experts are selected based on their background and experience in waste management sectors. Experts were divided according to major categories, for example, academics, practitioners, government officials and NGOs. These groups probably would have different perspectives. Since it is a goal to obtain a reasonable degree of consensus, it would be best to have panels that separate into these groups. Nevertheless, there are experts who may have experience or knowledge in more than one categories, which may lead to redundancy of data, thus, this study will not take this categories as results for analysis.

b) Communication with the experts

The only method as means of communication with the experts was email. The objective is to contact people in these organizations who are experts themselves, and who can provide additional contacts within and outside their own organizations. Emails were sent to experts as an invitation to participate in the survey and later, followed by a link of the online survey to be completed by the experts. Responds from the experts as consent to participate were also noted.

c) Design of the questionnaires

Responses from experts were recorded using various scoring methods. The most commonly employed linear numerical scales is Likert scales (see Hsu and Sandford, 2007; Ribeiro and Quintanilla, 2015; Verhagen et al., 1998). A Likert scale asks respondents to indicate their levels of agreement with a declarative statement (De Feo and Polito, 2015). In this study, a 5-point Likert scale was adopted. Designing a questionnaires requires brainstorming, narrowing and ranking the list of identified factors. In this study, the survey was divided according to six PESTLE elements; political, environmental, social, technological, legal and economics. This approach lead to the subsequent evaluation of studied factors within the established and proven PESTLE system (Kolios and Read, 2013; Srdjevic et al., 2012; Zalengera et al., 2014; Zhang, 2011; Zhang et al., 2011). The statistical analysis of data is discussed in Section 3.3.2.

d) Iteration and time requirement

Conducting a Delphi study is time-consuming as it consists a large number of statements. Researchers recommend that a minimum of 45 days for the administration with two weeks for experts to respond to each round is encouraged (Hsu and Sandford, 2007). Theoretically, the Delphi method can be conducted in as many rounds as required until consensus is achieved. However, up to three iterations are often sufficient to collect the needed information and to reach a consensus in most cases (Hallowell and Gambatese, 2010). This study employed a two rounds of Delphi to achieve the study aims and answer the research questions.

e) Conducting the survey

This study employed a two rounds of Delphi; the first round focusing on the visibility and influence of factors in MSW management while the second round of Delphi is mainly on finding the best combinations of factors that are most effective in the development of MSW management. The description of both Delphi rounds as follows:

Delphi round 1

In round 1, an online questionnaire survey was conducted using iSurvey, a survey generation and research tool for distributing online questionnaires made available by the University of Southampton (https://www.isurvey.soton.ac.uk/). The questionnaire was divided into two parts; questions on factors' visibility and influence. Similar applications of questionnaire tools have been applied in previous studies, e.g. Gregg et al. (2017); Grote et al. (2017). A pilot study was conducted to conform to professional standards. For a pilot study, respondents were asked to complete the questionnaire. Pilot studies frequently result in substantial revisions being made in the survey design, better estimate for the time to complete a questionnaire and the questionnaire can be shortened or questions deleted if the time taken to complete the pilot study was found to be too long (Barry et al., 2009). The first questionnaire in this study was piloted by five participants. The participants included the supervisory team and researchers from similar field. Several changes were made to the questionnaire after the pilot. The changes were mostly to ensure that the questions were understandable and that there was no duplication of factors. For questions on factors' visibility, respondents were presented with a list of factors and asked to classify them as "visible" or "invisible" according to stated definitions. For questions on factors' influences, experts were asked to evaluate the influence of identified factors by applying Likert scale to state opinions based on their experience and expert knowledge (Hartley, 2014; Li, 2013; Lozano et al., 2008). A bipolar Likert scale was employed to secure experts' views. Participants were required to choose a value ranging from "0=not at all influencial" and "4=extremely influencial". Experts were asked to use a slider to position their views on each question according to their own interpretation and experience (Cook et al., 2001; Rodrigues et al., 2015). The latters's responses were redefined in the result analysis for better interpretation and understanding, where intermediate value were redefined as follows: "1=slightly influential", "2 = somewhat influential" and "3=moderately influential".

Delphi round 2

Before initiating Delphi round 2, experts were asked again for their consent to participate in Round 2. Invitation to participate with the survey link was only sent to those experts who have agreed to participate. In round 2, the results from round 1 were reported back to the experts for further evaluation via multi-criteria decision analysis using 1000Minds software (https://www.1000Minds.com). The 1000Minds software uses the mathematical algorithm PAPRIKA (Potentially All Pairwise Rankings of All Possible Alternatives) to derive weights for each PESTLE factor using results from series of pairwise comparisons that randomly select pairs of all possible

combinations (Hansen and Ombler, 2009). The value model or the preference values are represented by the relative importance 'weight' of the criteria that is calculated via mathematical methods (Golan et al., 2011). With the PAPRIKA method, users are allowed to choose one alternative between just two, which is easier and natural as in ordinary daily decision-making (Johnson et al., 2012). The PAPRIKA algorithm can process any number of pair-wise rankings of the hypothetical alternatives required to establish experts' preferences, which therefore presents better confidence in decision-making (Golan et al., 2011; Isma'ili et al., 2016). Through iterative discrete pair-wise choices, the decision analytic software is able to assign relative weights to the criteria (Johnson et al., 2012). This study employed PAPRIKA method due to the robust, clear and less complex format of pair-wise comparison that generates individual weights for every decisions and combinations. 1000Minds is the only software that supports PAPRIKA method (Isma'ili et al., 2016; Taylor et al., 2013).

3.3.2 Data analysis and reporting

Primary data for the study were predominantly collected from survey using Delphi method. In addition, secondary data from various sources were used (see Chapter 4). The descriptive and specific statistical tests used to analyse the data and report the findings are briefly discussed below.

a) Test of normality

In all cases, data were tested for normality and equal variance, and parametric or non-parametric tests subsequently applied as appropriate. Normality tests are used to determine if a data set is a normal distribution (Ghasemi and Zahediasl, 2012). Statistical tests used to determine normality are Kolmogorov-Smirnov (K-S) test, Lilliefors corrected K-S test, Shapiro-Wilk test, Anderson-Darling test, Cramer-von Mises test, D'Agostino skewness test , Anscombe-Glynn kurtosis test, D'Agostino-Pearson omnibus test, and the Jarque-Bera test (Öztuna et al., 2006). K-S is a commonly used test and can be conducted in the SPSS Explore procedure (Thode, 2002).

b) Two tailed t-test for independent samples

A two-tailed t-test for independent samples was employed to determine whether the classification of factors was statistically significant different between comparator groups, which are the experts from developed and developing countries. This statistical test was employed for analyses to determine the influence of factors in the development of MSW according to the experts from developed and developing countries. This is applicable to a normally distributed data. Means of two comparator groups (developed and developing countries) were compared to see if there was a significant different between both groups. A two-tailed t test is the most important and frequently

used statistics to compare the difference between two samples when the variances of two normal distributions are not known (Kim, 2015; Ringwalt et al., 2011). According to Winter and Dodou (2012) and Leung (2011), t-test is commonly used in a Likert point questionnaire studies.

In this thesis, t-test was necessary to perfomed to determine the level of agreement among experts from developed and developing countries when classifying the degree of influence of factors in MSW management. This test was employed in Chapter 5.

c) Chi square

The Chi-square test of independence, which also known as the Pearson Chi-square test is one of the most useful statistics for comparing observed frequencies with theoretically predicted frequencies, i.e., it tests whether two variables forming a contingency table are associated. Chi-Square is one of the most important and frequently used statistics to assess association between ordinal and nominal (categorical) measures (Mchugh, 2013; Ongondo, 2011).

In this thesis, Chi square test was employed in Chapter 4 to determine the difference of factors' classification as visible or invisible by the experts. The data analysed was as nominal, hence Chi-Square was the most suitable nonparametric statistical test to utilise to test for associations between variables

Chapter 4: Classification of visible and invisible factors of solid waste management using PESTLE system

4.1 Introduction

Waste management requires long-term planning due to its complexity and the dynamic changes that occur in the societies. Rapid urbanization and the diversity of consumer products contribute to this complexity, whilst the quantity and composition of waste often reflects socio-economic status (Taherzadeh and Rajendran, 2014). Waste management systems therefore differ in developing and developed countries, albeit with some commonalities (Asase et al., 2009; Mukhtar et al., 2016). The fundamental factors in waste management systems can vary due to the differences in cities' characteristics (Contreras et al., 2010). Some factors are measurable and can contribute to efforts in projecting future conditions. Other factors, in contrast, exist that potentially influence the development of waste management systems but are qualitative (e.g. understanding and awareness). Such factors may be important but are frequently overlooked due to the limitations of financial, lack of experts and knowledge, lack of appropriate and continuous studies and low government support (Iacovidou et al., 2017; Maloba, 2012); it is a major logistical challenge -with little hard evidence- to suggest how real and significant impacts can be achieved by emphasizing these factors. Nevertheless, these factors should be recognised and addressed in the design and implementation of waste management systems. Defining which factors are critical to the success of MSW management can be difficult and complex due to the differing circumstances and realities at a local scale.

Numerous factors are known to have fundamental roles in sustainable practices on waste management (Barr, 2007; Periathamby et al., 2009b; Wilson, 2007). Research studies have previously addressed the significance of factors in MSW including: policy and strategy (Rudden, 2007; Taherzadeh and Rajendran, 2014; Wilson et al., 2001), age and aging communities (Pickerin and Shaw, 2015), community behaviour and interactions (Shaw, 2008), the socio-economic impacts on waste generation (Bandara et al., 2007), recycling (Johari et al., 2014), waste to resource initiatives (Storey et al., 2015), the collection of municipal waste (Coffey and Coad, 2010) and disposal of waste (Zurbrügg and Schertenleib, 1998). The impacts of some factors are evidently

visible. There are also “invisible” factors that are not easily quantifiable, but nonetheless have potential to influence changes in local waste management practices and behaviour. The influence of such invisible factors may be uncertain and challenging to determine. In principle, however, the recognition and utilisation of invisible factors is potentially very important; it is a starting point for the design of a waste management strategy or policies based on tangible local trends or evidence, rather than adopting practices from elsewhere which may not address local characteristics, customs, uniqueness or waste composition (Mukhtar et al., 2016).

Table 4.1. Definitions of visible and invisible factors in MSW

Factor type	Definition
Visible	Factors that are measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes, published for awareness and available for relevant access by public.
Invisible	Factors that are not considered at all in any of waste management processes, however, have influence the social behavioral and philosophical perceptions on solid waste management and practice

In this study, fundamental factors in waste management are classified as visible or invisible as defined in Table 4.1. Due to the influence of these factors in specific situations at a local scale, the influences exerted by invisible factors may differ in terms of their significance; the importance and roles of invisible factors may vary depending on the combination of other factors under local circumstances. Consequently, an approach that is successful in one setting may not be successful in a different setting: direct adoption should not occur without recognising and responding to local circumstances (Mukhtar et al., 2015). The approaches for setting up suitable collection systems, treatment methods and public awareness-raising may need to take into consideration both visible and invisible factors to achieve optimum results.

The first aim of this study was to establish, from the literature, a comprehensive list of factors pertinent to MSW and classify these according to the PESTLE (political, environmental, social, technological, legal and economic) system. The second, subsequent, aim was to seek experts opinion regarding whether these factors are considered to be visible or invisible in practice, and whether the classification differed between experts in developing and developed countries. It is envisaged that subsequent recommendations can be made with regard to if and how the status of MSW factors

(invisible, visible and/or PESTLE classification) may be taken into account to improve MSW performance and fitted to the contrasting situations in developing and developed countries.

4.2 Methods

Data was collected in two Delphi rounds, the focus of which was informed by published research. Initially, a comprehensive literature review was carried out in order to identify similar studies and factors that were highlighted in the past studies. Methods employed in this part of the sudy are as explained below.

4.2.1 Literature review and factors classification according to PESTLE

First, factors associated with MSW management were identified through a review of multidisciplinary literature (see Section 2.5). A holistic view of the development of MSW management requires an understanding and an appropriate consideration of a wide range of the possible factors involved in and influencing MSW management. In order to provide such a view, a multidiciplinary literature review of the possible determinants was undertaken and it was found that it is necessary to group the factors for structured analysis. This study employs a political, economic, social, technology, legal and environmental (PESTLE) approach to ensure that all idisciplines involved are duly considered and potentially factors are identified. The factors were categorised according to the PESTLE system as a platform for subsequent comparison of factors within and between PESTLE classifications. A PESTLE analysis is a framework or tool used to analyse and monitor the macro factors that may have a profound impact on a system performance (Zalengera et al., 2014; Zhang, 2011). This approach thus builds upon prior evaluation of fundamental factors in MSW within the established PESTLE classification system (Kolios and Read, 2013; Srdjevic et al., 2012; Zalengera et al., 2014; Zhang, 2011). The categorised set of MSW factors was subsequently employed as the basis of a Delphi study in which the factors identified were presented to a global expert panel to seek their views regarding the visibility of the factors at hand.

4.2.2 Delphi method

This study employed a two rounds of Delphi; the first round focusing on the visibility and influence of factors in MSW management. The second round of Delphi is mainly on finding the best combinations of factors that are most effective in the development of MSW management. This chapter presents and considers the results of first round of Delphi, spesifically for questions on

factors' visibility. The first round of Delphi method was employed to provide an expert overview and authoritative scrutiny of the visibility or invisibility of factors in MSW (Hsu and Sandford, 2007). This method is an interactive way of identifying and classifying factors that systematically utilises the knowledge, insights and experiences of selected experts (Chowdhury and Dhawan, 2016; Joos et al., 1999). Candidate participants were selected using an online search to identify persons with expert knowledge, including members of editorial panels from waste management-related journals, academics in higher education and established professionals from selected waste management companies and municipal authorities. Invitations to participate were sent to individuals via email. Respondents were presented with a list of factors and asked to classify them as "visible" or "invisible" according to stated definitions (Table 4.1). Respondents were also asked to provide information regarding their own role, expertise and experience in MSW management. The Delphi questionnaire was administered by iSurvey, a survey generation and research tool for distributing online questionnaires made available by the University of Southampton (https://www.isurvey.soton.ac.uk/) (see Appendix A for the survey form). Similar applications of questionnaire tools have been applied in previous studies (e.g Arifin, 2016; Behan et al., 2016; Cruickshanks et al., 2013). The survey was conducted in two rounds starting from 15 January 2017 and ended on 7 April 2017; first round started from 15 January to 30 January 2017 and the second round is from 7 March to 7 April 2017. In this chapter, attention will be focused on the visibility of the factors, which were addressed in the first round of the Delphi.

4.2.3 Statistical analyses

Statistical analyses were performed using the Statistical Package for the Social Sciences (version 24.0; SPSS, IBM Corp., Armonk, N.Y., USA); a widely applied software package for statistical analysis of data (e.g Gouda, 2015; Grazhdani, 2016; Hutner et al., 2017; Marouf et al., 2014; Mira et al., 2013). A chi square test was employed to determine whether the classification of factors was statistically significant different between comparator groups (see Section 3.3.2).

4.3 Results

4.3.1 PESTLE classification of factors in MSW management

The 43 identified fundamental factors are listed and briefly described in Tables 4.2 - 4.7. The observations do not represent an exhaustive list of factors or a quantitative profile; the specific

purpose to hand was to identify fundamental factors and to inform and guide the subsequent survey, providing a structure for the Delphi study (i.e the PESTLE classification) and definitive descriptions for each factor. The classification of factors into PESTLE are based on the established general definition for each PESTLE components.

Table 4.2. General and specific definitions of political factors in MSW management

Political factors		***Description/Notes***	***References***
	General definition	The ability and roles of government to affect management and regulation	
P1	Government stability	Strong government can hold its power and control over the country with minimal external influence	Plata-Díaz et al. (2014); Wilson et al. (2001)
P2	Corruption	Fraudulent conduct for personal benefits, typically related to bribery	Taherzadeh & Rajendran (2014); Jones et al. (2010)
P3	Accountability of leaders	Responsible and trusted leaders	Jones et al. (2010)
P4	Local government plan	The plan for future development of the local area	Rudden (2007) Wilson et al. (2001)
P5	Government priorities	Focus and attention on specific issues by the government	Moh & Abd Manaf (2016)
P6	Influence of politicians	Effect of politicians' behaviour and character on specific issues	Taherzadeh & Rajendran (2014)
P7	Bureaucracy	Excessively complicated administrative procedure	Godfrey & Scott (2011)

Table 4.3. General and specific definitions of environmental factors in MSW management

Environmental factors		***Description/Notes***	***References***
	General definition	The ability of environmental elements and resources to influence waste management behaviour and directions	
EN1	Environmental guidelines	Local/national guidelines that set specific environmental standards	Li (2007)
EN2	Environmental targets	Specific goals on environmental standards to be achieved within certain period of time	Li (2007)
EN3	Climate change	Changes in global and regional climate patterns resulted from unsustainable human activities	Zaman (2013) Johnson et al. (2011)
EN4	Geographical landform	Different features of the part of the earth	Li (2007)
EN5	Local weather	Specific weather conditions at a particular place/time	Emery et al. (2003)
EN6	Environmental awareness	Awareness on the adverse impacts onto the environment resulted from unsustainable human activities	Triguero et al. (2016) De Feo & De Gisi (2010)

Table 4.4. General and specific definitions of social factors in MSW management

Social factors		*Description/Notes*	*References*
	General definitions	The functionality of humans and their responses towards changes in waste management.	
S1	Seasonal variations	Specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not officially recognized by the government	Gómez et al. (2009) Emery et al. (2003)
S2	Religion	System of faith and worship to personal God	Fatimah Mohamad et al. (2011) Mohamad et al. (2012)
S3	Cultural	Social behaviour, belief, traditions of particular group of people	Thyberg & Tonjes (2015) Martin et al. (2006)
S4	Ethnicity	A particular group of people with same races, religious and origin that may have different culture from other groups of people of a country	Perry & Williams (2007)
S5	Local/national events	Special days of celebration include national holidays, commemoration and also racial or ethnic affiliation which are officially recognized by the government	Gibson & Wong (2011)
S6	Discrimination	A practice of unfair treatment of a group of people to other people, mainly with regards to the socio-economic status	Ma & Hipel (2016) Sembiring & Nitivattananon (2010)
S7	Socio-economic indicators	Changes in particular demographic components which are measured periodically	Triguero et al. (2016) Pickerin & Shaw (2015)
S8	Resource consumption patterns	Changes of natural resources use for human activities within particular period of time	Taherzadeh & Rajendran (2014)
S9	Shared norms	Rules of behaviour that are considered acceptable in group of society	Binder & Mosler (2007)
S10	Rural-urban daily migration	Movement of people from rural to urban areas on daily basis, mainly due to the economic and tourism factors	Henry et al. (2006)
S11	Philosophical change	The evolving thoughts and feelings on particular issues that reflected in the changing in behaviour	Wilson et al. (2001)
S12	Attitude-behaviour change	Difference of individual values or understanding on particular issues does not correlate with their actions	Triguero et al. (2016) Jones et al. (2010) Barr (2007)
S13	Resistance to change	Actions taken by individuals or group of people when they perceive or interpret change as a threat to them	Taherzadeh & Rajendran (2014)

Table 4.5. General and specific definitions of technological factors in MSW management

Technological factors		***Description/Notes***	***References***
	General definitions	The ability to apply suitable technology towards the improvement of waste management	
T1	Skilled workers and experts	Workers with specific knowledge, skills and ability to perform best in their work, while experts are someone who widely recognized as a reliable source of technique and skills	Periathamby et al. (2009)
T2	Application of suitable technology	Application of the appropriate technology that are best designed for efficient operation	Contreras et al. (2010) Wilson et al. (2001)
T3	Facilities availability	Adequate number of facilities are developed for specific use of the people	Taherzadeh & Rajendran (2014)
T4	Rate of technology change	Development of the related technology over certain period of time	Zaman (2013)
T5	R&D Activities	New innovative research that change the utilization, performance, management and practices	Periathamby et al. (2009)

Table 4.6. General and specific definitions of legal factors in MSW management

Legal factors		***Description/Notes***	***References***
	Genaral definition	The attributes and obligations of local authority and as institutions responsible to comply with waste management guidelines.	
L1	International directives	Environmental guidelines and instructions drafted by international organizations to create uniformity in actions	Contreras et al. (2010) Rudden (2007)
L2	Local policy	Policy that sets guidelines that determine the decision and actions on relevant matter	Taherzadeh & Rajendran (2014)
L3	Producers responsibility	Approach taken by the producers in managing waste as by products	Triguero et al. (2016)
L4	Consumer accountability	Responsibility of consumers in buying, consume and managing the waste from the products	Triguero et al. (2016)
L5	Relevant SWM law	Compliance and enforcement of the law towards environmental protection and social considerations	Contreras et al. (2010) Bai & Sutanto (2002)

Table 4.7. General and specific definitions of economic factors in MSW management

Economic factors		*Description/Notes*	*References*
	General definition	The ability of economic status to determine the marketability of recovered materials and waste products	
EC1	Potential income from waste	Monetary benefits from waste	Periathamby et al. (2009)
EC2	Trade restrictions on waste	Limitation on trade activities to selected waste	Ray (2008)
EC3	Third sector restrictions	Limitation on trade activities to non-formal business organizations	Williams et al. (2012)
EC4	Availability of funds	Financial assistance offered on particular projects or initiatives	Taherzadeh & Rajendran (2014) Wilson et al. (2001)
EC5	Interest and tax	Application of interest and tax on goods and services	Jones et al. (2010)
EC6	Economic growth patterns	Changes in the amount of goods and services produced per head of the population over a period of time	Johnson et al. (2011)
EC7	Incentives	Rewards offered on appropriate actions	Jones et al. (2010)

4.3.2 Delphi respondent profile

The Delphi respondent group comprised professionals from academia, private MSW consultants and companies, regulatory, local authorities and national government, charity organizations, business and trade and politics. In line with the specific aims 1 and 2 of this study (i.e focusing on the impacts of different factors between developed and developing countries), participants were classified according to their current location and its associated economic status (Table 4.8). The classifications of countries are based on the economic status which determined by the gross net income (GNI) per capita per year (The World Bank, 2015) as follows:

- Developing countries: Low-income – GNI per capita of $1,025 or less to $12,476
- Developed countries: High-income - GNI per capita of $12,476 and above.

Respondents are clearly guided that their opinion on the survey questions are based on their location where they get their most experiences in solid waste management. In this regard, the location indicated in the demographic profile question will be considered as their localities (see Apendix A, Section 7, Question 7.2).

Table 4.8. Classification of Delphi survey participants' current location and national economic status

Continents	Countries	Economic status according to GNI per capita	Classification	No of respondents
Africa	Mozambique	Low-income	Developing	1
	Tanzania	Low-income	Developing	1
	Togo	Low-income	Developing	1
	South Africa	Upper-middle income	Developing	1
Asia	Hong Kong	High-income	Developed	1
	India	Lower-middle income	Developing	1
	Indonesia	Lower-middle income	Developing	1
	Japan	High-income	Developed	2
	Malaysia	Upper-middle income	Developing	3
	South Korea	High-income	Developed	1
	Vietnam	Lower-middle income	Developing	1
Europe	Denmark	High-income	Developed	1
	Germany	High-income	Developed	2
	Greece	High-income	Developed	3
	Italy	High-income	Developed	6
	Netherlands	High-income	Developed	3
	Poland	High-income	Developed	1
	Slovenia	High-income	Developed	1
	Spain	High-income	Developed	1
	Sweden	High-income	Developed	2
	Switzerland	High-income	Developed	2
	United Kingdom	High-income	Developed	19
North America	Canada	High-income	Developed	1
	United States	High-income	Developed	7
Oceania	Australia	High-income	Developed	1
	New Zealand	High-income	Developed	1
South America	Argentina	Upper-middle income	Developing	1
	Brazil	Upper-middle income	Developing	1
	Chile	High-income	Developed	1
	Peru	Upper-middle income	Developing	1

A total of 70 respondents participated in the survey from the 200 contacted, comprising 83% respondents from developed countries and 17% respondents from developing countries. The classification of countries by gross net income (GNI) is appropriate and convenient for the purpose of this study. There were unequal number of respondents representing developed and developing countries. Generating a representative data in a survey was challenge due to individual

predispositions, contextual factors and the topic of the survey (Lupu and Michelitch, 2018). Candidate participants were selected using an online search to identify persons with expert knowledge, not to address spesifically where their experience mostly come from. Thus, it was difficult to determine the expected number of participants that represented developed or developing countries at the beginning of the study. In addition, as this is an online survey, one of the major issues with online surveys is having an updated and accurate email address list for potential participants (Bista, 2017). Often, experts, especially academicians, tend to have more than one email address and not all such email are frequently checked. Also, due to the work commitments, emails with survey invitations are often set aside for later completions. However, online surveys are the most common methods due to the rapid technology growth and the access of internet is extensive. On a global scale, online surveys are the most cost-effective way to reach the greatest number of people (Austin et al., 2013; Mccrea et al., 2016). Besides, the survey structure also influenced the rate of participation; the survey form is prepared in English, which may caused language barriers that may deter candidate participants, especially those from developing countries. Limited information is available about how response rates vary, especially in the developing countries across space and time, what techniques help increase participation and the extent to which non-response induces bias (Lupu and Michelitch, 2018). In this study, as the data is not normally distributed, chi square test is statistically appropriate for unequal sample size (Mchugh, 2013).

4.3.3 Determination of factors as visible or invisible with PESTLE classification

Respondents' classification of factors as visible or invisible is presented in Figures 4.1- 4.6. Each group of factors is considered in relation to PESTLE class. The horizontal axis shows the percentage of respondents' agreements. The left vertical axis shows political factors and the right vertical axis shows the ranking of the factors according to level of visibility. The sign of "=" means the factors are equally ranked.

Figure 4.1 shows the proportions of how Delphi respondents classified political factors as visible or invisible. The majority of respondents indicates that local government plan and government priorities in MSW management as the most visible factors and they were top ranked across all political factors. The influence of politicians and corruption in the management of solid waste were the most invisible factors. There was no overal consensus between respondents from developed and developing countries in classifying government stability and bureaucracy as either visible or invisible.

All political factors were also consistently ranked by experts from developed and developing countries.

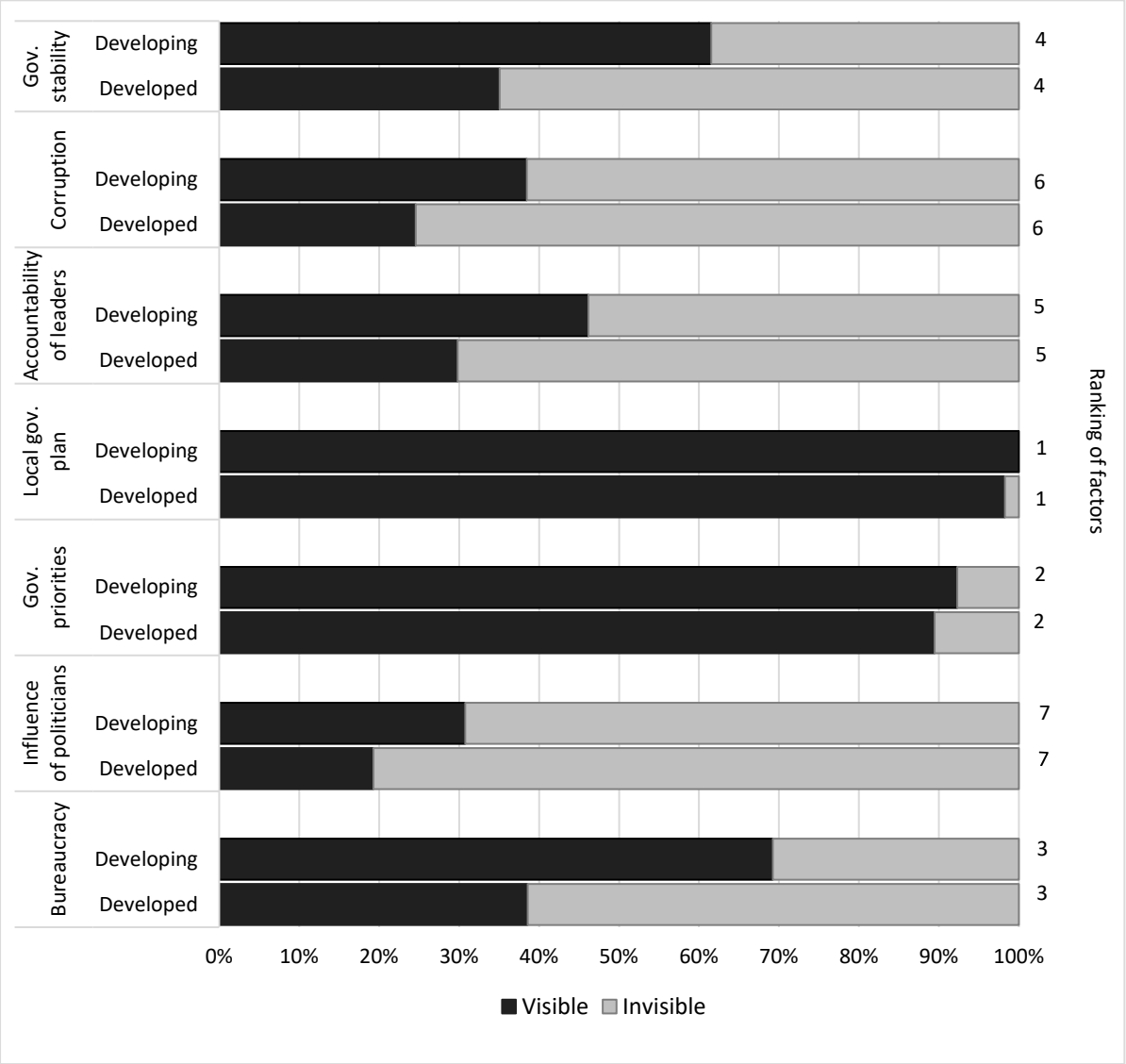


Figure 4.1. Proportions of Delphi survey participants classifying the political factors as visible or invisible.

Respondents strongly agreed that the establishment of environmental guidelines and clear targets were the most visible environmental factors (Figure 4.2). Climate change was classified as an invisible factor by experts from developed and developing countries, while respondents from developed countries also classified local weather and geographical landform as invisible factors. Respondents from developed countries have almost equal percentage of agreement on 4 of 6

environmental factors; climate change, geographical landform, local weather an environmental awareness. All environmental factors were ranked inconsistently by particpants experts.

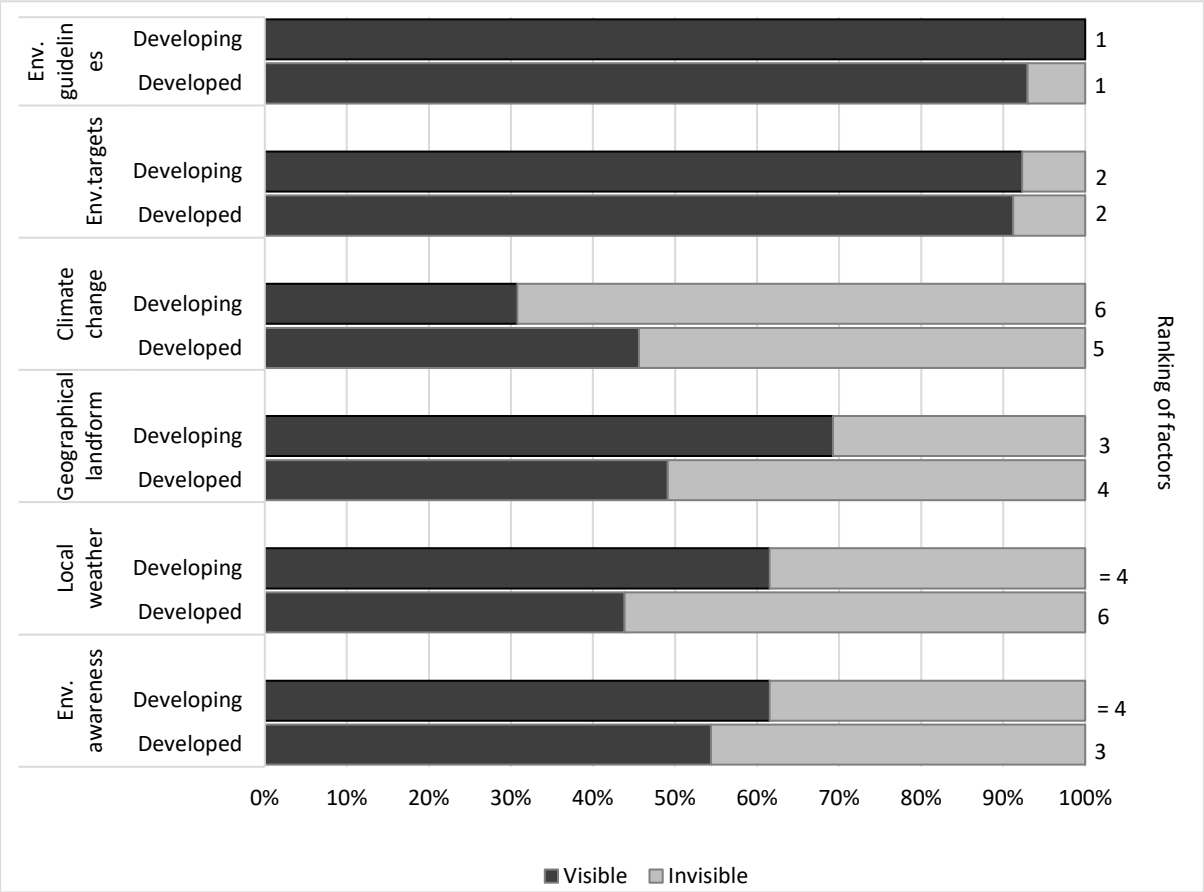


Figure 4.2. Proportions of Delphi survey participants classifying environmental factors as visible or invisible.

Figure 4.3 shows the proportions of respondents classifying social factors as visible or invisible. Respondents from developed countries agreed on a consistent ranking and classification of social factors, with the majority (8 of 13 factors) being considered as invisible, indicating a clear emphasis on and consideration of key social factors in local SWM systems. Local/national events and resource consumption patterns were marked as highly visible in developing countries; 4 out of 5 respondents regarded these factors as visible. Experts from developing countries had aclassified 9 of social factors as visible, with religion and discrimination as the most invisible factors. Experts from both countries had agreement on on classifying 4 factors as visible; seasonal variations, socio-demographic indicator, resource consumption patterns and philosophical shift. There were 4 factors were classified by respondents as invisible; religion, ethnicity, discrimination and shared norms.

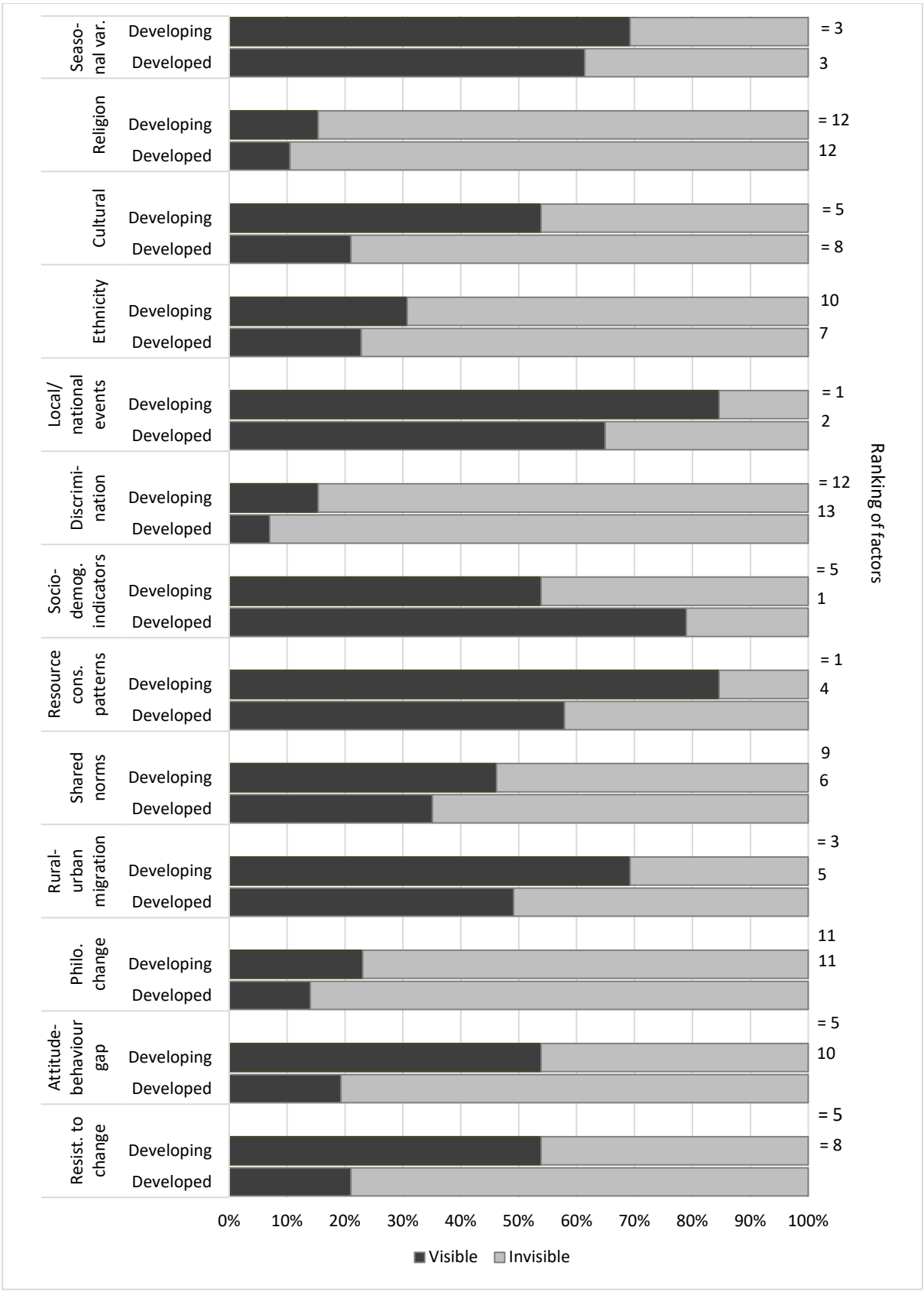


Figure 4.3. Proportions of Delphi survey participants classifying social factors as visible or invisible

The majority of technological factors were classified as visible, with facilities availability and suitable application of technology ranked as the most highly visible (Figure 4.4). Experts from developing countries ranked the need for skilled workers and experts that contribute to the efficiency of the MSW management system as highly visible as compared to the experts from developed countries. There were inconsistent ranking of factors despite of high agreement on factors' classification.

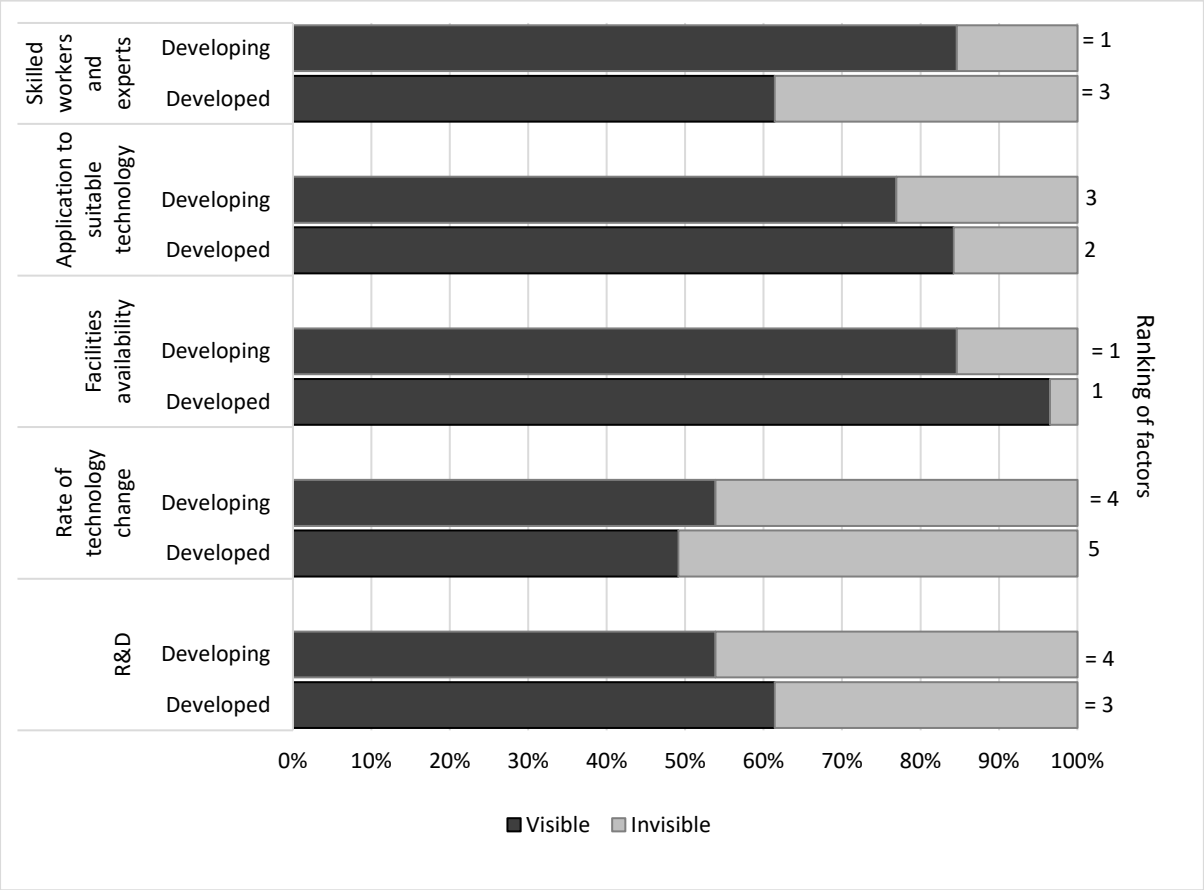


Figure 4.4. Proportions of Delphi survey participants classifying technological factors as visible or invisible.

Figure 4.5 below shows the proportions of respondents classifying legal factors as visible or invisible. Experts from developing countries classified all five legal factors as visible; 4 out of 5 legal factors were classified as visible by respondents from developed countries. Relevant solid waste management law and local policy were both considered visible factors by more than 95% of all respondents. Experts from both developed and developing countries have inconsistently ranked the all the legal factors. Experts from developed countries had classified consumer accountability as the most invisible legal factor.

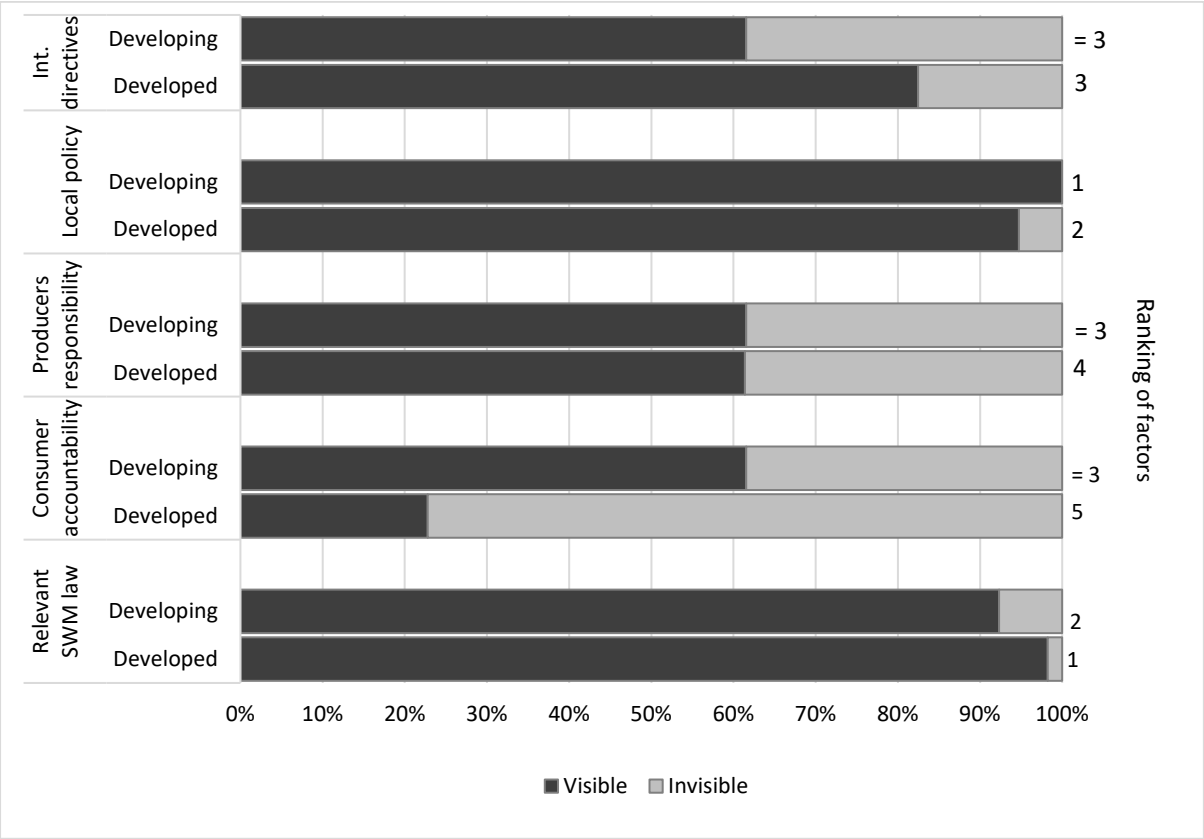


Figure 4.5. Proportions of Delphi survey participants classifying legal factors as visible or invisible.

Figure 4.6 shows the proportions of respondents classifying economic factors as visible or invisible. The majority of the respondents viewed most of the economic factors visible; however, the factors were ranked differently. In developing countries, experts regarded all of the economic factors as visible except for trade restrictions on waste. A strong agreement on the importance of available funds allocated for waste management was observed in developing countries; all respondents - without exception – considered this factor to be visible.

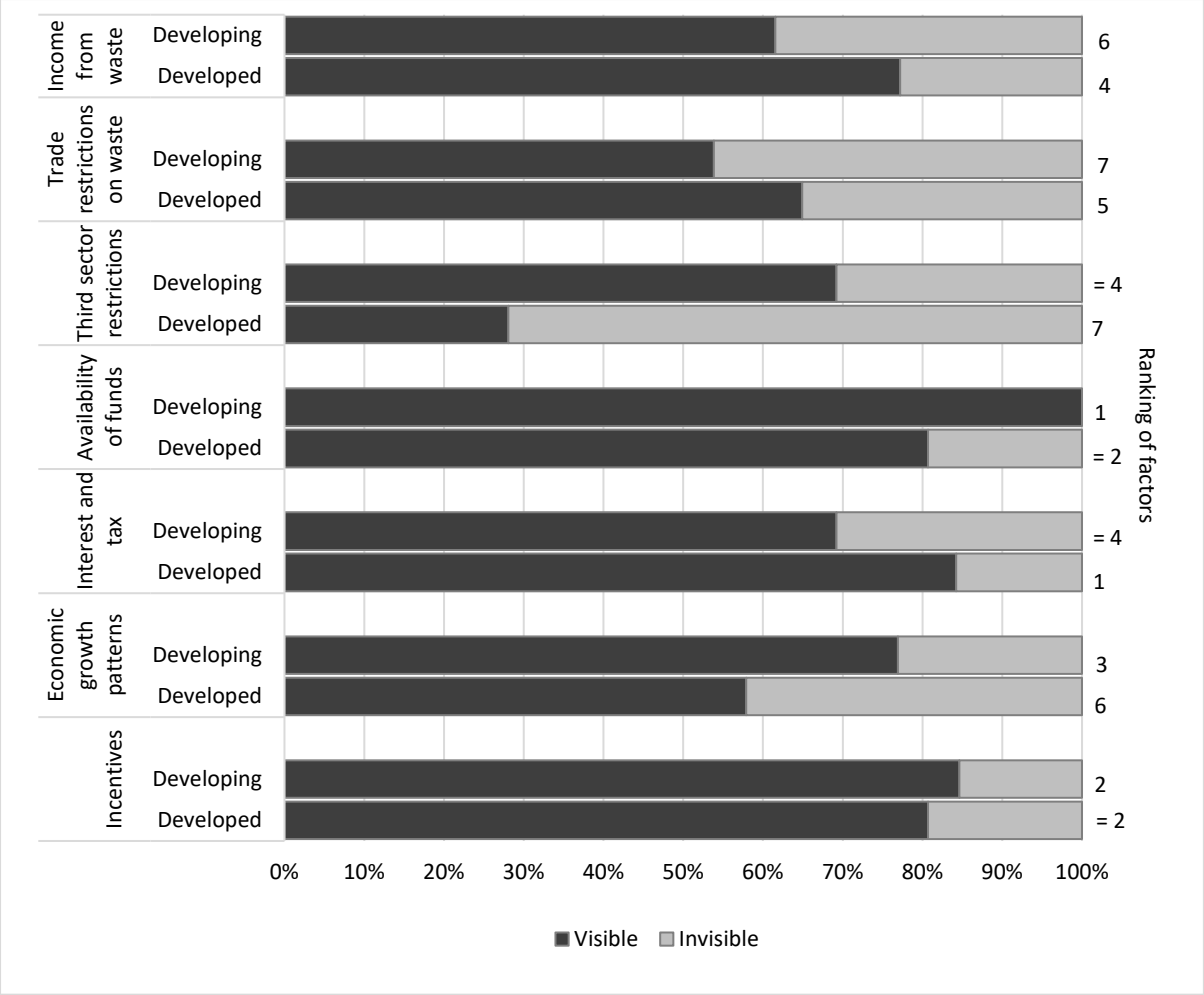


Figure 4.6. Proportions of Delphi survey participants classifying economic factors as visible or invisible.

4.3.4 Association between factors within PESTLE classification as visible or invisible

In order to investigate the association of factors between developed and developing countries, a Chi square test was employed and factors with significant association according to chi square p-value <0.05 are listed in Table 4.9. Lists of chi square p-values of all factors are in Appendix B. Statistically, there were associations between developed and developing countries for 8 factors; government stability, local weather, cultural, attitude-behaviour change, R&D activities, international directives, consumer accountability and trade restrictions on waste. These associations were significant at the P<0.05 level where chi-square was applied.

Table 4.9. List of factors with significant association according to chi square p value <0.05.

PESTLE classification	Factor	Counts	Developed countries		Developing countries		Chi square	P value
			Visible	Invisible	Visible	Invisible		
Political	Government stability	Observed	17	35	11	7	4.500	0.03
		Expected	20.8	31.2	7.2	10.8		
Environmental	Local weather	Observed	22	11	30	7	4.421	0.04
		Expected	24.5	8.5	27.5	9.5		
Social	Cultural	Observed	10	42	8	10	4.450	0.04
		Expected	13.4	38.6	4.6	13.4		
	Attitude-behaviour change	Observed	10	42	8	10	4.450	0.03
		Expected	13.4	38.6	4.6	13.4		
Technological	R&D Activities	Observed	31	21	11	7	4.421	0.03
		Expected	31.2	20.8	10.8	7.2		
Legal	International directives	Observed	44	8	11	7	4.387	0.03
		Expected	40.9	11.1	14.1	3.9		
	Consumer accountability	Observed	12	40	9	9	4.615	0.03
		Expected	15.6	36.4	5.4	12.6		
Economic	Trade restrictions on waste	Observed	36	16	8	10	4.519	0.03
		Expected	32.7	19.3	11.3	6.7		

4.4 Discussion

4.4.1 Overall factors classification by experts in developed and developing countries

Table 4.10 summarises the cumulative percentage of respondents' agreement in classifying factors in MSW according to PESTLE. The cumulative percentage of agreement were obtained by calculating the total score of agreement percentage for all factors with each of PESTLE components. Social factors were classified equally as visible and invisible according to experts from developing countries, whereas, experts from developed countries had classified them as invisible. For political factors, experts from developed countries had classified them as invisible whereas experts from developing countries considered them as visible.

Social and political factors are important but difficult to measure or assess (Chu et al., 2016). Social fragmentation in terms of ethnicities, cultural, religions (Figure 4.3) and geographical locations (Figure 4.2) resulted in different social perceptions, practices and behaviours relating to MSW; the distinct differences are more apparent in developing countries (Figure 4.3). In addition, waste

management practices such as separation at source and recycling are encouraged as daily behaviour based on necessity and not on legal obligation as in many developed countries. Therefore, there was conflicting evidence globally on the view of social factors due to the differences of social background and characteristics (McAllister, 2015).

Table 4.10. Overall summary classification of factors according to PESTLE classification analysis in the Delphi survey.

Factors in SWM	Developed countries (n=57)			Developing countries (n=13)		
	Percentage of agreement		Overall classification	Percentage of agreement		Overall classification
	Visible	Invisible		Visible	Invisible	
Political	48%	52%	Invisible	63%	37%	Visible
Environment	63%	37%	Visible	69%	31%	Visible
Social	36%	64%	Invisible	50%	50%	Equal
Technology	71%	29%	Visible	71%	29%	Visible
Legal	72%	28%	Visible	75%	25%	Visible
Economy	68%	32%	Visible	74%	26%	Visible

Of all the listed political factors, local government plan and government priorities were fully agreed by all experts as visible . A documented SWM plan, which is visible and accessible, is important to the development of local waste management systems (Zotos et al., 2009). Undoubtedly, government plays a fundamental role in waste management in terms of planning and providing required services as well as ensuring safe disposal of waste (Mukhtar et al., 2017). Government priorities in waste are commonly set through legislation, allocation of funding and facilities development. A local waste management plan that outlines the governmental framework, initiatives, implementation plan and targets the development of local waste management, alongside a demographic database and waste data trends, is commonly considered as the main point of reference for decision-makers and planners (United Nations Environment Programme, 2009). Unstable political circumstances appear to reduce the importance of environmental issues on a national agenda (Tsiko and Togarepi, 2012). Changes of government can clearly influence plans and their implementation at both local and national scales. A stable government with a well-established, highly-professional civil service and related institutions allows the establishment and maintenance of good relationships between politicians and authorities, ensuring better co-ordination of efforts in planning and development of efficient waste management services (Mohee and Simelane, 2015). However, government stability is

relative and may not always determine political stability (Wilson et al., 2001). There was a large difference in respondents' classification of visibility for government stability between developed (38%) and developing countries (62%). To illustrate, the recent so-called "Brexit" of the United Kingdom from the European Union and the subsequent re-election of the Prime Minister that caused political instability in the United Kingdom did not cause governmental institutions to be severely affected as they are strongly underpinned by a professional civil service with well-established local government plans (Cowell and Flynn, 2017). In such circumstances, politicians or appointed leaders generally were obliged to implement established national policy at a local level, including policies that affect waste management. This ensures that a federal government's plan can be broadly aligned throughout the country (Watson and Bulkeley, 2005), with minor alterations to take into consideration the local circumstances.

In contrast, Malaysia had experienced political instability after the 2008 General Election which resulted a contrast in political relations in some of the states between (i) states in the same political coalition as the federal government and (ii) states ruled by the opposition party and not aligned with the federal government (Nadzri, 2018). During this period, waste management in Malaysia was centralized to federal government, in line with the implementation of Solid Waste and Public Cleansing Management Act (SWPCMA) 2007, for better control of management and development of services and administration, and development of facilities (Sakawi, 2011). The instability caused resistance in states ruled by the opposition party (Penang and Selangor) as these states intended to keep the waste management under local control and not aligned with the national local waste management plan. As a result, different institutions emerged in waste management across the country and this caused non-uniformity with respect to implementation of the long-awaited Solid Waste and Public Cleansing Management Act (Sreenivasan et al., 2012).

The majority of respondents regarded resource consumption patterns as visible. Higher resource consumption relates to the stronger consideration of its consequences on local waste management in developing countries (Figure 4.3). Economic prosperity is commonly associated with demand for products and materials for consumption, especially amongst so-called "Millennials" (The Students and Staff of the Centre for Environmental Science, 2017), which in turn leads to higher demands on SWM systems. Preventing or inhibiting high rates of consumption and avoiding a "throw-away" mentality could reduce waste generation by enhancing reuse, resource recovery and recycling (Williams and Shaw, 2017). Apart from this, cultural and attitude behaviour change were statistically

associated between developed and developing countries. Cultural factors may present opportunities to transform waste management behaviour through social groups and communities which may be incorporated in SWM policies and practices, depending upon location (Crociata et al., 2015). Respondents from developing countries indicated that factors are not necessarily independent. Although culture, religion and ethnicity may well be closely associated in terms of behaviour and values regarding resource consumption and waste management, cultural factors are more commonly recognised and incorporated in SWM (Figure 4.3).

The experts from developed and developing countries had similar agreement on classifying the visibility of environmental, technological, legal and economy factors, suggesting that these four categories have emerged as important in our modern economy. Experts from developing countries generally considered most environmental factors to be visible - with the exception of climate change – suggesting that the adverse impacts of waste management activities on the environment are not clearly acknowledged and considered in local waste management systems. The majority of respondents from both developed and developing countries regarded environmental guidelines and targets as visible factors. This outcome indicates agreement that clear guidelines, which provide procedures and methodologies for monitoring and enforcing regulations with regard to environmental issues, are vital for improving MSW systems. Hence, having achievable and realistic targets is essential to drive initiatives towards improvement. We note that there was an association between experts from developed and developing countries on classification of local weather. For developing countries located within the tropics where humid weather is prevalent, deterioration of collection vehicle fleets and other MSW facilities may reduce their durability and thus influence economic costs of maintenance, breakdown management and replacement (Kumar et al., 2009; Seik, 1997). These results indicate that although such impacts are largely negative, they are classified as visible and commonly considered in planning and operations and, in principle, measures should therefore be in place to mitigate or avoid impacts on the economic value of investment, quality of operational services provided and selection of suitable waste treatment and disposal methods.

Advances in technology have proven to be effective for developing comprehensive waste management operations. With our growing human population and the enormity of waste that human generate, technological solutions for SWM are imperative. Suitable facilities for SWM permit resource recovery from the waste stream and thus contribute to more sustainable resource use (Abraham Lingan and Poyyamoli, 2014). Research leads to development and localization of

technology that drives the development of new waste management practices (Periathamby et al., 2009b). A lack of research and development activities can cause the selected technology to not operate effectively (or at all), thus wasting the resources allocated. Due to limitations on finance, expertise and research on applications of technology to wastes in developing countries (Badgie et al., 2012), there are fewer suitable and available facilities and hence they are less visible. Conversely, a lack of suitable facilities can contribute to stagnation or decline of local SWM systems; the availability of appropriate facilities enables and can motivate public participation.

Consumerism is related to purchasing power; however, little attention may be given to deciding the essential daily needs, durability, product origin or environmental consequences derived from the purchases. Advertising and promotion creates a desire to follow trends and fulfil personal desires and hence materials can be disposed for being perceived as old-fashioned or lacking durability - creating a wasteful society (Mukhtar et al., 2015). Developing countries lack a wide range of sustainable/green products in the market as well as the capacity to manage discarded items from unsustainable consumerism. Hence, accountability of consumers was considered a visible factor (62%) by experts from developed countries[S3]. There was also an association between developed and developing countries on consumer accountability as a MSW factor, hence justify the contradiction of experts' views when classifying this factor as either visible or invisible.

In developing countries, experts regarded all of the economic factors as visible except for trade restrictions on waste (no clear consensus). Strong agreement on the importance of available funds allocated for waste management was observed in developing countries; all respondents - without exception – considered this factor to be visible. There are more sources of financial support to develop SWM systems in developed countries (Periathamby et al., 2009b; Wilson, 2007; Wilson et al., 2001). Funds are not always available and appropriately allocated to SWM in developing countries, the operations and available resources are often disproportionately allocated to the high-income areas with higher tax yields where residents have stronger political influence. Trading of waste between developed and developing countries became an alternative solution to disposal for developed countries. This relationship was, in principle, beneficial to both partners; developing countries were generating income from recovery of resources from waste whilst developed countries secured reduction in disposal and treatment costs. However, this rapidly led to immoral and unethical practices that resulted in damaging human health and environmental impacts in developing countries. Thus, the importance of trade restrictions on waste in developed countries are

more invisible as compared with developing countries and there is a significant association between both types of country for third sector restrictions.

Stringent environmental standards and regulations have led to an increase in the application of technology in the waste sector, which proportionately increases the costs to run the operations. Policies, including both regulations and incentives, were shown to be effective in promoting MSW (Figure 4.1). However, in reality, the effectiveness of these policies was limited by implementation issues and differed from location to location. The potential economic benefits from waste/resource recovery resulted the market bloomed in waste trading and recovery. Synergetic business networking between developed and developing countries had benefitted not only in terms of financial and monetary, but also in securing the circular cycle of resources.

4.5 Conclusions

This chapter has identified 43 fundamental factors with regard to the development of SWM systems and classified them via a PESTLE system. Global experts classified these factors in terms of their visibility. We defined a visible factor (Table 4.1) as usually measurable by specific indicators or scales, quantifiable, considered in decision-making and implementation processes, and publically accessible. An invisible factor is defined as not usually measured or quantified but is still likely to influence waste generation, behaviour and operational practices, and perceptions about waste.

Experts from both developed and developing countries agreed that 24 factors are visible: local government plan, government priorities, environmental guidelines, environmental targets, environmental awareness, seasonal variations, local/national events, socio-demographic indicators, resource consumption patterns, philosophical change, skilled workers and experts, application of suitable technology, facilities availability, research and development activities, international directives, local policies, producers responsibility, relevant SWM law, potential income from waste, trade restrictions on waste, incentives from waste, availability of funds, interest and tax, and incentives. They also agreed that 8 factors are invisible: corruption, influence of politicians, climate change, religion, ethnicities, discrimination and shared norms. Experts from developed and developing countries generally agreed on the visibility of environmental, technological, legal and economic factors, suggesting that these four categories have emerged as important. The classification of political and social factors showed less consistency between developing and

developed countries; social and political factors are important but difficult to measure or assess because of their complexity.

This chapter highlights the need to adopt new perspectives in the selection of factors considered in regard to local waste management systems. By definition (Table 4.1), invisible factors are not currently recognised as contributors to waste management systems and even though they may be locally very important, they may have been neglected in decision-making processes. Recognising and making use of selected invisible factors within a local context may hasten the implementation and effectiveness of initiatives taken towards the development of SWM systems. Factors in waste management may vary in influence and change dynamically alongside urbanization; this dynamic varies from one country to another and so factors need to be re-evaluated periodically. Different combinations of factors influence the development of SWM systems. Alongside the use of a reliable evidence-base, addressing the factors – visible and/or invisible - that strongly influence local conditions is crucial if municipalities in developed and developing countries are to move towards more effective, locally optimised sustainable waste management systems. Further studies are required to evaluate the influence and interactions of these factors within local conditions in order to optimise the best combinations of factors as a means to aid decision-making.

Chapter 5: Factors that influence the development of solid waste management

5.1 Introduction

The development of MSW has historically been related to the factors that had influence in the past and continue to shape contemporary waste management systems (Mukhtar et al., 2017). Although there have been various studies of factors that influence solid waste management (e.g. (Afroz et al., 2011; Barr, 2007; Chen Liu and Wu, 2011; Periathamby et al., 2009b; Taherzadeh and Rajendran, 2014), there is a gap in understanding the interactions of factors that significantly influence the development of local waste management systems. There is also a need to highlight the factors that are not only visible, but also significantly influence the development of local waste management (Mukhtar et al., 2018). Previous scholars have identified factors influencing different elements of waste management systems; however, studies are largely limited to either single case studies or single elements of waste management. For instance, successful recycling systems are regarded to be influenced by waste separation behaviour (Stoeva and Alriksson, 2016), culture (Crociata et al., 2015), social self-interest and behaviourial change (Czajkowski et al., 2017; Tucker and Speirs, 2003), the use of situational factors – infrastructure, service provision and behaviour change - when developing waste policy (Timlett and Williams, 2011), as well as effective communications and education programs to educate the public (Kirakozian, 2016; Nguyen et al., 2017).

Meanwhile, waste generation rates are closely related to the changes in behaviour and attitudes (Barr, 2007), which are also influenced by the age distribution of the population (Shaw, 2017) and other socio-economic and demographic aspects (Afroz et al., 2011; Chen Liu and Wu, 2011). There are several policy instruments that effectively influence the development of solid waste management, e.g. policy tools such as waste regulations, legislation and specific penalties for non-compliance (Bai and Sutanto, 2002; Jones et al., 2010) and the introduction of revenue taxes on consumer accountability (Kirakozian, 2016; Welivita et al., 2015). The involvement of the government in terms of strategizing the regulation, policies and framework is a critical factor on the successful development and implementation of a local solid waste management plan (González-Torre and Adenso-Díaz, 2005; Shekdar, 2009; Taherzadeh and Rajendran, 2014). There is a clear

need to comprehensively study all the possible and relevant factors in MSW management to assess their potential contribution towards general improvements of systems at a local level.

The aim of this chapter is to quantify the influence of fundamental factors relevant to the development of MSW in developed and developing countries. This chapter is an extension of the work from Chapter 4 which has identified 43 fundamental factors concerning the development of MSW as a basis for experts' evaluation on the influence of factors through Delphi study. In Chapter 4, factors were classified according to their visibility (Table 4.1), which refers to the factors that are measurable and quantifiable and been considered in decision-making and implementation of national solid waste management plan. In this chapter, the influence of factors refers to the magnitude of impact that each factor contributes towards implementation of the national plan. It is noted that considering the factors' visibility and influence will lead to better evaluation of the impact that each factor has in the MSW development

5.2 Methods

5.2.1 Factors identification and PESTLE system

In Chapter 4, factors were derived from a multidisciplinary literature review in order to establish a list of fundamental factors associated with solid waste management. These factors were then classified according to the established and proven PESTLE system. PESTLE classifications are generic in nature; however, this analysis is useful as a transitional method to systematically give detailed guidance to decision-makers on the factors that are likely to influence MSW development. Despite its relative strength in terms of describing multi-dimensional aspects, the use of PESTLE analysis is inevitably narrative; analysis is restricted to the identification and conceptual evaluation of the relative influence of factors in MSW in order to determine those that should be subject to a more detailed analysis (Iacovidou et al., 2017). In this Chapter, the same factors were further evaluated with regards to their influence (see Chapter 4, Section 4.3.1, Tables 4.2 – 4.7).

5.2.2 Delphi study

This study adopted a two-rounds of Delphi that employed global experts on waste management as participants to seek their opinions regarding the influence of identified factors. The Delphi method is one of the best-known and most used as an effective tool for gathering expert opinions on a variety

of topics in different domains (Chowdhury and Dhawan, 2016; Toppinen et al., 2017). A Delphi study typically uses a series of questionnaires that involves paper-and web-based surveys or both (Okoli and Pawlowski, 2004; Ribeiro and Quintanilla, 2015; Strand et al., 2016), with feedback given to the experts after each round (Strand et al., 2016; Toppinen et al., 2017). The key characteristics of a Delphi study includes selection of the expert panel, anonymity and controlled feedback as well as statistical group responses (Muchangos et al., 2015; Strand et al., 2016). The panel was selected using online search to identify experts with relevant MSW knowledge, including editorial members of waste management related academic journals, academicians in higher education, politicians, officers from municipalities and waste management companies. The survey was run online between December 2016 and March 2017 using a questionnaire for the first round and choice experiment survey for the second round. Invitations to participate were sent with a link to online surveys. Respondents who were interested and agree to participate were later sent the survey link via email.

Delphi round 1

In round 1, an online questionnaire survey was conducted using iSurvey, a survey generation and research tool for distributing online questionnaires made available by the University of Southampton (https://www.isurvey.soton.ac.uk/). Similar applications of questionnaire tools have been applied in previous studies, e.g. Gregg et al. (2017); Grote et al. (2017). This chapter only discussing the results of first round of Delphi, spesifically for questions on factors' influence. Experts were asked to evaluate the influence of identified factors. Likert scale questions were employed to enable participants to state their opinions based on their experience and expert knowledge (Hartley, 2014; Li, 2013; Lozano et al., 2008). A bipolar Likert Scale was employed to secure experts' views. Experts were asked to use a slider to position their views on each question according to their own interpretation and experience (Cook et al., 2001; Rodrigues et al., 2015). Participants were required to choose a value ranging from "0=not at all influencial" and "4=extremely influencial". Nevertheless, the latters's responses were redefined in the result analysis for better interpretation and understanding, where intermediate value were redefined as follows: "1=slightly influential", "2 = somewhat influential" and "3=moderately influential".

Delphi round 2

Prior to start Delphi round 2, experts, who participated in Delphi round 1, were again asked for their consent to participate in Delphi round 2. In round 2, the results from round 1 were reported back to the experts for further evaluation via multi-criteria decision analysis using 1000Minds software

(https://www.1000Minds.com). The 1000Minds software uses the mathematical algorithm PAPRIKA (Potentially All Pairwise Rankings of All Possible Alternatives) to derive weights for each PESTLE factor using results from series of pairwise comparisons that randomly select pairs of all possible combinations (Hansen and Ombler, 2009). The value model or the preference values are represented by the relative importance 'weight' of the criteria that is calculated via mathematical methods (Golan et al., 2011). With the PAPRIKA method, users are allowed to choose one alternative from just two (Figure 5.1), which is easier and natural as in ordinary daily decision-making (Johnson et al., 2012).

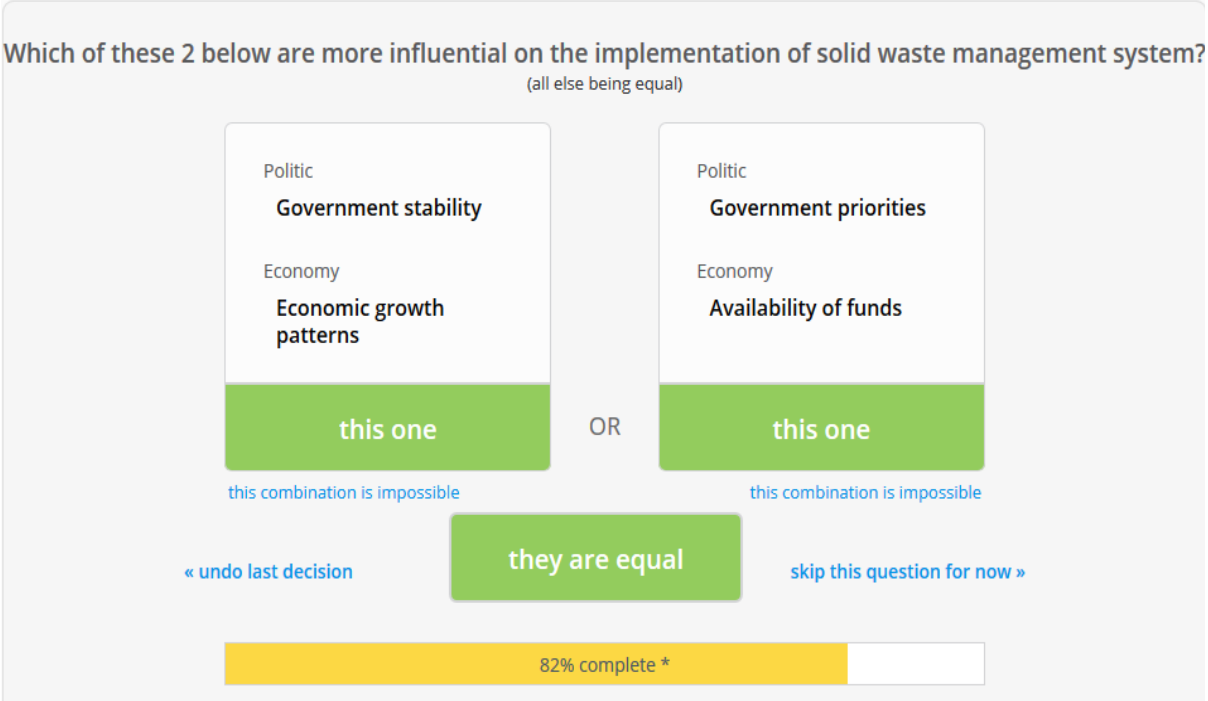


Figure 5.1. An example of choices presented in the round 2 Delphi study.

The PAPRIKA algorithm can process any number of pair-wise rankings of the hypothetical alternatives required to establish experts' preferences, which therefore presents better confidence in decision-making (Golan et al., 2011; Isma'ili et al., 2016). Through iterative discrete pair-wise choices, the decision analytic software is able to assign relative weights to the criteria (Johnson et al., 2012). Each respondent made an average of 13 choices to rank each of the 144 possible combinations of two pairs of PESTLE classifications. This study employed PAPRIKA method due to the robust, clear and less complex format of pair-wise comparison that generates individual weights for every decisions and combinations. 1000Minds is the only software that supports PAPRIKA method (Isma'ili et al., 2016; Taylor et al., 2013).

5.3 Results[WI4]

5.3.1 Delphi's respondents location profile

As mentioned in Chapter 4 (section 4.3.2), 70 experts from 31 countries took part in the survey, out of 278 invitations sent in Delphi round 1. While, in Round 2, 53 experts from 23 countries had participated, out of 70 invitations sent.

Table 5.1. Classification of Delphi survey participants' current location for both Delphi rounds

Continents	Countries	Classification	Involved in Delphi rounds	
			First	Second
Africa	Mozambique	Developing	✓	
	Tanzania	Developing	✓	
	Togo	Developing	✓	
	South Africa	Developing	✓	✓
Asia	Hong Kong	Developed	✓	
	India	Developing	✓	✓
	Indonesia	Developing	✓	
	Japan	Developed	✓	
	Malaysia	Developing	✓	✓
	South Korea	Developed	✓	
	Vietnam	Developing	✓	✓
Europe	Czech Republic	Developed	✓	✓
	Denmark	Developed	✓	✓
	Germany	Developed	✓	✓
	Greece	Developed	✓	✓
	Italy	Developed	✓	✓
	Netherlands	Developed	✓	✓
	Poland	Developed	✓	✓
	Slovenia	Developed	✓	✓
	Spain	Developed	✓	✓
	Sweden	Developed	✓	✓
	Switzerland	Developed	✓	✓
	United Kingdom	Developed	✓	✓
North America	Canada	Developed	✓	
	United States	Developed	✓	✓
Oceania	Australia	Developed	✓	✓
	New Zealand	Developed	✓	✓
South America	Argentina	Developing	✓	✓
	Brazil	Developing	✓	✓
	Chile	Developed	✓	✓
	Peru	Developing	✓	✓

Table 5.1 shows the list of Delphi participants for both rounds. A total of 39 experts (75%) participated from developed countries while the remaining 14 experts (26%) are from developing countries. The determination of countries' classification is consistent with round 1 of the Delphi survey (see section 4.3.2). We note that there was 25% decrease number of participating experts in Delphi round 2. Prior to initiating the survey, we had anticipated a dropout rate of 20-25% over the two rounds of consensus development based on previous studies (Day and Bobeva, 2005; Hsu and Sandford, 2007). In Delphi exercises, a minimum of 12 respondents is generally considered to be sufficient to enable consensus to be achieved; larger sample sizes can provide diminishing returns regarding the validity of the findings (Vogel et al., 2019).

5.3.2 Selection of factors

Factors employed in the first round were adopted in Chapter 4. Factors employed in the second round of Delphi were derived from the first round of Delphi study, where all factors with mean value of more than 3 ($\mu>3.0$) were selected as highly influential factors. Selected factors for both rounds of Delphi are as shown in Table 5.2. The number of factors selected in Delphi round 2 were reduced to ensure the questionnaire is convenient for experts to complete. PAPRIKA immediately identifies all possible pairs of hypothetical alternatives that can be pair-wise ranked. The number of questions to answer depends on the number of criteria and levels: the more criteria and/or levels, the more decisions. For instance, if calculating the possible pairwise for 43 factors (Table 5.2, round 1 of Delphi) with a maximum of 10 levels, there were approximately 6,048 questions that need to be answered by participants. Hence, the number of factors need to be reduced to ensure the questions were minimized, without jeopardizing the results (Hansen and Ombler, 2009).

Table 5.2. Factors selected for both rounds of Delphi

PESTLE class	Factors selected in Round 1 of Delphi	Factors selected in Round 2 of Delphi
Political	Government stability Corruption Accountability of leaders Local government plan Government priorities Influence of politicians Bureaucracy	Local government plan Government stability Government priorities
Environmental	Environmental guidelines Environmental targets Climate change Geographical landform Local weather Environmental awareness	Environmental awareness Environmental guidelines
Social	Seasonal variations Religion Cultural Ethnicity Local/national events Discrimination Socio-economic indicators Resource consumption patterns Shared norms Rural-urban daily migration Philosophical change Attitude-behaviour change Resistance to change	Philosophical change Resource consumption patterns
Technological	Skilled workers and experts Application of suitable technology Facilities availability Rate of technology change R&D Activities	Skilled workers and experts Rate of technology change Facilities availability
Legal	International directives Local policy Producer responsibility Consumer accountability Relevant SWM law	Local policy Relevant SWM law
Economic	Potential income from waste Trade restrictions on waste Third sector restrictions Availability of funds Interest and tax Economic growth patterns Incentives	Availability of funds Economic growth patterns

5.3.3 [WI5]Delphi round 1: PESTLE classification and influence of factors

Figure 5.2 shows the percentage of influence for overall factors according to their PESTLE classification. The majority of experts agreed that most of PESTLE factors were influential. Experts from developing countries regarded political factors as the most influential, with 82% of the experts ranked the factor as either moderately influential and extremely influential, while technological factors were seen as the least influential with highest percentage (7%) of agreements as either not at all influential or slightly influenctial among the experts. Conversely, experts from developed countries agreed on technological factors as the most influential; 4 out of 5 experts agreed that these factors were either moderately influential or extremely influential, while social factors were the least influential with close to 20% of the experts agreeing that these factors are as either not at all influential or slightly influenctial. Technological factors were viewed as more influential by experts in developed countries than by experts from developing countries. Overall, the distinct differences in agreement of quantifying the influence of factors indicates how developed and developing countries identify and consider the factors within their local settings, which provides the basis for further development of sustainable waste management.

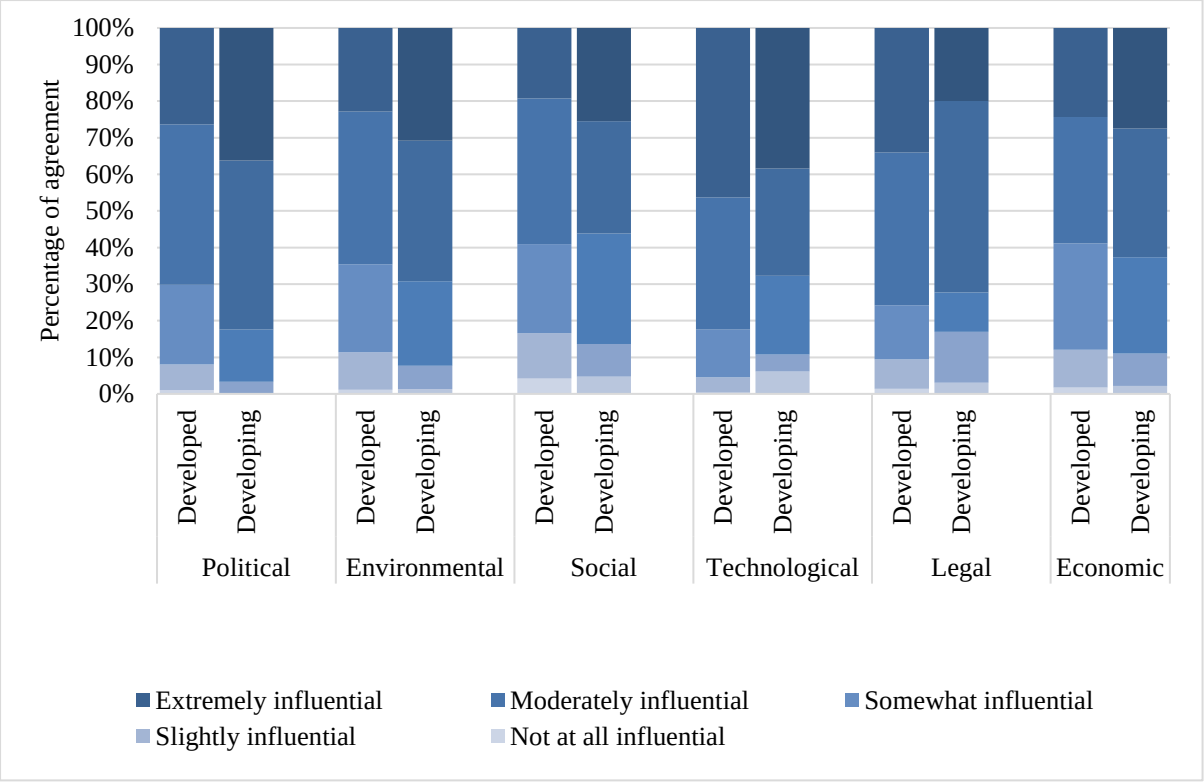
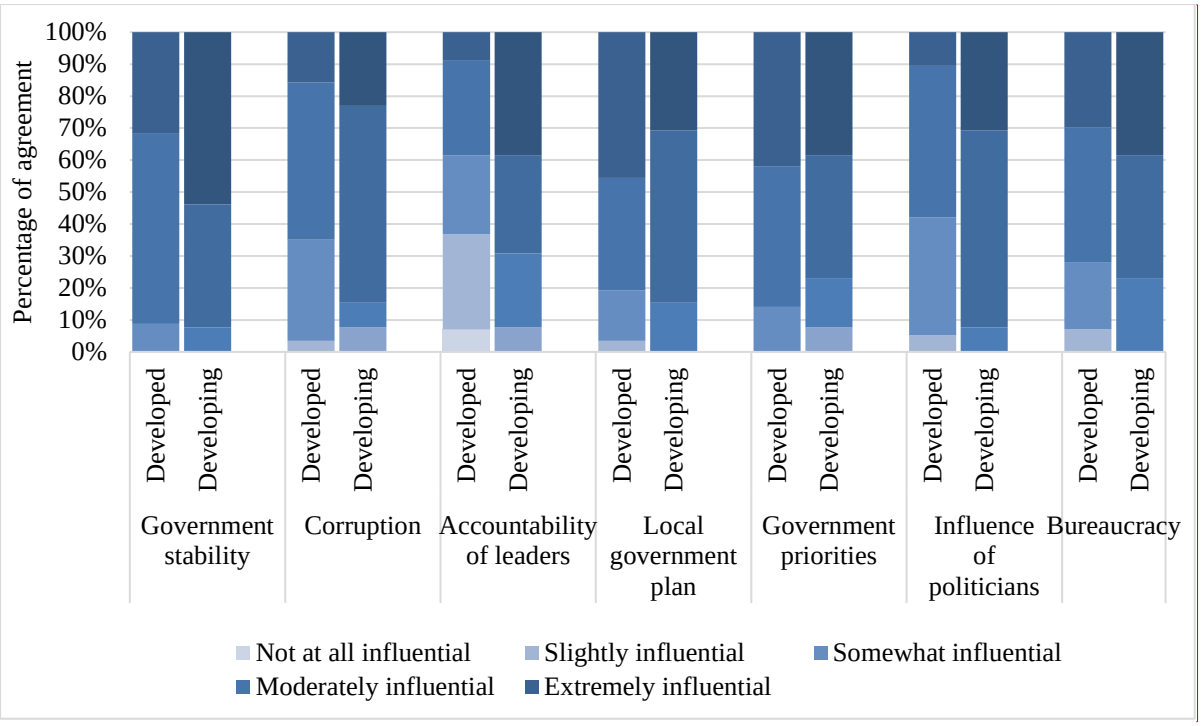


Figure 5.2. Proportions of Delphi responses on influence of MSW factors according to PESTLE classification in developed and developing countries.



[ME6]

Figure 5.3. Proportions of Delphi responses on influence of political factors according to developed and developing countries.

The influence of political factors were inconsistently ranked by experts from developed and developing countries (Figure 5.3). Governmental stability was regarded as highly influencial by experts in both developed and developing countries, with 4 out of 5 experts' agreeing in this regard. Nevertheless, the accountability of leaders was considered as the least influential by experts from developed countries, while all of the political factors were generally influential in MSW development according to experts from developing countries. There were differences of experts' views on the influence of corruption, accountability of leaders and political influences on the development of MSW strategies and policies, where experts from developing countries indicated higher agreement on these factors than those from developed countries.

Figure 5.4 shows the proportions of Delphi responses regarding the influence of environmental factors according to the experts from developed and developing countries. The importance of environmental guidelines and awareness was regarded as highly influential by the majority of experts from both developed and developing countries. Experts from developing countries, however, have stronger agreement than those in developed countries on the influence of environmental guidelines and awareness; 9 out of 10 experts had ranked these factors as either

moderately influential and extremely influential. Of all environmental factors, local weather was regarded as the least influenctial factors by experts in developed countries; 28% had ranked these factors as either not at all influential or slightly influential. Overall, experts from developed countries regarded climate change, geographical landform and local weather as the least influential environmental factors, while experts from developing countries has acknowledged that all of the environmental factors influence their waste management systems.

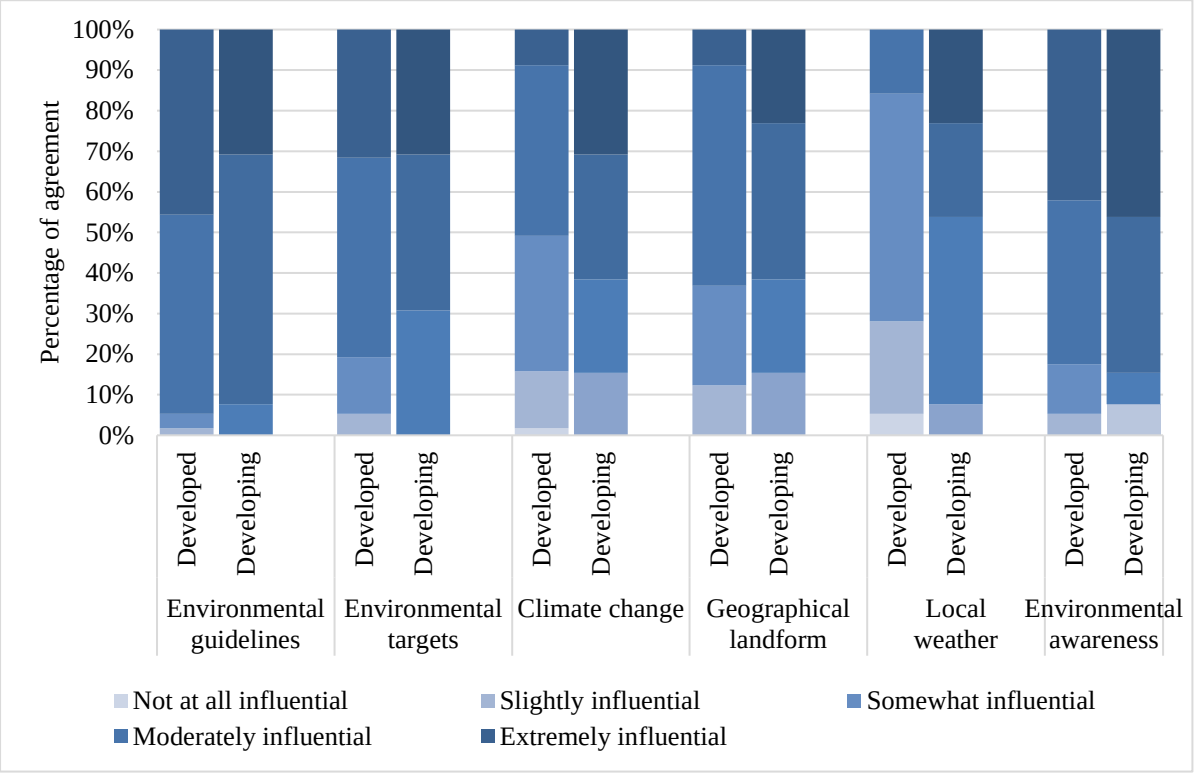


Figure 5.4. Proportions of Delphi responses on influence of environmental factors according to developed and developing countries.

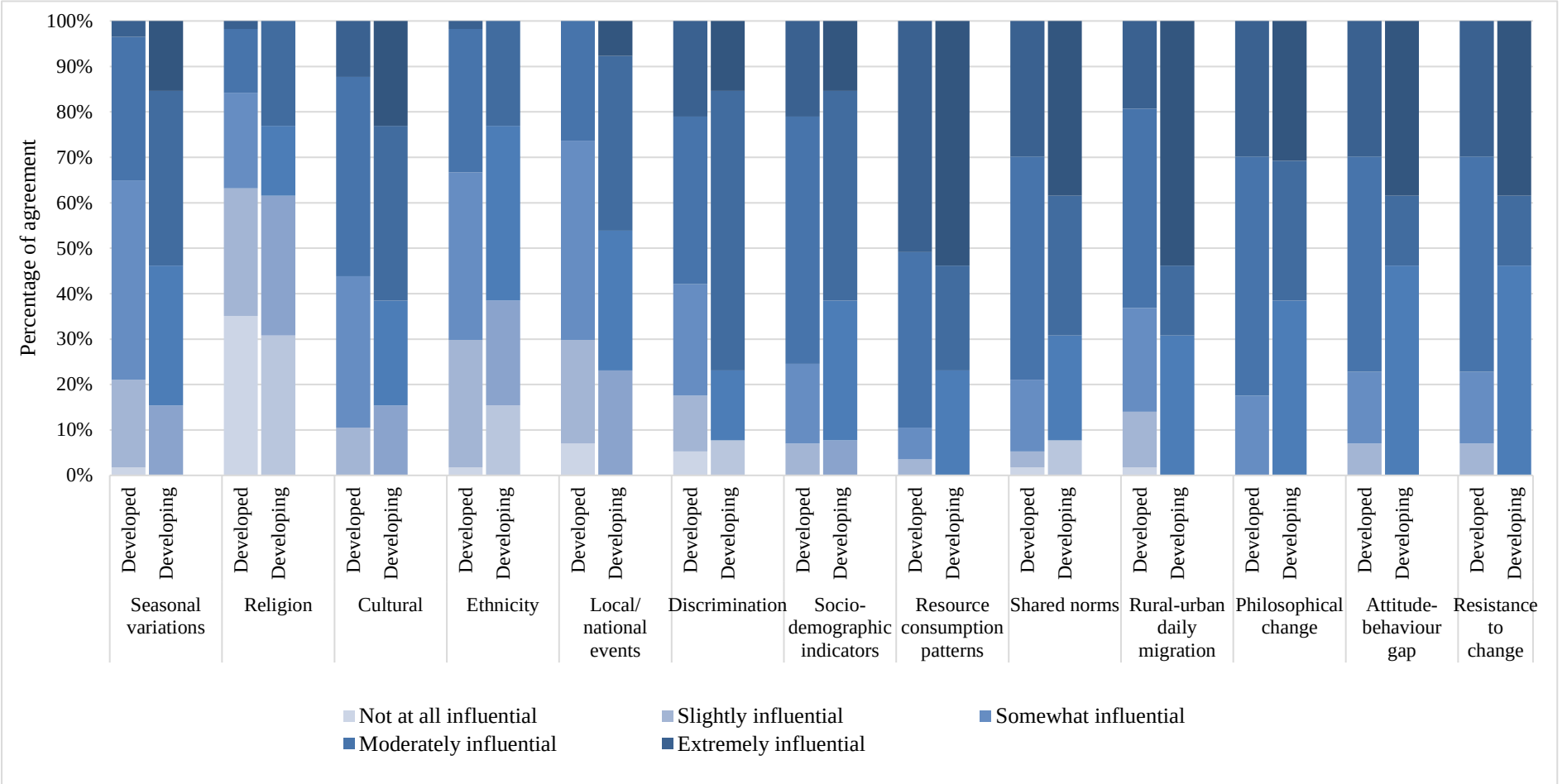


Figure 5.5. Proportions of Delphi responses on influence of social factors according to developed and developing countries

Social factors were ranked inconsistently among experts from developed and developing countries (Figure 5.5). Resource consumption patterns were agreed as highly influential factors by slightly more than half of all experts from both developed and developing countries. Experts from developed countries also viewed societal behaviour such as shared norms, philosophical change, attitude behaviour gap and resistance to change were highly influential; an average of 30% of all respondents agreed that each of these factors was extremely influential in their local waste management system. Apart from resource consumption patterns, daily migration of residents from rural to urban was viewed as extremely influential (53%) to the waste management system development. Religion was regarded as the least influential by experts in both developed and developing countries; more than 60% of respondents viewed religion as either not at all influential or slightly influential. There were six factors ranked to be more influential in developed countries than in developing countries: resource consumption patterns, shared norms, socio-demographic indicators, philosophical change, attitude-behaviour gap and resistance to change.

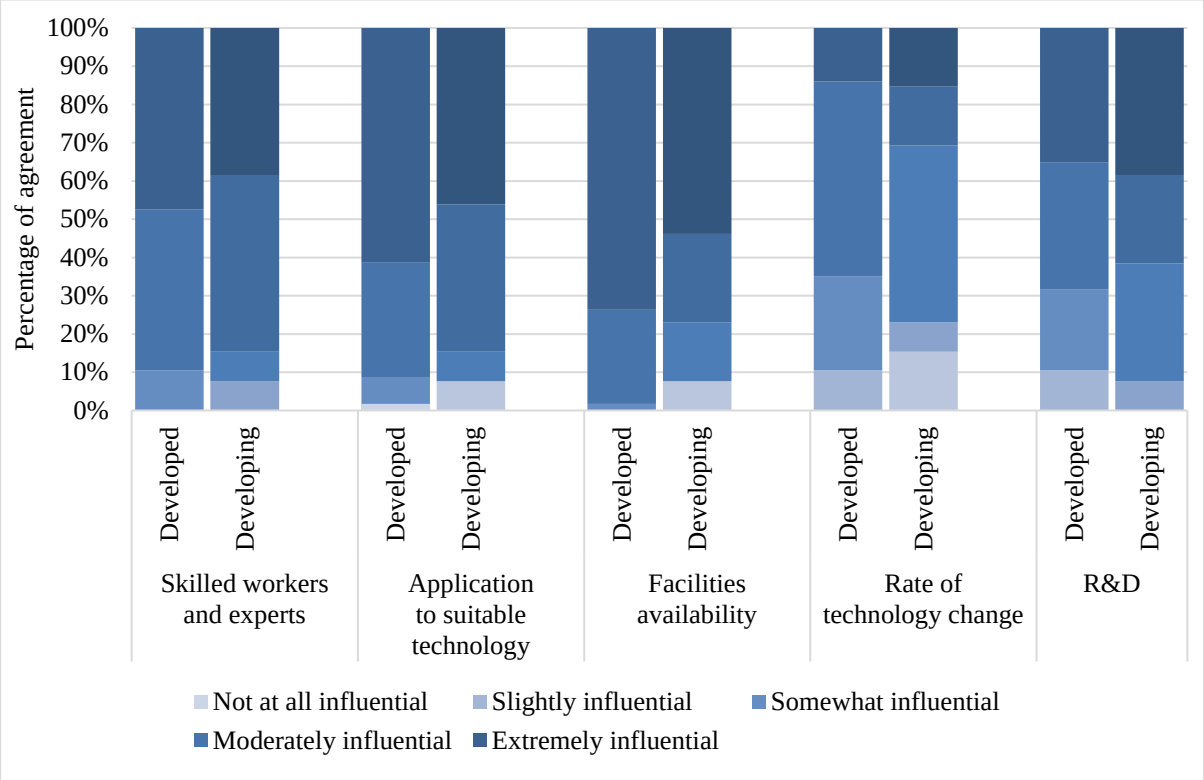


Figure 5.6. Proportions of Delphi responses on influence of technological factors according to developed and developing countries.

All technological factors were regarded as highly influential in solid waste management systems, with more than 60% of the experts from both developed and developing countries agreeing that

technological factors were either extremely influential or moderately influential (Figure 5.6). The availability of facilities was ranked as influential, with more than 90% agreement among experts. Nevertheless, the changes in technology was regarded as least influential due to the uncertainty of the likely pace in technology change over the coming decades.

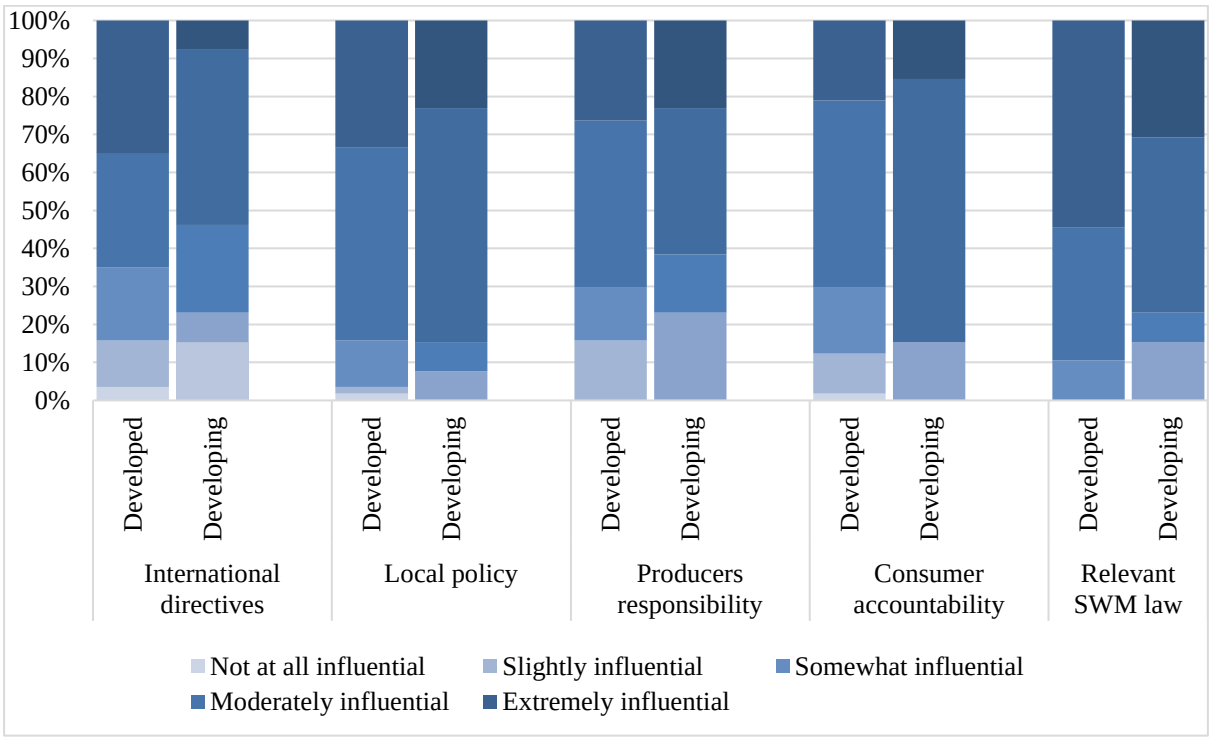


Figure 5.7. Proportions of Delphi responses on influence of legal factors according to developed and developing countries.

The establishment of documented local policy and implementation of relevant SWM law were the most highly influential legal factors with more than 80% agreement of experts from both developed and developing countries (Figure 5.7). Application of international directives and producers' responsibilities were ranked as least influential with 55% and 62% of agreement respectively by experts from developed and developing countries. There was a significant difference on the influence of international directives: experts from developed countries had stronger agreement, with more (35%) the experts ranking this factor as extremely influential than for experts from developing countries (8%). Similarly, the implementation of relevant SWM law was also significantly more highly ranked as extremely influential by 55% of the experts in developed countries as compared with 30% of the experts from developing countries.

Most of the economic factors were ranked inconsistently by majority of the experts (Figure 5.8). Experts from developed countries viewed changes in economic growth patterns as highly influential, with 9 of 10 experts' viewing this factors as either extremely influential or moderately influential. Conversely, experts from developing countries agreed on the influence of funds availability in their waste management development, with close to 85% of experts stating this factor to be either extremely influential or moderately influential.

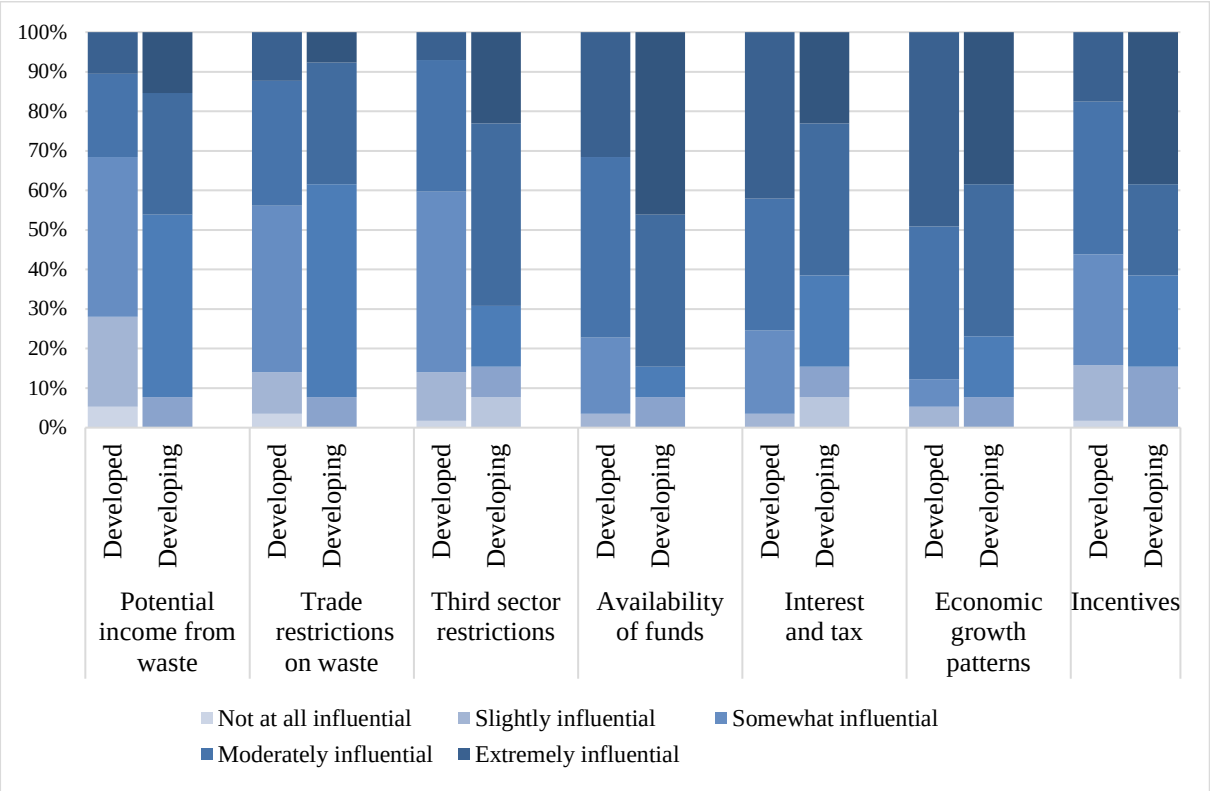


Figure 5.8. Proportions of Delphi responses on influence of economic factors according to developed and developing countries.

5.3.4 Association on factors influence with PESTLE classification

In order to investigate the association of factors between developed and developing countries in terms of their influences on the development of MSW, a t-test was employed. Factors with significant association according to the p-value <0.05 are listed in Table 5.3. Lists of t-test p-values of all factors in terms of their influences are in Appendix C. There were only 7 out of 43 factors that were statistically associated in terms of their influence.

Table 5.3. List of factors with significant association according to t-test p value <0.05.

Factors		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Local government plan	Equal variances assumed	-1.301	68	**0.018**	-0.28846	0.22166	-0.73077	0.15385
	Equal variances not assumed	-1.443	36.350	**0.018**	-0.28846	0.19993	-0.69380	0.11688
Government stability	Equal variances assumed	1.078	68	**0.025**	0.43590	0.40444	-0.37116	1.24295
	Equal variances not assumed	1.084	29.946	**0.027**	.43590	0.40200	-0.38515	1.25694
Local weather	Equal variances assumed	3.790	68	**0.000**	2.33761	0.61680	1.10680	3.56841
	Equal variances not assumed	3.614	27.342	**0.001**	2.33761	0.64684	1.01118	3.66404
Cultural	Equal variances assumed	0.103	68	**0.018**	0.07051	0.68329	-1.29297	1.43400
	Equal variances not assumed	0.106	31.054	**0.016**	0.07051	0.66587	-1.28744	1.42847
Research and development	Equal variances assumed	0.624	68	**0.045**	0.17094	0.27398	-0.37577	0.71765
	Equal variances not assumed	0.651	32.063	**0.040**	0.17094	0.26256	-0.36384	0.70572
Relevant SWM law	Equal variances assumed	-1.117	68	**0.028**	-.23718	0.21240	-0.66101	0.18665
	Equal variances not assumed	-1.044	26.516	**0.020**	-.23718	0.22716	-0.70368	0.22932
Availability of funds	Equal variances assumed	0.236	68	**0.014**	0.05342	0.22640	-0.39835	0.50519
	Equal variances not assumed	0.223	26.953	**0.025**	0.05342	0.23959	-0.43822	0.54506

5.3.5 Delphi round 2: Interaction of factors according to their influence

5.3.5.1 Ranking of entered alternatives

It is important to evaluate individual's preferences of selecting the highly influence factors for each PESTLE classification. In order to establish the preferences of factors according to individual choices, all possible alternatives (combination of factors) were entered and results gathered represent the actual alternatives that were ranked by individual experts in the survey. We have listed top 5 combination of factors that ranked by experts from developed and developing countries (Table 5.3).

Table 5.4. Combination of factors that are ranked by experts according to developed and developing countries

TYPE OF COUNTRIES	RANK	POLITICAL	ENVIRONMENT	SOCIAL	TECHNOLOGICAL	LEGAL	ECONOMIC
Developed	1st	Government priorities	Environmental guidelines	Resource consumption patterns	Facilities availability	Relevant SWM law	Economic growth patterns
	2nd	Government priorities	Environmental guidelines	Resource consumption patterns	Skilled workers and experts	Local policy	Availability of funds
	3rd	Local government plan	Environmental guidelines	Philosophical change	Facilities availability	Relevant SWM law	Availability of funds
	4th	Government priorities	Environmental awareness	Resource consumption patterns	Skilled workers and experts	Relevant SWM law	Availability of funds
	5th	Government priorities	Environmental guidelines	Philosophical change	Skilled workers and experts	Relevant SWM law	Availability of funds
Matched factors		**Government priorities**	**Environmental guidelines**	**Resource consumption patterns**	**Skilled workers and experts**	**Relevant SWM law**	**Availability of funds**
Number of factors matched and percentage		**4 out of 5 80%**	**4 out of 5 80%**	**3 out of 5 60%**	**3 out of 5 60%**	**4 out of 5 80%**	**4 out of 5 80%**
Developing	1st	Government priorities	Environmental guidelines	Resource consumption patterns	Facilities availability	Relevant SWM law	Economic growth patterns
	2nd	Local government plan	Environmental awareness	Resource consumption patterns	Facilities availability	Relevant SWM law	Availability of funds
	3rd	Government stability	Environmental guidelines	Resource consumption patterns	Skilled workers and experts	Relevant SWM law	Availability of funds
	4th	Local government plan	Environmental guidelines	Resource consumption patterns	Facilities availability	Local policy	Availability of funds
	5th	Local government plan	Environmental awareness	Resource consumption patterns	Facilities availability	Local policy	Economic growth patterns
Matched factors		**Government priorities**	**Environmental guidelines**	**Resource consumption patterns**	**Facilities availability**	**Relevant SWM law**	**Availability of funds**
Number of factors matched and percentage		**3 out of 5 60%**	**3 out of 5 60%**	**5 out of 5 100%**	**4 out of 5 80%**	**3 out of 5 60%**	**3 out of 5 60%**

Experts from both developed and developing countries had similarly ranked the combination of factors. Combination of PESTLE factors that were highly ranked by experts were governmnet priorities, environmental guidelines, resource consumption patterns, facilities availability, relevant SWM law and economic growth patterns. Notably, there were differences of factors ranking from second to fifth ranks. Experts from developed countries had 80% agreement on the factors ranking for all PESTLE factors except for social and technological. While, experts from developing countries had full agreement on factors ranking for social, whereas political, environment, legal and economic had least agreement of factors ranking.

5.4 Analysis of visibility and influence of factors

Based on the findings in Chapter 4 and results from section 5.3.3, the visibility of factors was classified and the influence of each factors was quantified via the Delphi study. This section discusses the analysis of factors within PESTLE classifications. The analysis focused on how these factors were classified according to both their visibility and influence. An influence and visibility matrix analysis has been applied to establish the interactions of factors that effectively can accelerate the development of SWM. This matrix is based on the percentage of agreement of Delphi respondents on (1) classifying factors as either visible or invisible and (2) quantifying their influence. This is done by positioning factors in relative terms according to the two broad criteria in a two-by-two matrix. This exercise in positioning the factors will indicate the degree of importance of each factors by evaluating the consideration of factors in the National SWM plan and how impactful the factors are in implementation of the plan, according to the experts from developed and developing countries.The application of the matrix will be able to help decision-makers in prioritizing factors that are important according to their local circumstances and context. Factors were later categorised into four sections as shown in Figure 5.9.

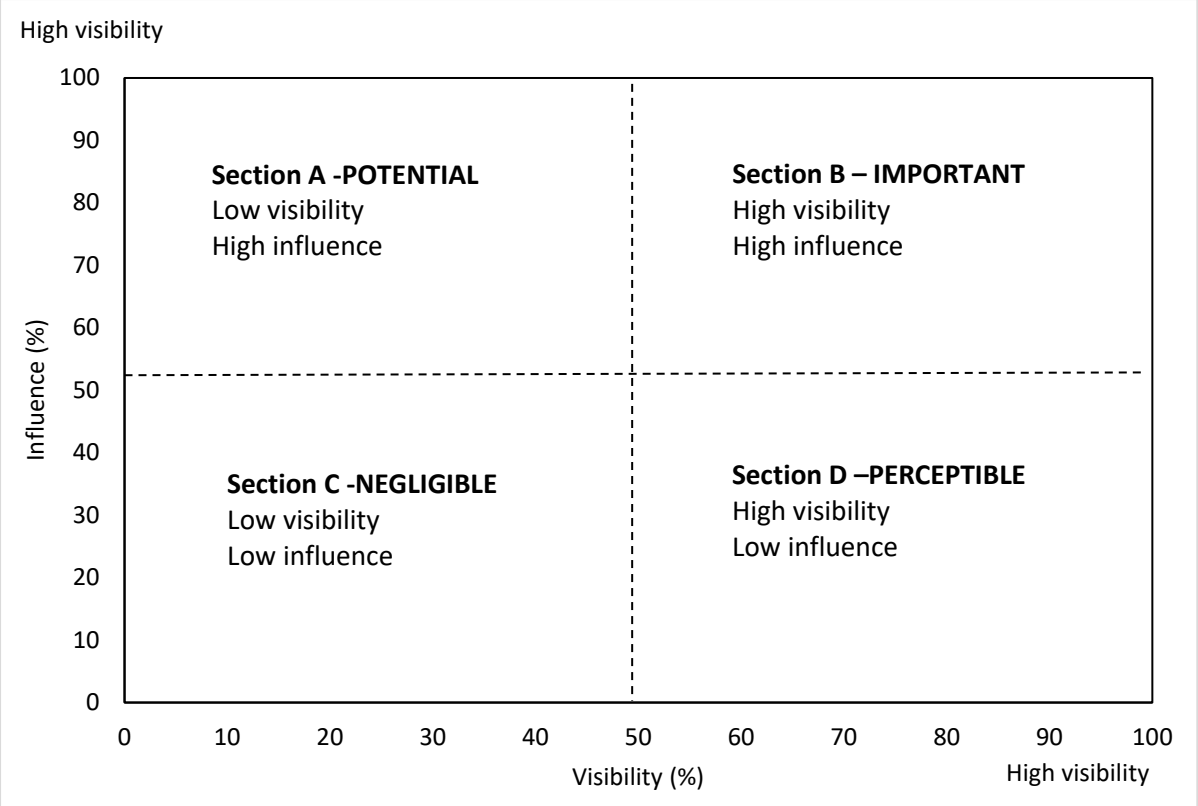


Figure 5.9. Details on sections in analysis of matrix on factors' visibility and influence

Brief explanations of each sections of the matrix (Figure 5.9) are as follows:

- Section A: Low visibility, High influence
    - Factors in this section were categorised as potentially of importance and not commonly included in the national SWM plan due to insignificant impacts to the development of local SWM. Nevertheless, the impact can be significant if the factors were appropriately and correctly emphasized or combined with other factors. Factors in this section can dynamically accelerate the development of SWM with appropriate emphasizes within the local SWM context.
- Section B: High visibility, High influence
    - Factors in this section were categorised as important and are vitally considered in the development of SWM for optimization of improvement efforts. Factors listed in this section were ranked as important and must be included in the national SWM plan for desirable result within a certain period of time.

- Section C: Low visibility, Low influence
    - Factors in this section were categorised as negligible with the least significant contribution to the development of the SWM system. Factors ranked in this section have insignificant impact but, nevertheless, cannot be ignored. It is worth considering these factors in future studies as factors in waste management changes dynamically alongside the urbanization and other supporting elements that contributes to the development of waste management.
- Section D: High visibility, Low influence
    - Factors in this section were categorised as perceptible and were mainly considered in the development of SWM. However, the impacts were relatively low and may not be significant in certain local circumstances..

5.4.1 Political

Figure 5.10 shows the influence and visibility of political factors according to the experts from both developed and developing countries. Generally, political factors have important roles in improving SWM efficiency (Mmereki et al., 2016). The majority of the experts had similar agreement on all political factors as both potential (high influence, low visibility) and important (high influence, high visibility) factors in the development of SWM. Fundamentally, the existence of documented evidence, i.e. local government plan and government priorities on the relevant issues on waste management, were deemed to be classified as important factors. Also, experts from developing countries had viewed government stability and bureaucracy as important; something developed countries had least considered. While political stability was desirable as means of financial support and visible in developing countries, it may open the opportunity for cronyism with impunity and increase the susceptibility of corruption; this is a dilemma that may affect the administrative, decision-making process as well as authoritative process in waste management (Di Maria et al., 2018b; Hussain, 2014). With stronger political engagement to address the functionality of government institutions in the development of SWM, developed countries may not experience similar situations.

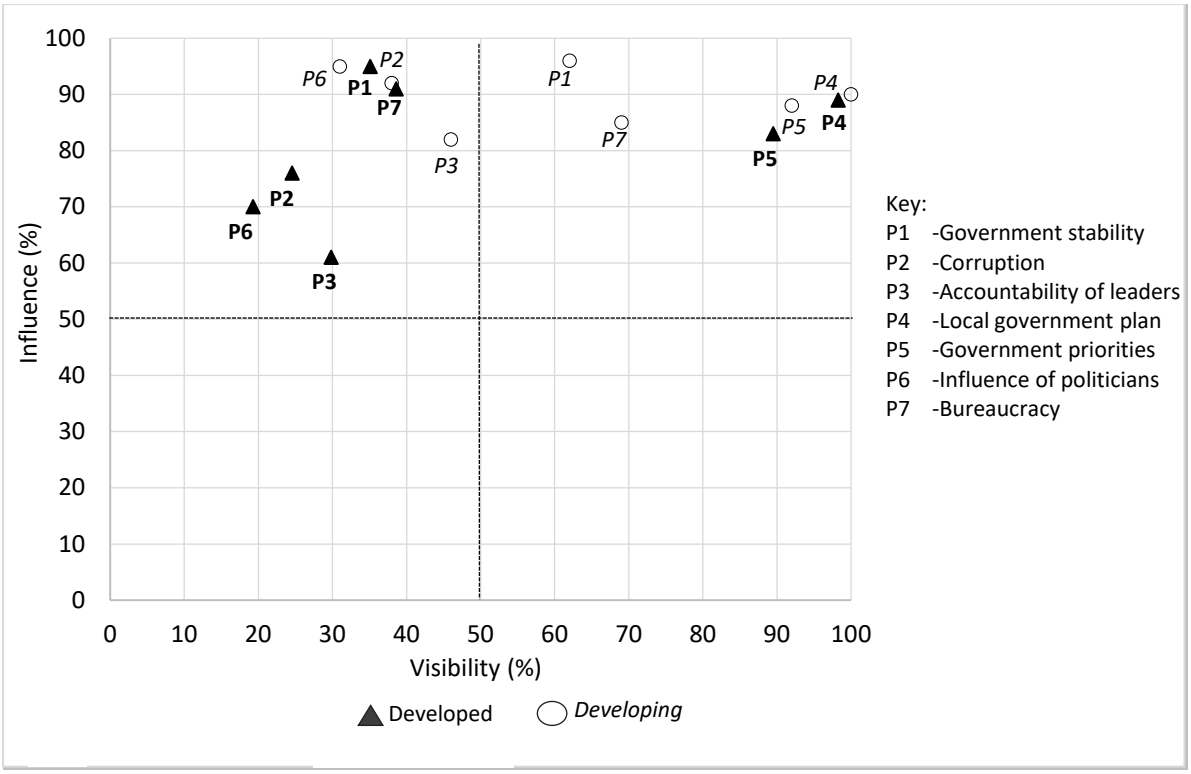


Figure 5.10. Matrix of influence and visibility of political factors in developed and developing countries.

Both bureaucracy and corruption are viewed as equally important but considered differently by experts from both developed and developing countries. The influence of politicians and leaders in the government much depend on how they emphasize their priority in issues related to waste and investment of related waste treatment facilities development, which align with their political interest/agendas; hence, this factor was considered to be a potential factors by experts. Politicians tend to take the path of least resistance to get influence and votes by making desirable shifts of environmentally-friendly SWM practice into a more economical and efficient solution. However, implementation of the proposed plan will determine the public trust of the government institution, thus politicians' influence can attain public interest and engagement in the success of the national SWM plan. In developing countries, this strategy had worked to influence people to believe that the change is real and positively improved, not only for the SWM services and system, but also for their social and economic status (Zurbrügg, 2003). Despite differences in specific local policies and plans across countries, national priorities for waste need to be consistently moving towards driving up the waste hierarchy, thus making a transition and a move to sustainability. Setting up priorities in waste management requires allocation of funding, ensuring effective implementation of policies and execution of the local waste management plan. This has summed up that the needs of the local

government plan and government priorities in the development of SWM were vitally important in both developed and developing countries. Nevertheless, whilst most of political factors are of high influence, their consideration in the development of waste management are somehow limited.

5.4.2 Environmental

Experts from both developed and developing countries ranked the environmental guidelines and targets as important (high influence, high visibility) (Figure 5.11). Efficient planning of SWM systems requires accounting for the complete set of environmental effects and burden associated with activities that generated waste (Emery et al., 2007); hence environmental guidelines and targets were deemed important environmental factors in the development of SWM. The specifications of environmental standards and guidelines, complemented by achievable and realistic targets, can be useful tools for organisations, operators and other stakeholders in the waste sector. The established targets display the government's priorities on waste sector in providing adequate waste services, minimizing adverse impacts resulted from waste disposal and treatment, as well as encouraging public engagement in waste management at local level (Moh and Abd Manaf, 2016).

With the development of awareness of environmental pollution and various consequences of climate change, a sustainable SWM system is critically important. Good resource management and climate change were observed in some of the developed countries such as Switzerland and Scandinavia (Wilson, 2007), nevertheless, the absence of new-vision and long-term international directives related to combatting climate change resulted from waste sectors activities in developing countries (Marshall and Farahbakhsh, 2013). This led to the results where environmental factors were ranked by experts as important in developing countries, with the exception of climate change. Overall, the establishment of clear environmental guidelines and realistic targets for environmental standards related to waste sector are the most important environmental factors in waste management development.

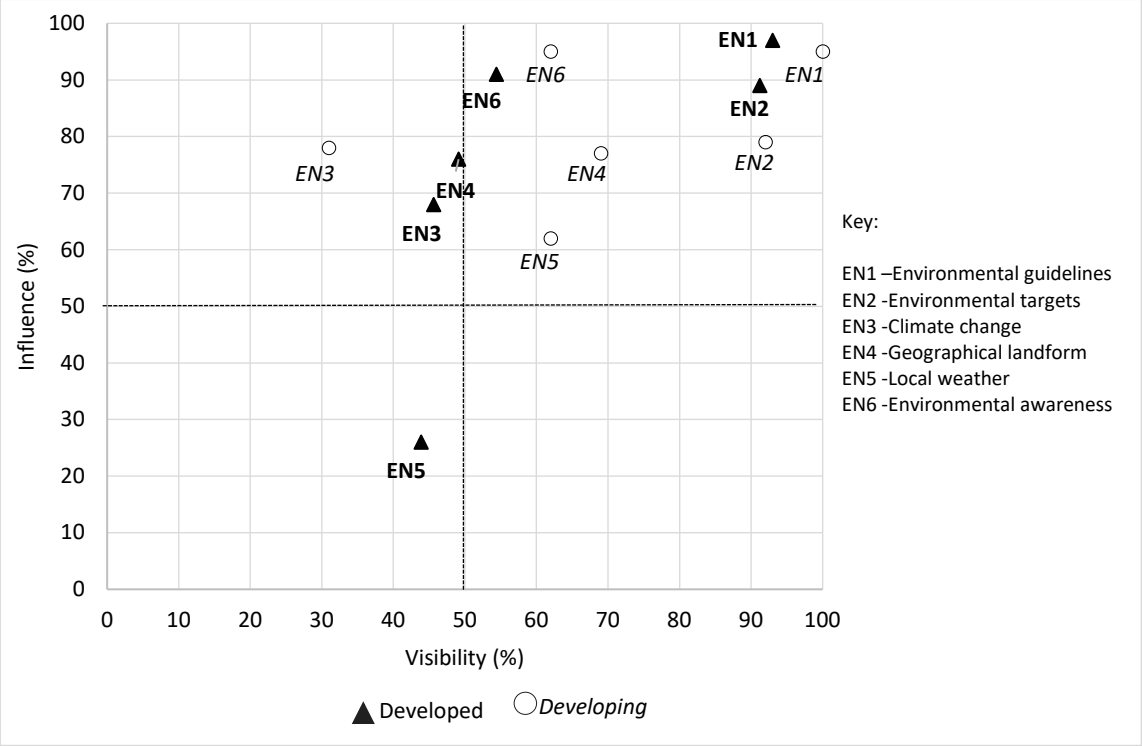


Figure 5.11. Matrix of influence and visibility of environmental factors in developed and developing countries.

5.4.3 Social

Figure 5.12 shows the influence and visibility of social factors in developed and developing countries. Social factors relevant to SWM were classified and distributed inconsistently with significant number of factors not clearly agreed among experts. Developing countries had more uncertainties on the importance of social factors as compared with developed countries. There was no agreement among experts from both types of the countries on any factors that were deemed to be important; the wide variety and unique social backgrounds and characteristics from one country to another lead to specific approaches addressing social engagement and influence in local SWM. Social activities such as celebrations of events, daily migration of people from rural to urban areas, and resource consumption patterns are regarded as important factors by experts in developing counties. Whilst, with more reliable sources of database on social characteristics as compared with developing countries (Mukhtar et al., 2016), relevant indicators on social characteristics are deemed as important. Socio-demographic indicators seemed to have effects generally on the waste generation rate, resource consumption, operational planning of waste management services as well as infrastructure planning and development. For instance, in the case of households' education level

and income, those with high education, perhaps not necessarily, have a greater concern for the environment and are more likely, potentially, to be able to pay for waste management services, if required, as compared with those less well educated (Triguero et al., 2016).

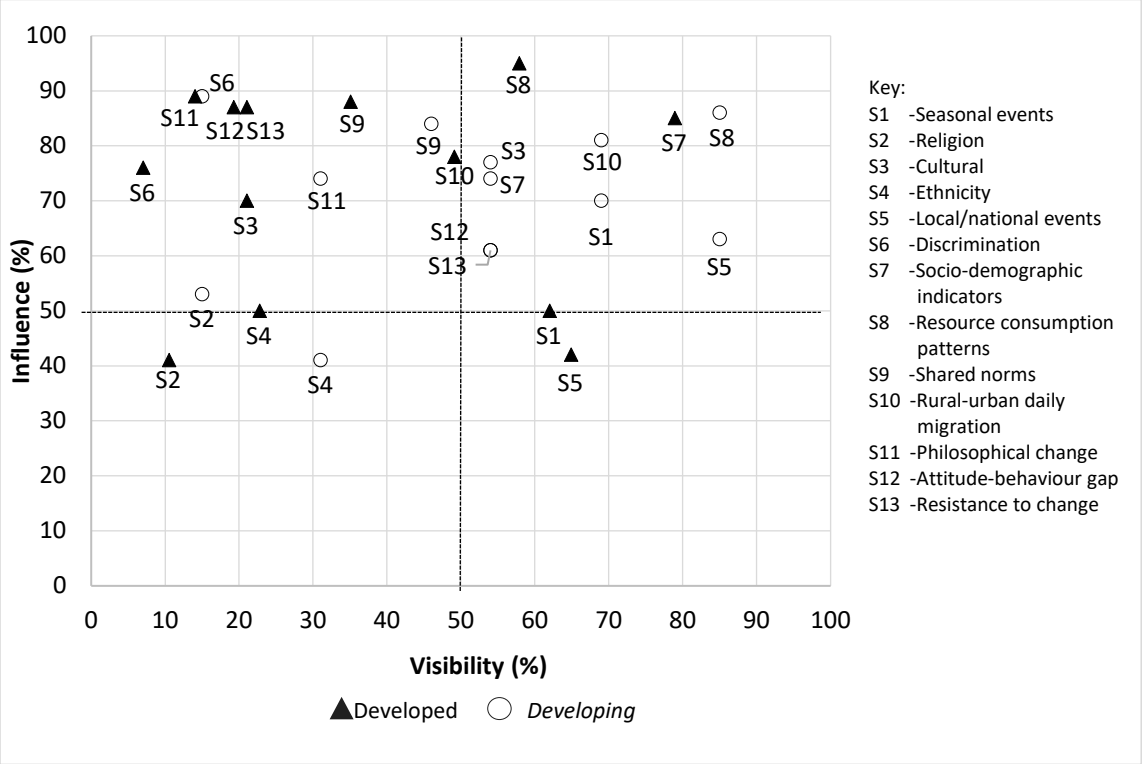


Figure 5.12. Matrix of influence and visibility of social factors in developed and developing countries.

Resource use, waste production and environmental degradation are accelerated by population growth and increasing consumption of resources (Mmereki et al., 2016). Understanding the changes and complexity in resource consumption is important to not only sustain the utilization of natural resources, but, ultimately, to reduce the amount of waste generated and the associated environmental pressures. Religion and ethnicity were closely agreed by experts from both type of countries as negligible or not important. Ethnicity and religion prejudices in waste behaviour are sensitively addressed although were significantly different in terms of potential for improvement (Mohamad et al., 2011). Religious institutions have potential for enhancing public behaviour in terms of good practice in waste management through the systematic institutional operation and conducting programmess (Mohamad et al., 2011; Mukhtar et al., 2017). Successful case studies in this area are extremely limited, therefore, optimism for religion to influence waste management development need to be better understood (Mohamad et al., 2012).

Similar to religion, different ethnicity backgrounds have different influence on waste behaviour, and the complexity and their impact on multi-ethnic interactions in a community is hard to recognize and measure. Most of the developing countries were multi-ethnic (Fearon, 2003); where, perhaps oddly, this does not appear to be considered to be influential by the majority of the experts. Perry and Williams (2007) reported that significant differences exist between attitudes and awareness of different generation ethnic minorities. Potentially, further understanding and specific approaches to different ethnic groups in order to educate and disseminate information on waste management practice may prove to be successful initiatives. Developed countries had put substantial consideration on the occurrence of events, despite its low influence in the overall development of the system. Operationally, these factors may impact the system, but it do not influence the development of the system. It may appear as good publicity to the waste operators and a city's image. Developed countries had considered social factors as invisible, but evidently when comparing these factors in terms of their influence on the system, there were factors that are potentially considered as highly influential. Developing countries had stronger motivation on social factors to be influential in the development of waste management systems, with 8 out of 13 social factors ranked as important in the matrix.

5.4.4 Technological

Technological factors were generally regarded by experts from developed and developing countries to be of high influence, high visibility (important), indicating how technology plays fundamental roles in modern SWM globally. Figure 5.13 shows the matrix analysis of influence and visibility of technological factors in developed and developing countries. The majority of the experts from developed countries had ranked all factors as important in SWM. Availability of facilities and their suitability with local waste circumstances are important in modern SWM system. Research and development activities related to SWM were highly influential but invisible in developing countries; the contributions of research activities in improving local waste conditions were not fully acknowledge and recognized (Periathamby et al., 2009b). An absence of experts, lack of support from the government and industries as well as low number of facilities and research institutions has limits on the significant needs of research activities.

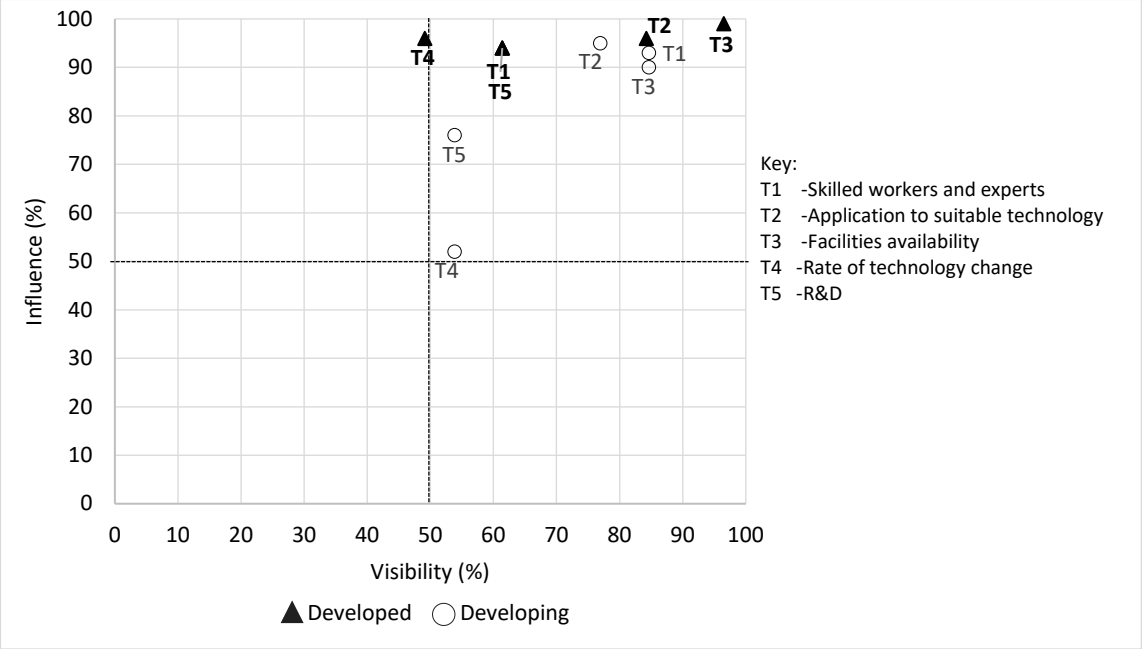


Figure 5.13. Matrix of influence and visibility of technological factors in developed and developing countries.

Knowledge transfer from developed to developing countries is important to equalize the development of global waste management system, however, it does comes with high costs that most of the developing countries could not afford to pay. Apart from this, the incompatible or inadequate facilities as well as the different characteristics of waste, local condition and social backgrounds are the main challenges for a beneficial exchange. Overall, despite the strong emphasis on the importance of technological factors as shown in Figure 5.13, there are remaining challenges to uplift the application of technology, especially in developing countries which are substantially related to the lack of financial support (Figure 5.15), implementation of relevant policies (5.14), socio-status (Figure 5.12) as well as political conditions of the countries (Figure 5.10).

5.4.5 Legal

Majority of legal factors were marked as being of high influence and high visibility, with exceptions of international directives and producer responsibility in developing countries. Strong emphasis, consideration and implementation of the policies, regulations and law were important to establish uniformity in the local waste management system. Compliance of environmental legislation with regards to SWM are important to determine weather it can expedite or limit any waste management policy implementation (Periathamby et al., 2009b; Wilson et al., 2011). Laws and regulations on

waste in developed countries are more stringent and influenced by the international and regional directives that set uniform standards across all member countries (James, 1996). Waste laws were reported to be inefficiently implemented in developing countries due to the weak implementation institutions, lack of understandings among the stakeholders, interference of politics as well as limited available resources for implementation activities (Marshall and Farahbakhsh, 2013; Muchangos et al., 2015).

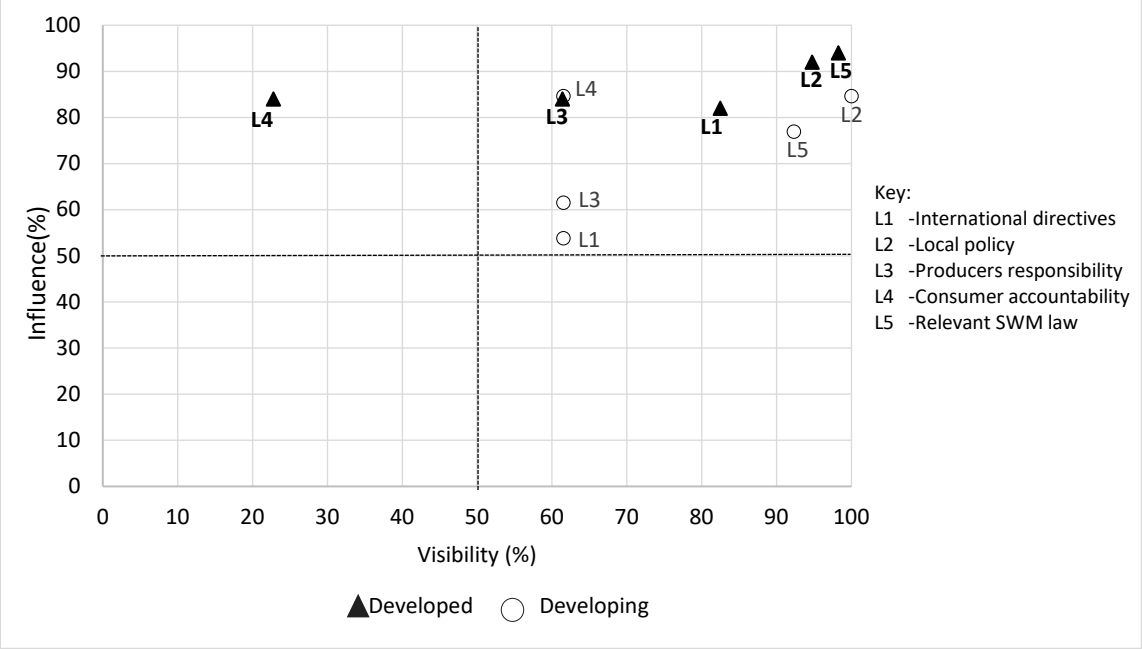


Figure 5.14. Matrix of influence and visibility of legal factors in developed and developing countries

Results indicated that the establishment of local policy and relevant law were deemed to be important in both developed and developing countries. There were several factors that ranked similarly in terms of visibility but with different degrees of influence. There was some consideration of consumer accountabilities, producer responsibilities and the implementation of international laws in shaping the legal enforcement of waste management in developing countries, as agreed by the experts. Lack of implementation of or compliance with the international law forces developing countries to emphasize more the implementation of local law instead. Developed countries have addressed their SWM by implementing effective and functioning policy frameworks and comprehensive local policy. The clarity in defining terms and regulation able to guide enforcers' authorities to efficiently implement the outlines laws in the same ultimatum. [S7]In contrast, developing countries experienced low efficiencies in governmental institutions that are not financially adequate and lack co-operation and co-ordination among stakeholders. Therefore,

emphasizing the appropriate and required legal factors, especially on the efficient implementation of the appropriate regulations, proved to be crucial for developing countries. The roles of legislation and relevant law on SWM are to initiate the systems that help to decide, evaluate and monitor the conditions of local waste system. International agreement will be able to assist in promoting sustainable development by optimizing resources use, facilitating best waste management practice and encouraging the development of the necessary corresponding legislation and regulations (Meyers et al., 2006). However, poor enforcement of regulations was seen as a way to execute daily operations such as disposal and collections of waste at affordable costs as well as increasing revenues for the authorities (Vij, 2012).

5.4.6 Economic

Most of economic factors were ranked as being of high influence and high visibility (Figure 5.15). Waste is part of the economy which provides input through material or energy recovery. Conversely, the management of waste has economic implications in terms of productivity, capital investment and environment. We note that availability of funds is important according to the experts in from developing countries. Funds were always important, however, financial mismanagement leads to persistent lack of funds for improving services and capacity-building (Henry et al., 2006). Positive economic growth could potentially seed the development of facilities; investments in appropriate waste treatment facilities could minimise impacts on the environment (Kumar et al., 2017), thus generating potential job opportunities for society (Ion and Gheorghe, 2014). Trade restrictions were debated aggressively in developed countries, which motivates the argument of public and environmental health concern against economic and financial profit in particular. Economic factors related to monetary offerings (incentives, potential income from waste and interests) were proved to be the most important in global waste management. Potential income from waste was ranked as the least important economic factor by experts in developed countries. In developed countries, the primary aim of waste management concerns protecting public health, rather than generating income from waste (Marshall and Farahbakhsh, 2013; Velis et al., 2009). Experts from developing countries viewed potential income generated from waste as moderately influential. Influence of restrictions on waste trading was ranked as moderate. Movement of waste across countries has negative impacts, especially to the developing countries as the trading activities can increase the exposures to hazardous pollutions in exchange for opportunities to stimulate their economic development (Mukhtar et al., 2017; Ray, 2008).

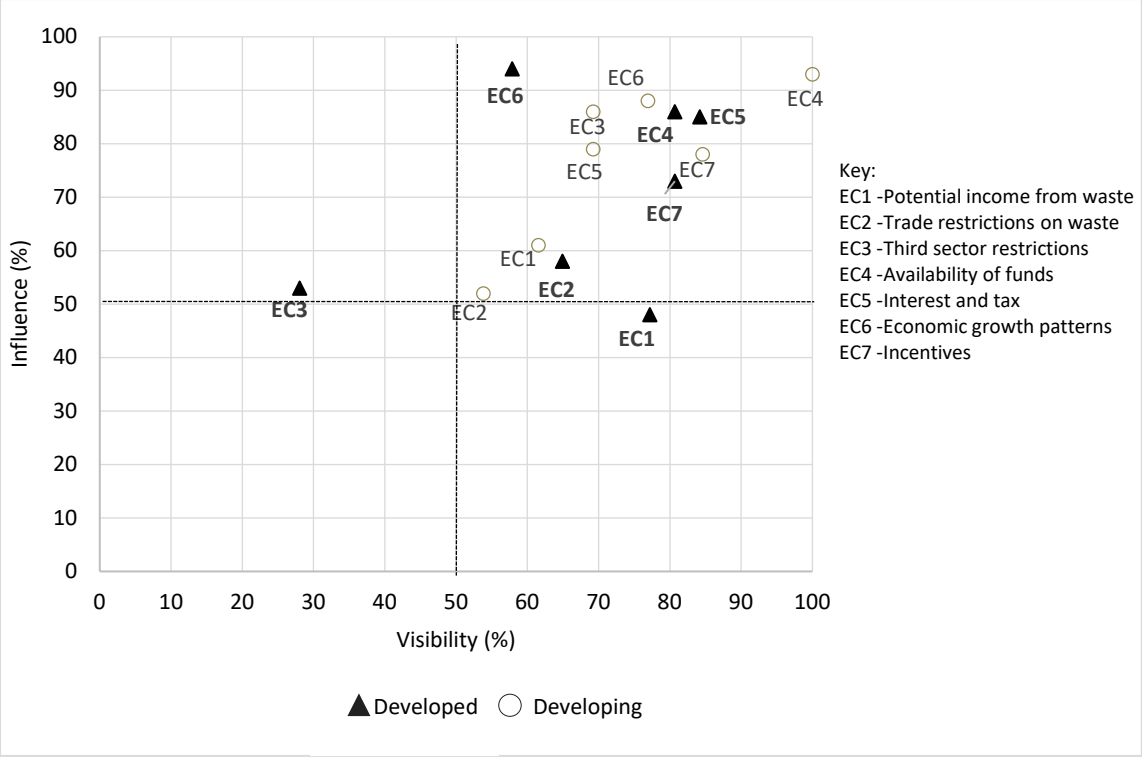


Figure 5.15. Matrix of influence and visibility of economic factors in developed and developing countries.

Due to the insignificant cases or evidence, the negative impacts resulting from waste trading were not widely discussed and were outstripped by the publicity to portray developed countries as main resource exporters to developing countries (Ray, 2008). Developed countries had unclear consensus on the influence of restrictions on third sector and waste trading as well as potential income from waste, despite encouraging growth, interest and benefits on those trades. This may have resulted from various international responses to problems associated with global waste trade and argument to regulate it over the years.

5.5 Discussion

In the result section, factors were analysed within the PESTLE classifications. While in this section, the factors were classified using the similar matrix, the discussion mainly focused on the interactions of factors within countries classifications. Using a Delphi approach, experts from all over the world, including both developed and developing countries, have reached certain consensus on the influence and visibility of factors that are important to the development of global SWM. Figures 5.16 and 5.17 showed, in the form of a matrix, a visual representation of how visibility and influence were

cross-analysed with respect to PESTLE factors in developed and developing countries, respectively classified as: low visibility and influence; low visibility and high influence; high visibility and low influence; or high visibility and influence. Experts from developed countries had classified 21 out of 43 factors (49%) as high visibility and influence (Figure 5.16), whereas experts from developed countries had classified 34 out of 43 factors the same (79%) (Figure 5.18). Factors classified as high visibility and influence by both experts from developed and developing countries were mainly relevant to the roles and responsibilities of government institutions in providing adequate facilities as well relevant policies and strategies as the effective tools in driving the initiatives towards improvement of the local waste system. For instance, the establishment of local policy and relevant SWM law that were supported by the implementation of local government plan and environmental guidelines on standards of compliance concerning the waste sector activities are similarly considered as important (high visibility and influence) in the development of SWM globally. This observation emphasizes the task relevant to policy implementation with proper guidelines and plan by the authority demonstrates the clear direction of initiatives towards achieving sustainable SWM (Hezri and Nordin Hasan, 2006). There are significant differences in the proportions of factors considered as potential (high influence, low visibility) classified by the experts from developed countries with 18 factors (42%); experts from developing countries considered only 8 out of 43 factors the same way (19%).

Experts in developing countries had clear agreement to consider almost all factors related to solid waste management development to be either important or potential. The dispersion of factors across the matrix indicates that substantial numbers of factors were considered differently in the development of SWM across developing countries; developing countries are progressively taking all the possible factors that can accelerate the development of SWM. This claim might be bias as compared with how experts in developed countries had classified their factors; this can be related to the comparison on the chronological evidence of the earlier development of SWM in developed countries.[S8] Developed countries started to initiate their waste management strategies early in the 18th century as awareness of public health issues and the value of resources emerged (Kollikkathara et al., 2009; Louis, 2004; Velis et al., 2009). There are clear differences in waste management systems between developed and developing countries. Wilson (2007) and McDougall et al. (2001) highlight that waste management practices in developed cities now focus on optimization strategies for resource conservation. Developing countries, often categorized as “underdeveloped”, need urgent and impactful strategies to cope with the massive generation of waste. With along historical

evidence and long-established waste management systems, developed countries had shifted their attention to be more focused on higher impact factors rather than taking a holistical approach. Majority of the factors ranked as potential by respondents in developed countries were mainly political and social factors related to social behavior, for example, philosophical change and social resistance to change, which were acknowledged as high influence, but not commonly considered in the planning or implementation processes. Experts from developing countries had classified occurrences of disruption in SWM systems. Corruption, discrimination and interference of politicians in the SWM process had potential to influence the SWM system. Although, these factors are considered as invisible, however may delay the implementation of improvements in general. Also, the social perceptions of the waste which fundamentally underpinned the waste behaviour was potentially an influence on the development of the system. The influence of religion and diverse of ethnicity has insignificant impact on SWM in general. Experts from developed countries had classified the management of waste generated from events and seasonal celebrations of festivals as not significant influences, but, for certain reasons, these factors were visible in the SWM systems. Overall, developing countries had more wide-ranging considerations of factors in their waste management planning and strategy which were validated by the mixture of factors that were considered important and of high influence in their local waste conditions.

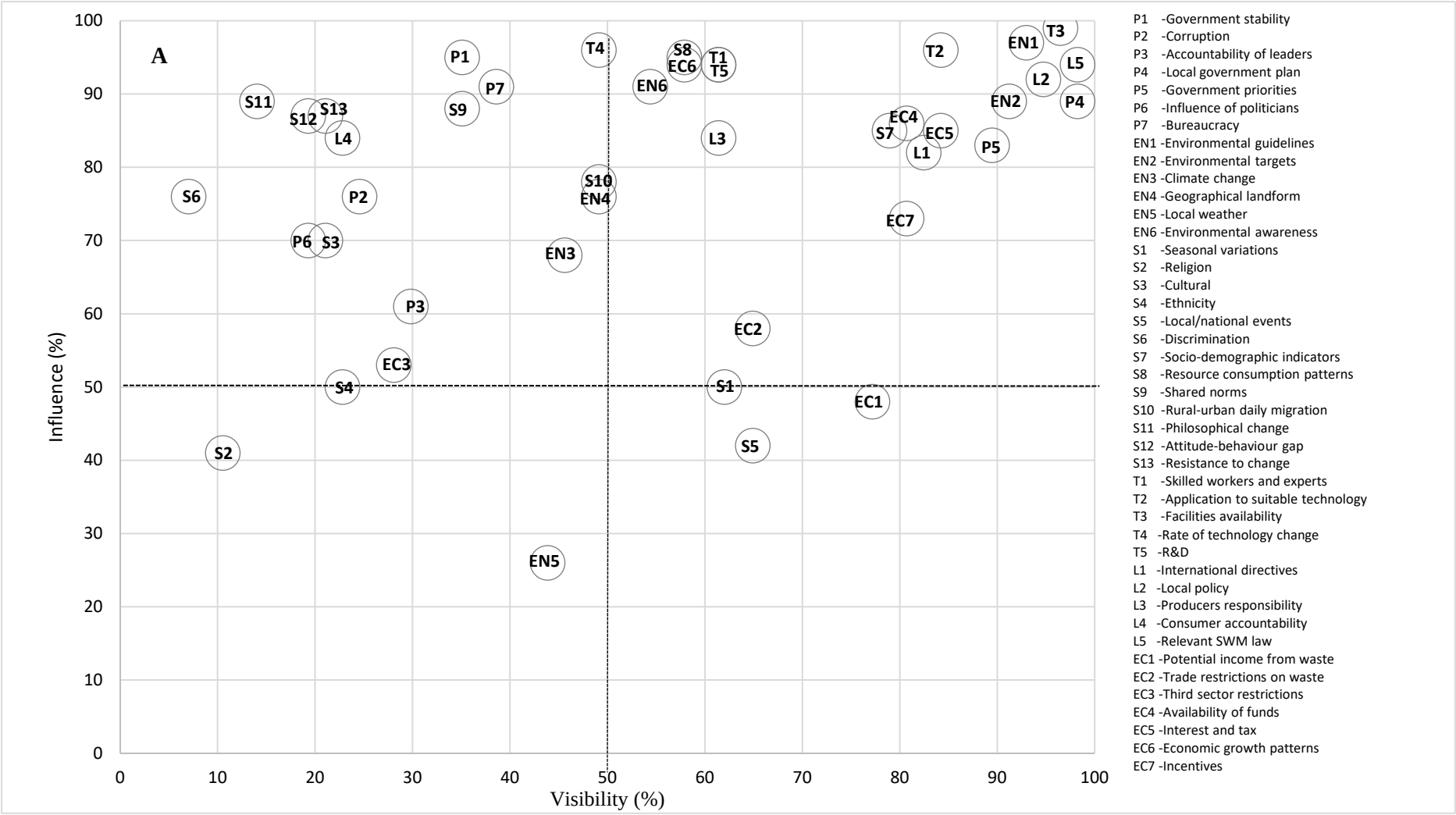


Figure 5.16. Matrix of influence and visibility of factors in developed countries.

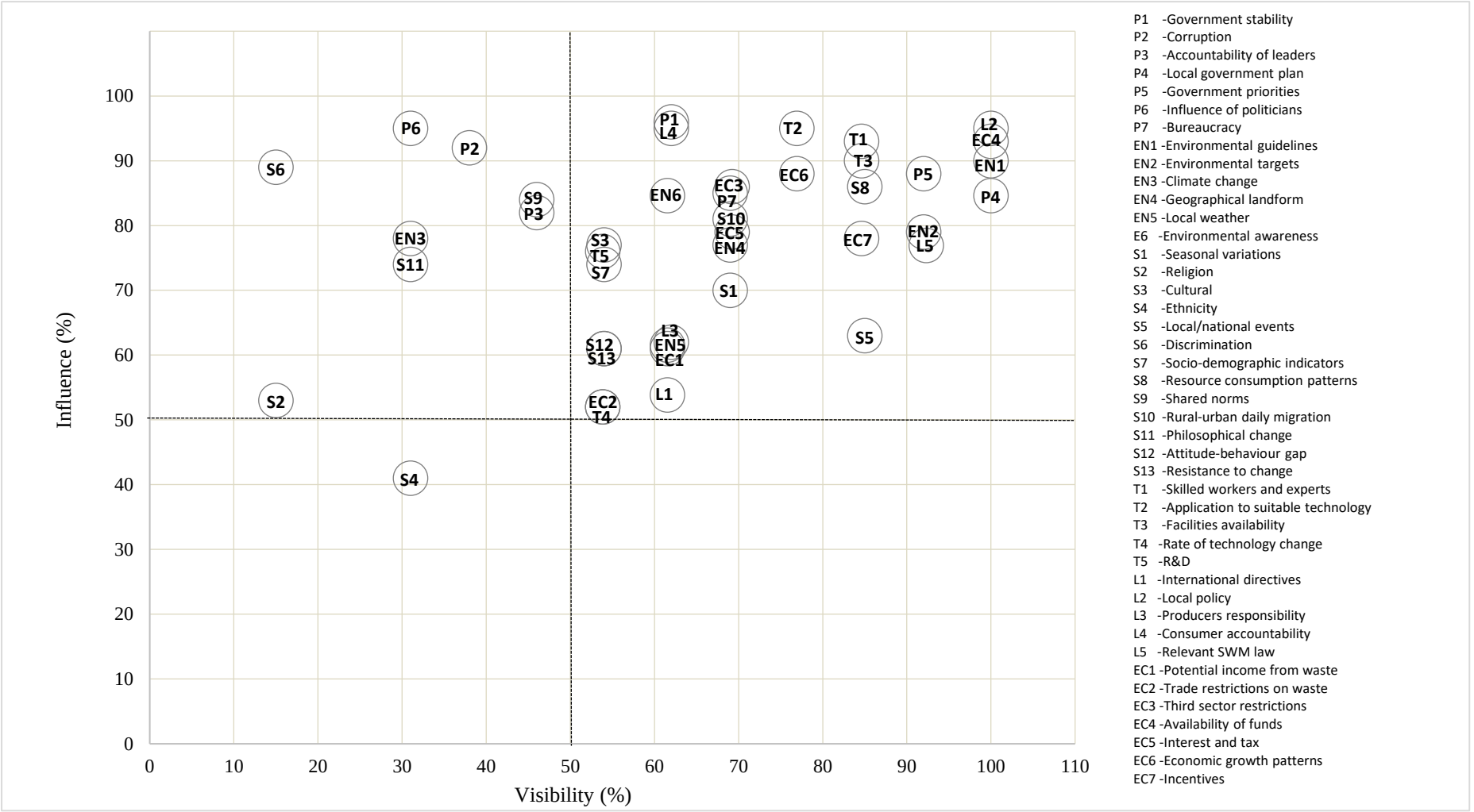


Figure 5.17. Matrix of influence and visibility of factors in developing countries

Experts from both developed and developing countries have different perspectives and interpretation regarding classifying factors as either visible, invisible or no clear consensus, as well as quantifying the influence of factors. Table 5.5 summarizes the number of factors that are classified by Delphi respondents in both developed and developing countries. The purpose is to highlight the similarities and differences in factors' classification according to the four sections of the matrix. This also serves as a starting point to develop a common ground of understanding of the interactions of factors that are important in the development of SWM in developed and developing countries. By understanding the important factors in waste management as well as fitting the consideration of factors to the local context, available resources and capability of the authority, decision-makers will be able to establish their own checklist of the impactful factors that are projected to motivate initaitaives towards sustainability.

Table 5.5. Summary on number of factors that were classified by Delphi respondents according to PESTLE classification

Sections	PESTLE	No of factors		Matched factors among experts
		Developed countries	Developing countries	
Section A-Potential (High influence, Low visibility)	*Political*	*5*	*3*	*3*
	Environmental	*2*	*1*	*1*
	Social	*7*	*4*	*3*
	Technological	*1*	-	-
	Legal	*1*	-	-
	Economic	*1*	-	-
Total		**17**	**8**	**7**
Section B-Important (High influence and visibility)	Political	*2*	*4*	*2*
	Environmental	*3*	*5*	*3*
	Social	*3*	*8*	*3*
	Technological	*4*	*5*	*4*
	Legal	*4*	*5*	*4*
	Economic	*5*	*7*	*5*
Total		**21**	**34**	**21**
Section C-Negligible (Low influence and visibility)	Political	-	-	-
	Environmental	*1*	-	-
	Social	*2*	*1*	*1*
	Technological	-	-	-
	Legal	-	-	-
	Economic	-	-	-
Total		**3**	**1**	**1**
Section D-Perceptible (Low influence, High visibility)	Political	-	-	-
	Environmental	-	-	-
	Social	*1*	-	-
	Technological	-	-	-
	Legal	-	-	-
	Economic	*1*	-	-
Total		**2**	**0**	**0**

Table 5.6. Summary of fundamental factors that are important in the development of SWM according to developed, developing countries and their matched factors between both types of countries.

PESTLE class	Developed countries	Developing countries	Overall matched
Political	Local government plan Government priorities	Government stability Local government plan Government priorities Bureaucracy	Local government plan Government priorities
Environmental	Environmental guidelines Environmental targets Environmental awareness	Environmental guidelines Environmental targets Geographical landform Environmental awareness	Environmental guidelines Environmental targets Environmental awareness
Social	Seasonal variations Resource consumption patterns Socio-demographic indicator	Resource consumption patterns Rural-urban migration Socio-demographic indicator Seasonal variations Cultural Local national events Attitude behavior gap Resistance to change	Seasonal variations Resource consumption patterns Socio-demographic indicator
Technological	Skilled workers and experts Application to suitable technology Facilities availability Research and development	Skilled workers and experts Application to suitable technology Facilities availability Research and development Rate of technology change	Skilled workers and experts Application to suitable technology Facilities availability Research and development
Legal	International directives Local policy Producers responsibility Relevant SWM law	Local policy Producers responsibility Consumer accountability Relevant SWM law	Local policy Producers responsibility Relevant SWM law
Economic	Availability of funds Trade restrictions on waste Economic growth patterns Incentives Interest and tax	Availability of funds Trade restrictions on waste Third sector restrictions Economic growth patterns Interest and tax Incentives	Availability of funds Trade restrictions on waste Economic growth patterns Interest and tax Incentives

Data shown in Table 5.5 show that experts from developed and developing countries had highest agreement on the factors that are considered important. The experts from both developed and developing countries had similarly classified 21 factors as important, which indicated that these factors are vitally important in the global development of SWM, despite the range of localities of respondents. Among all the factors that are matched across all respondents, legal and technological factors are widely agreed as being important, whereas social factors are not universally-agreed as important in global SWM. Differences of social backgrounds makes social factors difficult to define and incorporated in the development of SWM. Hence, specific approaches need to be carefully evaluated prior implementation if significant impact is to follow.

Table 5.6 shows the summary of important factors in developed and developing countries with the overall matched factors to indicate common agreement on factors that impacted the development of SWM. Overall, above results revealed that the fundamental factors in SWM are interconnected, with variations over time and localities. Economic factors were the most strongly agreed by experts from developed and developing countries. This indicates that the integration of circular economy in resource recovery and urban mining related to the waste management has emerged towards positive progress. Hence, experts were of the view that decision-makers and implementation authorities were now gaining momentum, not only in the developed countries, but also among developing countries, albeit slowly. This approach is expected to achieve efficient economic growth while minimizing environmental impacts. Notably, the circular economy has mainly been recognized as a strategy for waste management or for the implementation of environmental policies and has been accompanied by increasing policies which are geared towards resource efficiencies. Factors that are relevant to the development of SWM should not be taken considered in isolation. The extent to which and how the factors interact as well as how they affect decisions on designing future waste management systems vary by country type. Hence, due to the nature and interactions of the factors, it is not possible to conclude generically which factors are more important than others. Although these factors are generic to the respective regions, differences (in some cases significant) at the country level should be expected. Recognition of these factors and their interactions is crucial in decision-making when designing systems and strategies

~~5.6~~

~~5.7~~

~~5.8~~5.6 Conclusions

This chapter aimed to quantify and compare the fundamental factors that influence the development of SWM within and between developed and developing countries. Due to paucity of similar research, the findings from this chapter constitute a preliminary evaluation on the influence of SWM factors which demonstrates the PESTLE analysis contribution to the assessment of SWM. Results indicate that there are similarities and differences in the classification of factors according to their influence and visibility. The majority of the experts had high agreement on economic factors as the high influence and visibility; the application of circular economy is proven in bringing together the over-arching aims of secure access to resources, societal welfare,

economic growth and environmental protection. Application of the PESTLE model in classifying the factors into six broad groups has led to more structured analysis and provides more holistic perspectives in quantifying the influence of factors in different SWM conditions. Acknowledgement of factors according to their influences in the SWM was able to establish a common ground for the evaluation of factors in both developed and developing countries. Furthermore, a single approach in evaluating factors that influence the development of SWM may not be adequate to support the development of planning and decision making for development of policies and strategies of SWM, hence further analyses are required to address and emphasizes all relevant factors that are not only highly influential, but also considered/visible within the local context of SWM. Understanding the factors that influence the development of SWM is important in making decision on choices of SWM which to be implemented whether at local-, national- or even global level. Emphasizing on the less important factors with low influence could lead not only to wasting resources and time, but also to disastrous consequences through disruption of the current system. The fundamental factors in SWM are also interconnected and varies over time and localities. Factors that are relevant to the development of SWM should not be considered in isolation. The extent to which and how the factors interact as well how they affect decisions on designing future waste management systems are vary by country type. Hence, due to the nature and interactions of the factors, it is not possible to generically conclude which factors are more important than others. It is also important to evaluate the application and considerations of the fundamental factors in existing waste management plans and strategies in different localiaties so that the effectiveness of actual implementation can be measured and improved by emphasizing the correct combination of factors that works best.

Chapter 6: General discussion

6.1 Introduction

This thesis addressed the analysis of fundamental factors in MSW in developed and developing countries by evaluating the interactions of visibility and influence of identified factors. This has been achieved by conducting a Delphi study to get experts' views from developed and developing countries on factors' classification according to their visibility and influences, contribute towards the fulfilment of the research aims and objectives. This chapter will give an overview of the factors identified and assessed in Chapters 4-5 discussed in the context of how various factors interact to influence the development of solid waste management. The main findings of Chapters 4-5 will first be briefly recapped after which a detailed discussion of the nature and interactions of the factors will follow.

6.2 Overview of results

In Chapter 4, a list of fundamental factors in the MSW was established from the literature. The factors were classified according to PESTLE (political, economic, social, technological, legal and economic) for clarity in results analysis. The factors were then classified as visible or invisible by the participants (experts), who represented developed and developing countries. Among six PESTLE categories' factors, environmental, technological, legal and economic factors were similarly classified as visible by experts from both developed and developing countries. No clear classification by experts from developing countries on social factors where they were equally classified as visible and invisible according to experts from developing countries. Experts from developed countries had classified them as invisible. For political factors, experts from developed countries classified them as invisible whereas experts from developing countries considered them as visible. There was agreement among experts on classification of factors as visible, with exception of social factors. These findings indicate that social background differences influence the consideration of factors in national solid waste management plans and their implementation. Classification of factors as visible or invisible provides significant information to the decision makers and implementation authorities. It indicates that there is no single globally generalizable approach that could be taken to addressing MSW issues. The approach taken by a country towards g SWM issues needs to be addressed within local circumstances and context. An

approach to addressing MSW issues in one locality will have different impacts and consequences compared to another as different PESTLE and visible/invisible factors have different local significance. However, there were also 8 factors with significant associations between both developed and developing countries; government stability, local weather, cultural, attitude-behaviour gap, research and development, international law, consumer accountability and trade restrictions on waste. These associations indicate that some factors have global reach and have common importance globally.The investigation of fundamental factors that are important in the development of MSW are insufficient by just classifying the factors as visible or invisible. The classified factors were then futher assessed according to their influence by experts. In Chapter 5, experts were asked to evaluate the degree of influence of each factors from a Likert scale of 0 to 4. Technological factors were considered as the most influential factors and social as the least influential factors. Results indicate that there are similarities and differences in classification of factors according to their influence and visibility. The majority of the experts had high agreement on economic factors having both high influence and visibility; the application of circular economy is proven in bringing together the over-arching aims of secure access to resources, societal welfare, economic growth and environmental protection. The extent to which and how the factors interact as well how they affect decisions on designing future waste management systems vary by country type. Hence, due to the nature and interactions of the factors, it is not possible to generically conclude which factors are more important than others. The results have established common ground in identifing (in)visible and (non-)influential factors to support decision making in the development of MSW in developed and developing countries. Finding the fundamental factors and its interactions that are highly influencial in both developed and developing countries provides better insight to planners and decision makers in selecting factors with significant impact to accelerate the future development of local solid waste management system. Making the right decision in selecting factors is vital to avoid the possibility of e.g. extra costs, false assumptions, operational errors, selection of incorrect infrastructure or services, and adverse social or environmental consequences that could jeopardize improvement strategies towards achieving sustainable waste management

6.3 Considerations of fundamental factors in selected MSW plan and strategies

From the foregoing discussion, it can be presumed that the extent to which the factors interact and the nature of those interactions and how they affect the decision and development of waste management vary by country and time. For example, between 14th and 16th centuries, the earlier

development of waste management in western countries such as United Kingdom and United States of America were underpinned by the environmental and public health concern due to the uncontrolled disposal of waste. The public had urged towards the establishment of proper waste management system, which has led to the authorities priorities of setting up services and legal framework. Likewise, the historical evolution of waste management in developing countries such as Malaysia and China were also underpinned by the similar reasons as western countries, but in much later period, approximately during mid of 19th centuries.

While some of the factors are commonly recognized and addressed in general waste management plan (visible factors), there are also factors that are not commonly considered but potentially influence the efficiency of local waste management if appropriate attention is given (invisible factors). It is not possible to conclude generically which factors are more important than others; regional, environmental background, social characteristics, legal, political circumstances, technology application and economic status dictate which factors are of highest relevance on a case-by-case basis. The considerations of factors in waste management plan and strategies varies between localities and time; such considerations are depending on the time and capabilities of the authorities. Though the task of managing solid waste has global ramifications, different countries and regions have different priority areas that they need to consider in order to deal with the challenge. In addition, though only a handful of country examples have been highlighted in this study, previous studies suggest that similar challenges exist in other countries in the various continents. The evidence suggests that there are similarities and differences in terms of considerations of factors in the national SWM strategies and plans (Table 6.1).

In general, strong emphasis was observed on environmental, technological, legal and economic factors, which are commonly considered in waste management plans. Ultimately, efforts towards achieving sustainable waste management aim to protect the environment via: (1) mitigating the adverse impact of waste management activities and (2) advocating efficient resource management. However, each locality has its unique path, with its own sequence and overlap of development stages, in accordance with local characteristics and priorities. While considerable attention has been paid to environmentally-focused and sustainable waste management, what motivates the implementation is very much influenced by the legal tools and economic benefits that drive the engagement and interest of the stakeholders. Although some of the countries had consider the same factors in their waste management plan regardless their locations and status as illustrated in Table 6.1, overall, the considerations of factors may not be clearly emphasizes in the plan

Table 6.1. Application of fundamental SWM factors in selected SWM plan and strategies

PESTLE class	Developing countries	Developed countries			
	Malaysia	**England**	**Hong Kong**	**Australia**	**New Zealand**
	National SWM Plan 2013	**Waste management Plan for England 2013**	**Blueprint for Sustainable Use of Resources 2013-2022- Use Less, Waste Less**	**National Waste Policy 2009 - Less Waste, More Resources**	**The New Zealand Waste Strategy - Reducing Harm, Improving Efficiency 2010**
Political	Local government plan Government priorities	Local government plan		Local government plan Government priorities	
Environmental	Environmental targets Geographical landform Environmental awareness	Environmental targets	Environmental targets	Environmental guidelines Environmental targets	Environmental guidelines Environmental awareness
Social	-	-	-	Resource consumption patterns	Resource consumption patterns
Technological	Application of suitable technology Facilities availability R&D Activities	Application of suitable technology Facilities availability	Facilities availability	Facilities availability	-
Legal	Local policy Relevant SWM law	Local policy Producer responsibility	Producer responsibility Relevant SWM law	International directives Producer responsibility Local policy Relevant SWM law	-
Economic	Availability of funds	Trade restrictions on waste Availability of funds Interest and tax Incentives	Availability of funds Incentives	-	Potential income from waste

For instance, although social factors are not at all addressed in any of the selected waste management plans, however, the ultimate goal of the plan is protecting public from the adverse consequences of waste management activities. Social factors are generally neglected or comprise marginal considerations, more so in developed than developing countries. However, as cities grow, public health becomes a major concern and a driving force in shifting the focus of waste management towards higher efficiency. If and when environmental concerns become prominent in public and political view, environmental protection becomes a key goal for solid waste management policies. This results in development and application of engineering control measures for the reduction of negative environmental impacts of waste disposalHowever, as cities grow, public health becomes a major concern and a driving force in shifting the focus of waste management towards higher efficiency.

As environmental concerns become more prominent in public and political arenas (Figure 5.11), environmental protection has become a key goal for solid waste management policies. This has resulted in the development and application of engineering control measures for the reduction of negative environmental impacts of waste disposal. However, these technologies are costly, so, ironically, once they are installed, most city policies seek to minimise the amounts of waste that require disposal. This, in combination with growing concerns about depletion of natural resources, serves to create a renewed focus on resource management in the form of recycling and, more recently, on prevention and reuse.The same policy instrument can be designed and implemented in many different ways, however, the influences of different factors and how the factors are considered in their plans and strategies on SWM development may influence its effectiveness. For example, the considerations that impact the availability of facilities are vitally important; however, the main factors that differentiate implementation is the affordability to authorities in terms of providing adequate and workable facilities to suit local needs. A reliable approach is critical in recognizing the factors that are important within the local context; to start from the existing strengths of the city and to design a local own system upon them. Observing from other countries' experiences and practice provides an opportunity to 'pick and mix', however, the adaptations and implementations of the solutions need to work in a particular local situation. The key here is to identify simple, appropriate and affordable solutions that can be implemented progressively with appropriate considerations of local circumstances, especially in terms of recognizing the role of influential but invisible factors.

6.4 Application of conceptual model on waste management status as factors' evaluation on decision support

For the purpose of discussion, a conceptual model on waste management status was adopted from Mukhtar et al. (2016). The conceptual model presented in this thesis is used to demonstrate the current waste behaviour of the society in different timeline and anticipated population growth. However, it is possible to extend it further as a useful model to aid policy makers and waste management practitioners in decision making. A model based on society's waste behaviour would help visualise the current status for managing waste from timeline and aid in predicting the likely direction of local initiatives towards achieving sustainability on waste management. This could be related to the considerations of the fundamental and important factors discussed in Chapter 5, in the national waste management plan, strategies and policy. Identifying the most important factors in SWM within the local context could help to create the ideal combination of factors that would maximise the efficiency of initiatives in improving the system within desirable timeline. Figures 6.1 and 6.2 shows the predictive route from wasteless to wasteful and ultimate aim, towards wastingless society, in two different conditions; least/inefficient consideration of factors (Figure 6.1) and efficient consideration of fundamental factors (Figure 6.2) in SWM (Mukhtar et al., 2016). The conceptual model was used to predict the possible route and timeline towards achieving sustainability in waste management. In Figures 6.1 and 6.2, population growth is represented by the increasing gap between the curved solid lines. The horizontal dashed line represents the threshold between sustainable and unsustainable waste management practice. Periods of waste management characterized by "wasteless", "wasteful" and "wasting less" status are delineated by vertical dotted lines. The indicative current positions of a local waste management on the route from wasteless to wasting less status are shown as black dot.

Various information and data need to be incorporated prior to determining the current waste management status; consideration of historical data and evidence can be useful to illustrate the development of local waste management. Ideally, every local waste management plan targeted to move towards sustainability within a short period of time and existing resources. However, due to various limitations within the local circumstances, for example, funding, facilities availability and social engagement, some countries might take longer time to make sustainable waste management to materialize. In Figure 6.1, when least or inefficient consideration of factors, the consequences are not only in terms of longer time required, but also more resources are wasted, thus jeopardizing inspiration towards sustainability. Developing countries, for example, have

looked upon developed countres' experiences and tend to implement similar practices without prior considerations of local circumstances. Adaptability and customization of others' experiences may take longer time to suit with the local circumstances , wasting more time and resources. Even worse, if the authority continues to incorrectly emphasize certain factors within the local context, alongside increased population and waste generation, the sustainability of waste management status will be far more difficult to achieve. It is more important to understand the interactions of factors that are impactful in implementing such initiatives. Using findings from Chapter 5 (Figure 5.16 and 5.17) and the conceptual model as a basis for developing waste management plans, the practitioners can exhaustively identify the key factors for successful selection of appropriate sustainable waste management systems in the local context.

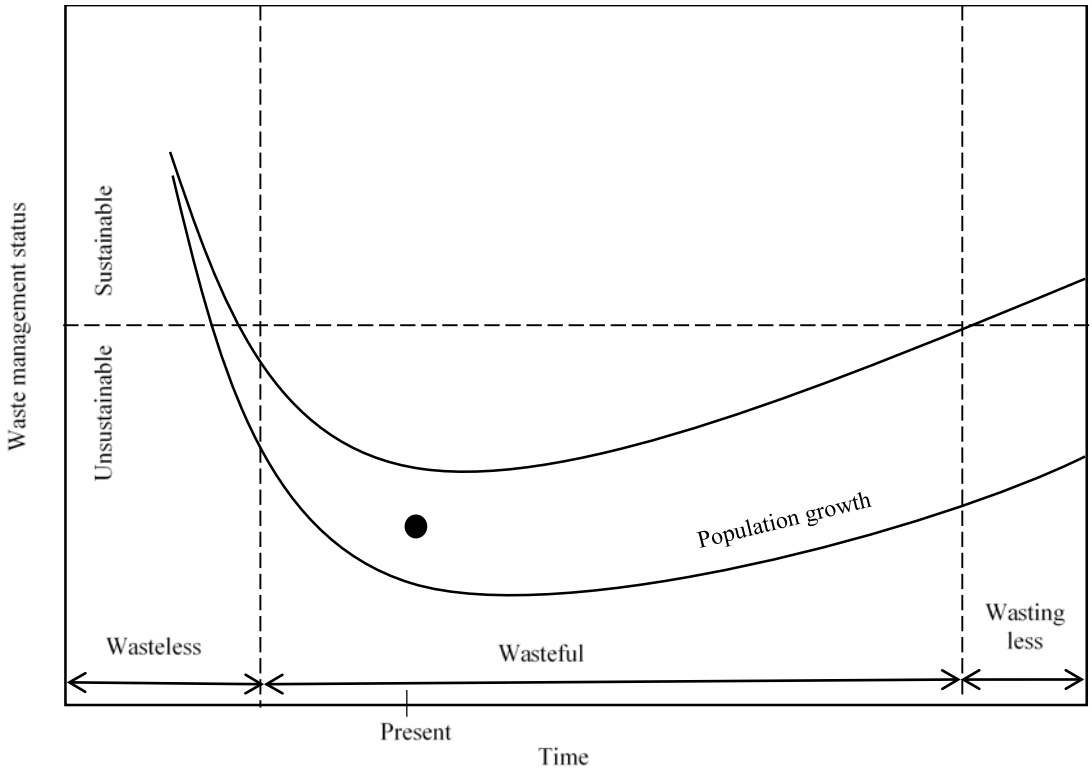


Figure 6.1. A[M9][ME10] conceptual model representing the evolution of waste management in a least/inefficient consideration of factors

Initiatives towards achieveing sustainable waste management status can be rapidly expediated with appropriate and efficient considerations of factors that are important within the local context. As dicussed in previous sections, preparation of waste management plans and strategies are very complex and unique to each localities. Decision makers would create their checklist of factors based on the classifications of important factors according to their influence and visibility

(Figure 5.16 and 5.17) within the PESTLE system. Ultimately, based on their desirable outcomes and current status of waste management, decision makers would be able to identify the important factors that need to be taken into consideration when developing a local waste management plan and strategies. The final important point is to determine the most important and relevant factors that suit with the local waste circumstances supported by authoritative background data. The purpose of a checklist is to illustrate some common factors and their interactions that drives the initiatives more rapidly. However, to further support the decision makers, an advanced decision support system is proposed and described below.

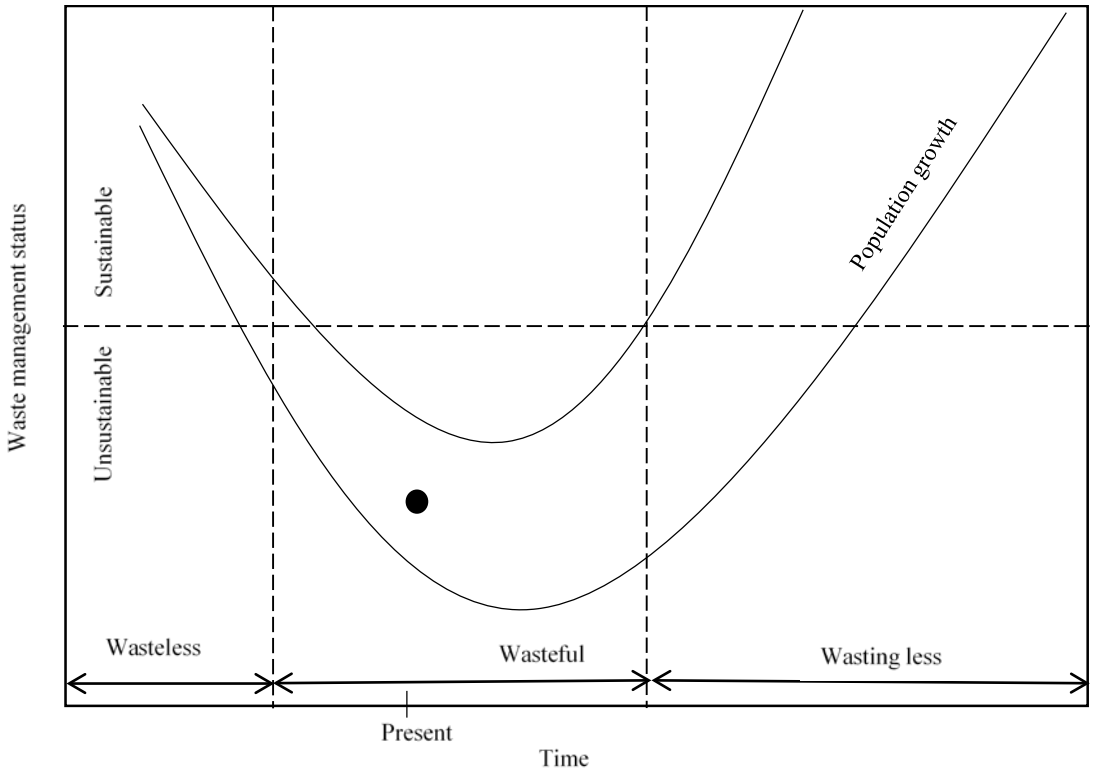


Figure 6.2. A[M11][ME12] conceptual model representing the evolution of waste management in efficient consideration of factors

A model based on society's waste behaviour would help to visualise the current status for managing waste and aid in predicting the likely direction of local initiatives towards achieving more sustainable waste management. This could be related to the considerations of the fundamental and important factors (Table 5.6), in the national waste management plan, strategies and policy. Identifying the most important factors in SWM within the local context could help to create the ideal combination of factors that would maximise the efficiency of initiatives in improving the system within desirable a timeframe. Historical data need to be incorporated prior to determining the current waste management status; consideration of the

historical data and evidence can be useful to illustrate the development of local waste management. The guide described in this section is aimed primarily at the waste practitioner. From a waste management point of view, the primary aim of the following decision support by application of the conceptual model is to influence the interaction of factors so as to ultimately achieve the best possible decision outcomes for developing a localised waste management plan. In its simplest form, the decision support model consists of 3 basic steps:

1. Evaluation of current waste management status
2. Assessment/analysis of influencing factors; and
3. Developing decision tree using PESTLE factors

Step 1: Evaluation of present waste management status

The first step by the waste practitioner would be to understand and evaluate the present waste management status. This can be accomplished by gathering the background data that would enable the assessment of initiatives taken in the development of local waste management. By trailing the historical data and evidence, the decision makers can position themselves according to the waste management status (sustainable/unsustainable) and social behaviour (wasteless/wasteful/wasting less). Apart from this, the projected demographic patterns, such as population expansion, changes in social characteristics (e.g age of the population, education background, number of households, etc) and economic growth are also required to illustrate the projected waste generation and anticipated changes in the future waste behaviour. The evaluation of waste management status can be undertaken by self-position according to Figure 6.1 and 6.2.

Step 2: Assessment/analysis of influencing factors

Using the conceptual framework as a guide, the practitioner would exhaustively identify the factors influencing the waste management system to further plan for improvement. These factors and the supporting evidence for their inclusion are listed in Table 6.2. For basis of comparison, we use the factors that were classified as important by Delphi experts to compare with the factors' considered in the present waste management plan in Kuala Lumpur. The important factors that are already considered in the waste management plan are shown red and ticked off (✓). Alongside with the urgency to rapidly improve their waste management system to equalize with the urbanization and aspiration of sustainability in waste management, the drastic improvement are required. By establishing the comparison as shown in Table 6.2, the waste practitioner will

then make their decision on further considerations of factors that are important and tailor them according to their local context. The checklist (Table 6.2) gives a clear indication not only on which key factors the practitioner has to take into consideration, but to reconsider factors that are not important but currently included in the present waste management plan. By accomplishing this step, the projected time of route towards sustainable waste management status can be reduced, as shown in Figure 6.2. The purpose of the checklist is to illustrate some common factors that could influence the further improvement of waste management status. Considerations of historical evidence and background data need to be included to aid the designing of action plan and framework.

Table 6.2. Comparison of factors consideration between existing waste management plan and factors that listed as important by the Delphi experts for developing countries

PESTLE	**Kuala Lumpur (Malaysia)**	
	Actual considerations of factors in the National SWM Plan 2013 (Table 6.1)	**Factors that are important in developing countries according to Delphi (Table 5.5)**
Political	Local government plan✓ Government priorities✓	Government stability Local government plan✓ Government priorities✓ Bureaucracy
Environmental	Environmental targets✓ Geographical landform Environmental awareness✓	Environmental guidelines Environmental targets✓ Geographical landform Environmental awareness✓
Social	-	Resource consumption patterns Rural-urban migration
Technological	Application of suitable technology✓ Facilities availability ✓ R&D Activities	Skilled workers and experts Application to suitable technology✓ Facilities availability✓
Legal	Local policy ✓ Relevant SWM law✓	Local policy✓ Producers responsibility Consumer accountability Relevant SWM law✓
Economic	Availability of funds✓	Availability of funds✓ Interest and tax Economic growth patterns Incentives

Step 3: Developing decision tree using PESTLE

The guidance described in this section is aimed primarily at the waste practitioner. From a waste management point of view, the primary aim of the following decision support model is to

consider the interaction of factors according to PESTLE using the conceptual model so as to guide decision makers to ultimately achieve the best possible decision outcomes when designing their waste management plan and strategy. The environmental, technological, legal and economic are the important factors that commonly agreed in global waste management (Table 5.5). It is essentially important for waste planners to consider these four group of factors when designing their plans and strategy, despite of differences in waste management settings. The diagram represents all the elements of PESTLE and showing the relationships between the key factors in existing waste management plan and strategy in Kuala Lumpur (Figure 6.3). Social factors are currently not fully considered in the system, although the ultimate aim of designing the system is to protect public health and environmental. Political factors are focusing more on the government institutions' responsibilities to establish legal framework that influence the technological and economic factors.

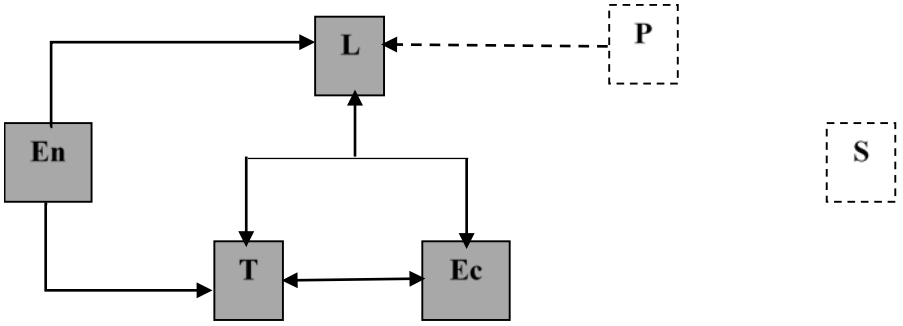


Figure 6.3. Current emphasizes of waste management in Kuala Lumpur.

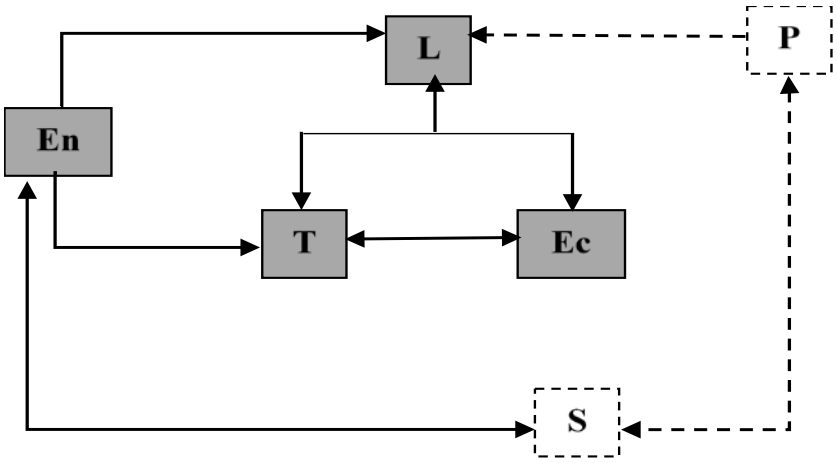


Figure 6.4. Projected emphasizes of waste management in Kuala Lumpur.

To move forward, by considering important and correct factors in SWM the decision-making can be improved. By evaluating their current waste management status and factors that are important within the local context, waste practitioner can position the factors according to their interactions to aid further decision making. Application of the proposed conceptual model and their application to aid decision makers can be the basis of an important decision support tool since it offers an alternative approach to contextualise the present situation whilst offering insights on how to rethink strategies to best manage it by evaluating factors that are important in the waste management. Furthermore, decision making process as well plays a pivotal role in ISWM since decision makers decides on the appropriate technologies in addressing waste management issues. These are extremely difficult and perhaps impossible to value in monetary perspective, however, they should be given consideration alongside the financial impacts in policy formulation and decision making.

Chapter 7: Summary

This PhD study has achieved both of its main aims. The first aim of the study was to critically review the fundamental factors that are relevant on the development of SWM system. Based on the research presented in Chapters 4 and 5, these two chapters highlights the fundamental factors that historically underpinned the factors that significantly impacted the development of SWM in developed and developing countries. The identification of fundamental factors that are relevant in the SWM was achieved through an extensive literature review of past studies that highlighted single case studies or emphasizing of selected factors that were significantly influence in the development of SWM. Secondly, the study aimed to investigate the interactions of visibility and influence of factors can contribute to the development of SWM systems. Chapters 4 and 5 elucidated the factors in terms of their visibility and influence in both developed and developing countries. The overall conclusions drawn from this study in relation to each of the study objectives are presented in the following sections.

Objective 1.1: Identify and characterize the fundamental factors that relevant in the development of SWM

The study perfomed in Chapter 4 has lead for the first time to the establishment of 43 fundamental factors that are generally influencial in terms of the development of global SWM. The comprehensive list of SWM factors were then classified according to the PESTLE (political, environmental, social, technological, legal and economic) system for more detailed classification and to enable more effective insights. The list of factors was established to inform and guide the subsequent survey, providing a structure of Delphi study with definitive description for each factor.

Objective 2.1: Classify and critically review the visible and invisible factors in SWM in developed and developing countries

The assessment of factors in Chapter 4 has critically defined each of the identified factors in SWM within the study context in order to guide the panel experts in the Delphi survey. By fulfilling this objective, findings provide a clear classification of factors according to the PESTLE system, and subsequently show that there are factors which may classified as visible and invisible in developed and developing countries. This new approach to classification is the first time invisible factors have been identified as potentially influentialto SWM. By classifying factors as visible or invisible, from the waste management point of view, it can explore a broader horizon of factors' evaluation and

emphasize the selection of important factors to be considered at local level. This aims to ultimately achieve the best possible decision outcomes. It has been shown that there are similarities and differences on factors' classification as either visible or invisible by experts from developed and developing countries. The importance of understanding and recognising selected factors within the local context that can accelerate the implementation and effectiveness of initiative taken towards the development of SWM was also emphasized and discussed in the chapter.

Objective 2.2: Investigate the interactions of visibility and influence of factors to establish the ideal combinations of factors that works best in the development of SWM

In Chapter 5, the influence of fundamental factors in SWM via Delphi study were evaluated. The influence of factors were ranked according to their contributions in the development of SWM by experts from developed and developing countries.This work can guide planners and decision makers to select the most important and locally effective factors that can accelerate the improvement towards sustainability of SWM. The discussion was illustrated with the matrix analysis of visibility and influence of factors in Chapter 6 to establish the ideal combinations of factors that potentially works best towards developing a sustainable waste management system, particularly in developed and developing countries.

7.1 Contributions to the body of knowledge

This research has contributed to existing knowledge and thinking in its subject area in various ways, some of which have already been published in peer-rewviewed journals, as outlined below:

- The critical assessment on the evolution of SWM with comparison of selected developed and developing countries (Chapter 2).
- Identification of 43 fundamental factors that are relevant in the development of SWM in developed and developing countries (Chapter 4).
- Employing PESTLE analysis for clear categorisation of factors for further investigation of factors that are important in the development of SWM (Chapter 4 and 5).
- Establish a clear list of factors that are important in the development of SWM in developed and developing countries (Chapter 5).
- Identification, recognition and classification of SWM factors as either visible or invisible.

- Statistical comparison on the significant different of Delphi respondent's views on classification of factors in terms of visibility and influence between developed and developing countries (Chapters 4 and 5).
- Employing Delphi study to seek experts' views from various countries across the world on classification of factors as visible and invisible as well as quantifying and ranked the influence of different factors in SWM (Chapters 4 and 5).
- Formulation of matrix analysis between visibility and influence to establish ideal combination of factors that works best in different type of SWM can be established (Chapter 5).
- Formulation of a framework on the application of conceptual model on waste management status as decision support tool by evaluating important factors in SWM (Chapter 6)
- Development and demonstration of a decision support model for decision/policy makers and waste practitioners for the development of waste management plan (Chapter 6)

7.2 Recommendations

The outcomes of this thesis provide the basis for further investigations into a variety of research topics, which are discussed below:

7.2.1 Extension of geographic application

The evaluation of factors in SWM in terms of visibility and influence in this study are highlighted within developed and developing countries SWM context. The outcomes of this research has fundamentally proven that there are different factors that affect the development of SWM in different local settings. Further research is required to investigate broader geographical areas across the world to characterize the localize factors that are works best to efficiently improve the local SWM systems.

7.2.2 Extension of investigation on different functional elements in SWM

Six functional elements in waste management are: (a) waste generations, (b) waste handling (sorting, storage and processing at the source), (c) collection, (d) sorting, processing and transformation of solid waste,(e) transfer and transport and finally (f) disposal. In order to improve each of the elements in SWM towards the overall improvement, there is a need to addressed and investigate different combination of

factors that have significant impact in different elements in SWM. Such research may be applicable to all SWM settings, however considerations of local settings need to be included for accurate projections and reflected actual local conditions.

7.2.3 Exploration of factors investigation on different activities of waste management

There are numerous activities related to waste sectors, for example waste recovery, recycling, waste minimization, separation at source, application of treatment technology, zero waste etc. Each of the activities were underpinned by different sets of factors that can accelerate the improvement initiatives towards sustainable SWM in general. Local settings of SWM need to be considered when exploring and investigating the impact of factors according to visibility and influence as well.

7.2.4 Further investigation on each of the PESTLE factors

This study categorised factors according to PESTLE for analysis. Such approach provides deeper analysis on the macro factors that influenced SWM system. In depth research on each of the PESTLE factors that affected the system and development of SWM are needed in order to further emphasize on the specific PESTLE factors for further improvement. Separate PESTLE factors can be evaluated by researchers from various background, which opens the opportunities for expansion of this study to multi-disciplinary researchers with regards to SWM development.

Appendix

Appendix A: Questionnaires for Chapter 4 and 5

INFLUENTIAL FACTORS IN SOLID WASTE MANAGEMENT (SWM)

Dear participants,

Thank you for agreeing to participate in this online survey. This is voluntary participation and you have the right to withdraw at any time if you wish.

General information:

1. Please answer each question to your best knowledge and experience in your expert skills. All information provided will be kept confidential.
2. The purpose of this study is to evaluate the influential factor in solid waste management and should take about 15-30 minutes to complete. Please attempt to answer all the questions.
3. In order to progress through this survey, please use the navigation links:
    - Click the Next button to continue to next page
    - Click the Previous button to return to the previous page
    - Click the Done button to submit your survey

Participant's consent:

By completing this questionnaire, you are consenting to have your results used in this study. In relations to the Data Protection, as a participant of this study, you declare that you:

- agree to take part in this research project and agree for my data to be used for the purpose of this study
- understand my participation is voluntary and I may withdraw at any time without my legal rights being affected
- are happy to be contacted regarding other unspecified research projects. I therefore consent to the University retaining my personal details on a database, kept separately from the research data detailed above. The 'validity' of my consent is conditional upon the University complying with the Data Protection Act and I understand that I can request my details be removed from this database at any time.

Participant info section:

Researcher : Erni Mariana Mukhtar
Ethics number : 21160
Please read this information carefully before deciding to take part in this research. If you are happy to participate, you will be asked to sign a consent form.

1. What is the research about?

This study aims to classify and investigate how selected factors may influence, impact and contribute towards the improvement *of* solid waste management systems. The results of this study will be able to find the interactions of these factors that serves to specific local waste conditions.

2. Why have I been chosen?

   You have been chosen as a potential participant because of your expertise and experience related to this stud area, which is one or more of the following: solid waste, politics, environment, social-based activities, technology development or application, legal and economy.

3. What will happen to me if I take part?

   This study consists of two online survey rounds. The first round is an online questionnaire administered via iSurvey, which will require you to evaluate influential factors in solid waste management using a 5-point Likert scale. In some parts of the questions, you will be asked to classify the factors as visible or invisible according to the description given in the particular questions. The overall process will take approximately 15 to 30 minutes of your time.

   The second round of the survey involves a comparison of the most important factors identified in round l using an online comparison method. Participants will be shown pairs of factors and will be asked to select the most important combination. The overall process will take 15 to 30 minutes of your time. From this two-round data collection phases, the most meaningful combination of influential factors in waste management will be identified.

4. Are there any benefits in my taking part?

   As an appreciation of your participation in this survey, you are welcome to receive a summary report for each of data collection phase.

5. Are there any risks involved?

   No risks have been identified.

6. Will my participation be confidential?

   All data collected during this study will be confidential, and handled in compliance with the Data Protection Act and University policy. Data will be stored on a password-protected computer, and will only be used for the purposes of this study. Only those involved with the study will be able to access information. Whilst complete anonymity cannot be promised, all files containing any personal information will be made anonymous to prevent identification of participants. Confidentiality will be maintained as the data will remain anonymous in any publication of results.

7. What happens if I change my mind?

   You have the right to withdraw at any time without affecting your legal rights. Participants involved in the first round can withdraw before or during the second round without any prior consent.

8. What happens if something goes wrong?

   In the unlikely case of concern or complaint, kindly refer to the Research Governance Manager, University of Southampton, UK at 02380 595058 or email to rgoinfo@soton.ac.uk

9. Where can I get more information?

   If you have any concerns or inquires regarding the questionnaire, please contact the principal researcher Erni Mariana Mukhtar at emm1v13@soton.ac.uk

Thank you.

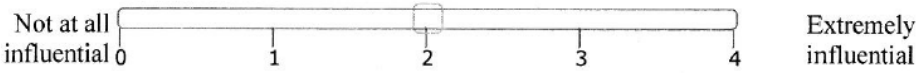
By clicking on the "next" button here below, participants are recoding their informed consent to take part in this survey

Section 1: Political

For question l.1 to 1.12, please rate how influential are the subfactors related to political on the implementation of local SWM system.

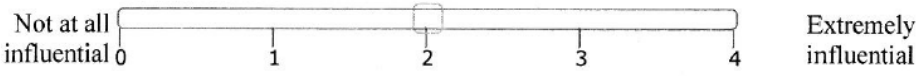
Question 1.1

How influential is a government stability on the implementation of SWM local strategy?



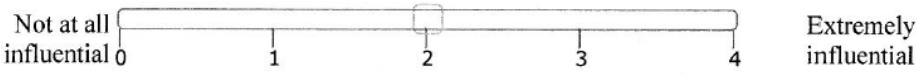
Question 1.2

How influential are the existence of SWM policies on the implementation of SWM system?



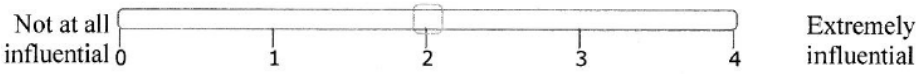
Question 1.3

How influential are the effective implementation of SWM policies on the implementation of SWM system?



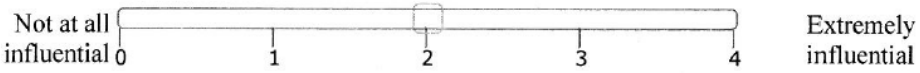
Question 1.4

How influential are the fair award of SWM contracts on the implementation of SWM system?



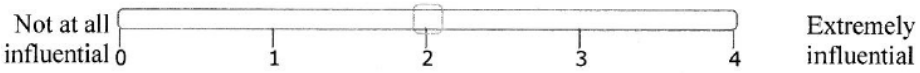
Question 1.5

How influential is a close monitoring on funds distribution of SWM projects on the implementation of SWM system?



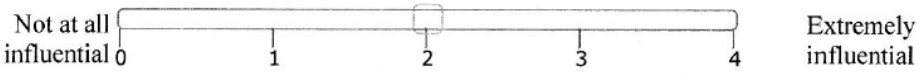
Question 1.6

How influential are the accountability of national leaders on the execution of local SWM plan?



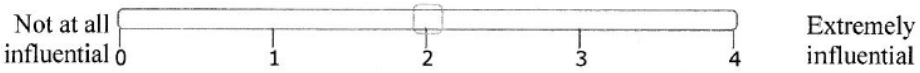
Question 1.7

How influential are the local political conditions on the implementation of SWM system?



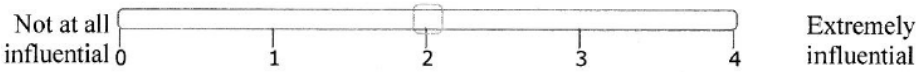
Question 1.8

How influential are the government priorities on SWM issues in regards to the implementation of SWM system?



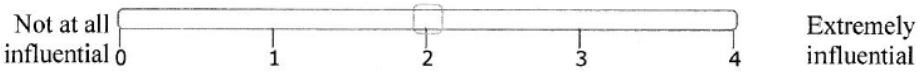
Question l. 9

How influential are the politicians influence on the implementation of SWM local plan?



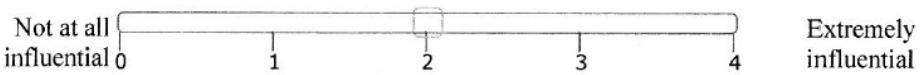
Question 1.10

How influential are the politicians on the SWM contracts awarding process?



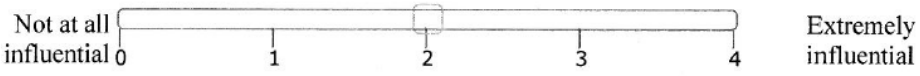
Question 1.11

How influential is bureaucracy on the decision making of SWM issues?



Question 1.12

How influential is bureaucracy on the approval process of SWM project fund distribution?



Question 1.13

For question no 1.13, please classify the following political factors as VISIBLE or INVISIBLE in the context of solid waste management according to the description given below:

- **Visible factors** in waste management are defined as factors that arc measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes, published for awareness and available for relevant access by public.
- **Invisible factors** are defined as factors that are not considered at all in any of waste management processes, however, have influence the social behavioral and philosophical perceptions on solid waste management and practice.

Visible Invisible

Government stability
(Strong government can hold its power and control over the country with minimal external influence)

Corruption
(Fraudulent conduct for personal benefits, typically related to bribery)

Accountability of leaders
(Responsible and trusted leaders)

Local government plan
(The plan for future development of the local area)

Government priorities
(Focus and attention on specific issues by the government)

Influence of politicians
(Effect of politicians' behavior and character on specific issues)

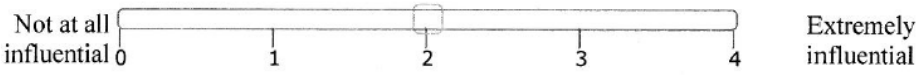
Bureaucracy
(Excessively complicated administrative procedure)

Section 2: Environmental

For question 2.1 to 213, please rate how influential are the subfactors related to environment on the implementation of local SWM system.

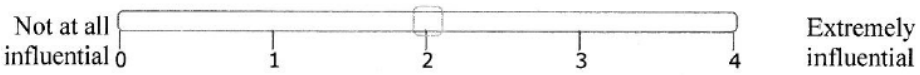
Question 2.1

How influential are the specifications on environmental standards in SWM guidelines with regards to the waste collection operations?



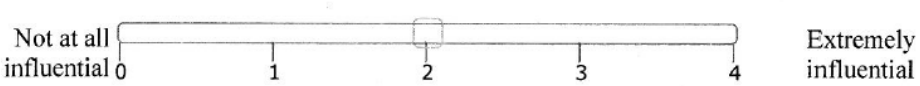
Question 2.2

How influential are the SWM guidelines with specifications on environmental standards in regards to the waste treatment operations?



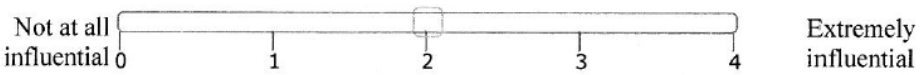
Question 2.3

How influential are the SWM guidelines with specifications on environmental standards in regards to the waste disposal operations?



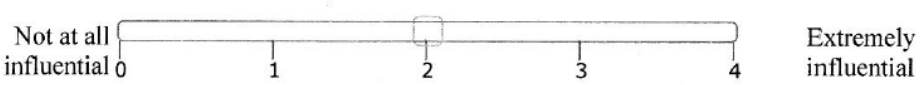
Question 2.4

How influential are the specific environmental targets on the sustainable SWM initiatives?



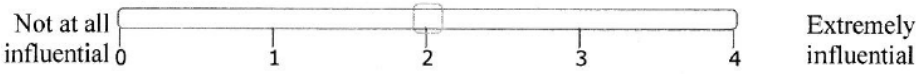
Question 2.5

How influential are the awareness on the climate change impact on the sustainable SWM initiatives?



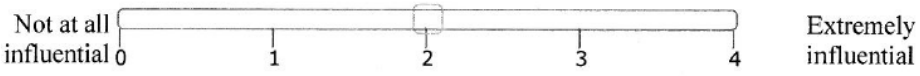
Question 2.6

How influential are the awareness on the climate change impact on the development of appropriate SWM infrastructure?



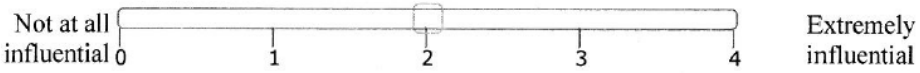
Question 2.7

How influential is the geographical landform on the solid waste operational planning?



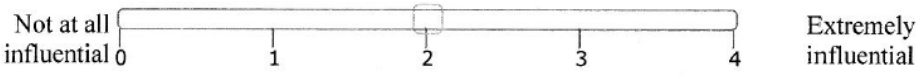
Question 2.8

How influential is the geographical landform on the solid waste operational costs?



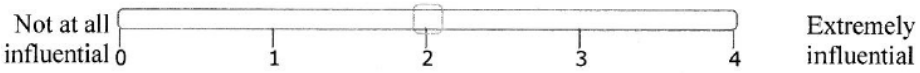
Question 2.9

How influential is the geographical landform on the development of SWM infrastructure and facilities?



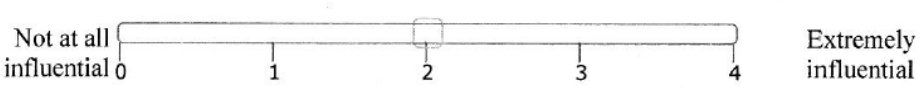
Question 2.10

How influential is local weather on the solid waste characteristics?



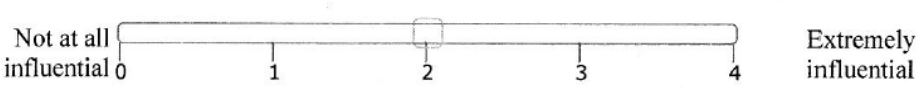
Question 2.11

How influential is local weather on the solid waste generation rate?

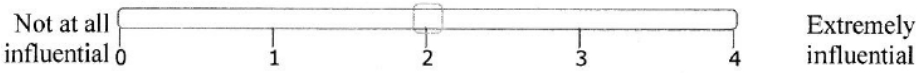


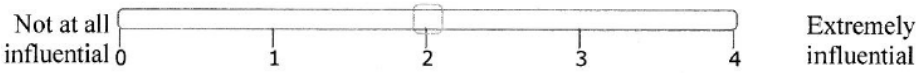
Question 2.12

How influential is the local weather on the development of solid waste treatment facilities?

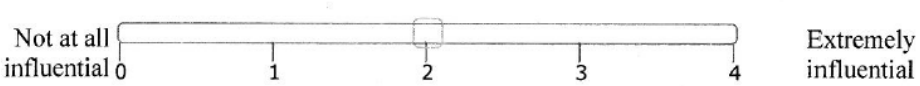


Question 2.13





How influential is the environmental awareness on changing public attitudes towards sustainable waste management practices?



Question 2.14

For question no 2.14, please classify the following environment factors as VISIBLE or INVISIBLE in the context of solid waste management according to the description given below:

- **Visible factors** in waste management are defined as factors that arc measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes, published for awareness and available for relevant access by public.
- **Invisible factors** are defined as factors that are not considered at all in any of waste management processes, however, have influence the social behavioral and philosophical perceptions on solid waste

management and practice.

Visible Invisible

Environmental guidelines
(Local/national guidelines that set specific environmental standards)

Environmental targets
(Specific goals on environmental standards to be achieved within certain period of time)

Climate change
(Changes in global and regional climate change patterns resulted from unsustainable human activities)

Geographical landform
(Different features of the part of the earth which makes the terrain)

Local weather
(Specific weather conditions at a particular place and time)

Environmental awareness
(Awareness on the adverse impact onto the environment resulted from unsustainable human activities)

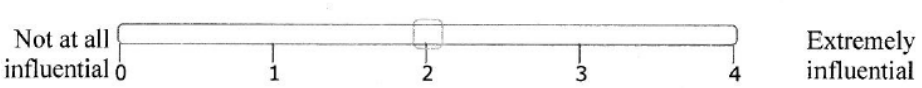
Section 3: Social

For question 3.1 to 3.28, please rate how these subfactors related to social does influence the local solid waste management systems.

Question 3.1

How influential are local seasonal events on the changes, either temporarily or permanently (or both), in solid waste generation rate?

(Note . Local seasonal events refer to the specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not officially be recognized by the government)

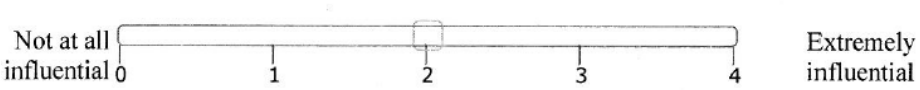


Question 3.2

How influential are local seasonal events on the changes, either temporarily or permanently (or both), in solid waste characteristics?

(Note . Local seasonal events refer to the specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop

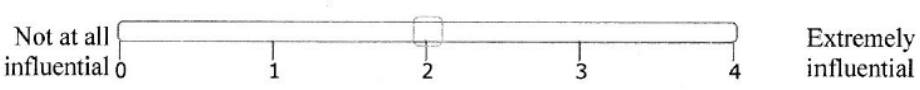
harvesting and also racial, religious or ethnic affiliation which may or may not officially be recognized by the government)



Question 3.3

How influential are local seasonal events on the changes, either temporarily or permanently (or both), in solid waste operational (collection and transfer) system?

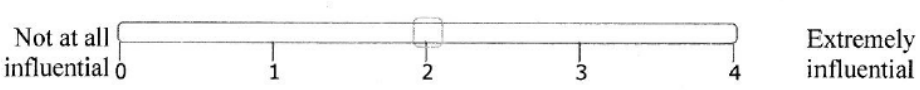
(Note . Local seasonal events refer to the specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not officially be recognized by the government)



Question 3.4

How influential are local seasonal events on the changes, either temporarily or permanently (or both), in solid waste treatment processes?

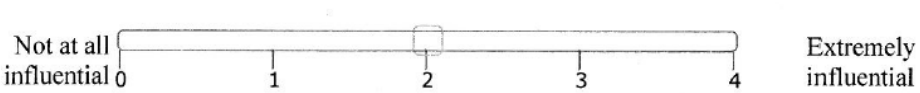
(Note . Local seasonal events refer to the specific annual celebrations at particular times o[the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not officially be recognized by the government)



Question 3.5

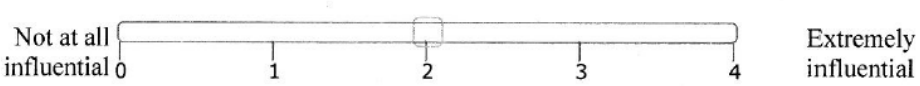
How influential are local seasonal events on the changes, either temporarily or permanently (or both), in solid waste disposal methods?

(Note . Local seasonal events refer to the specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not officially be recognized by the government)



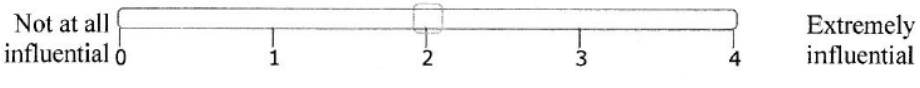
Question 3.6

How influential are religions on the SWM practices in the society?



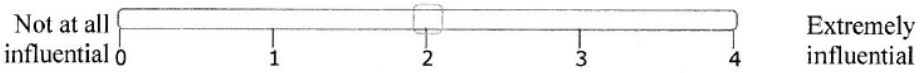
Question 3.7

How influential are cultural practices in the society on waste generation?



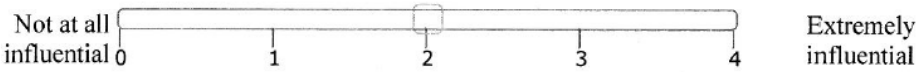
Question 3.8

How influential are cultural practices in the society on waste characteristics?



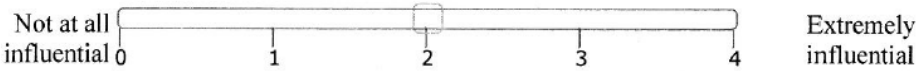
Question 3.9

How influential are cultural practices in the society on public waste behaviour?



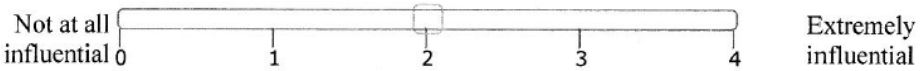
Question 3.10

How influential are different ethnicity practices in the society on waste generation?



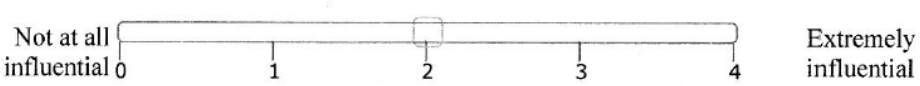
Question 3.11

How influential are different ethnicity practices in the society on waste characteristics?



Question 3.12

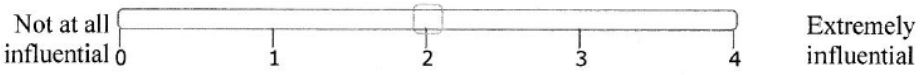
How influential are different ethnicity practices in the society on public waste behaviour?



Question 3.13

How influential are the celebrations of local and national events on the changes, either temporarily or permanently (or both), in solid waste generation rate?

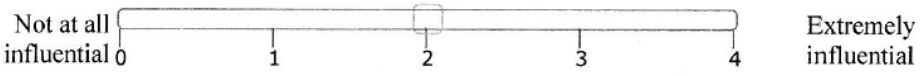
(Note . Local and national events refer to special days of celebration includes national holidays, commemoration events and also racial or ethnic affiliation which are officially recognized by the government)



Question 3.14

How influential are the celebrations of local and national events on the changes, either temporarily or permanently (or both), in solid waste characteristics?

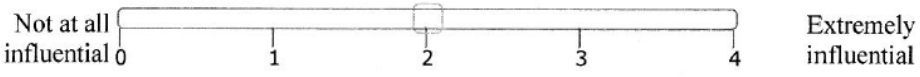
(Note . Local and national events refer to special days of celebration includes national holidays, commemoration events and also racial or ethnic affiliation which are officially recognized by the government)



Question 3.15

How influential are the local and national event on the changes, either temporarily or permanently (or both), in solid waste operational (collection and transfer) system?

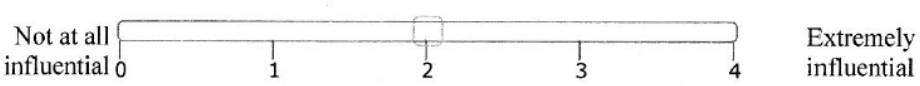
Note . Local and national events refer to special days of celebration includes national holidays, commemoration events and also racial or ethnic affiliation which are officially recognized by the government)



Question 3.16

How influential are the local and national event on the changes, either temporarily or permanently (or both), in solid waste treatment processes?

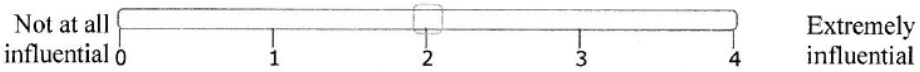
(Note . Local and national events refer to special days of celebration includes national holidays, commemoration events and also racial or ethnic affiliation which are officially recognized by the government)



Question 3.17

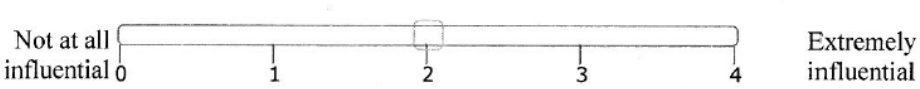
How influential are the local seasonal event on the changes, either temporarily or permanently (or both), in solid waste disposal methods?

(Note . Local and national events refer to special days of celebration includes national holidays, commemoration even1s and also racial or ethnic affiliation which are officially recognized by the government)



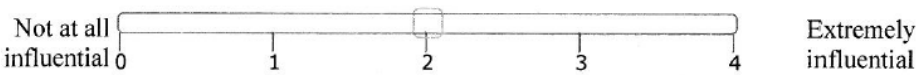
Question 3.18

How influential are social-economic status on the quality of waste management services provided?



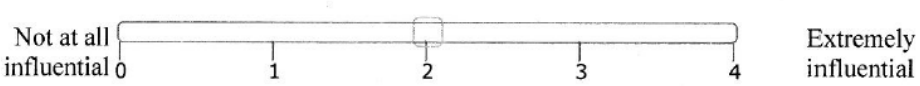
Question 3.19

How influential is the size of population on waste generation rate?



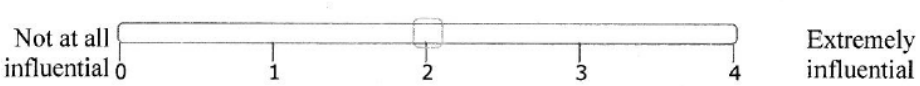
Question 3.20

How influential are the number of people living in the same house/premise on waste generation rate?



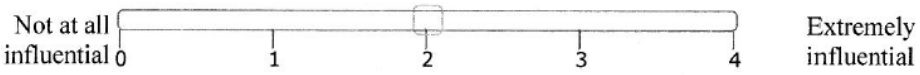
Question 3.21

How influential is the age factor on waste generation rate?



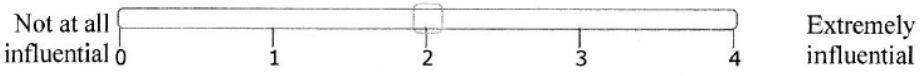
Question 3.22

How influential is education background on waste generation rate?



Question 3.23

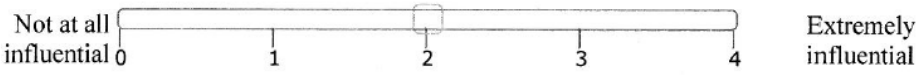
How influential are resource consumption patterns on waste generation rate?



Question 3.24

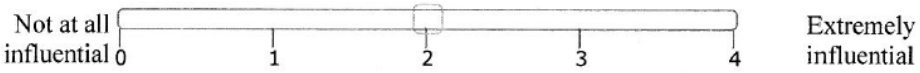
How influential are shared social norms on public waste behaviour?

(Note . Shared social norms are rules of behaviour that are considered acceptable in group of society)



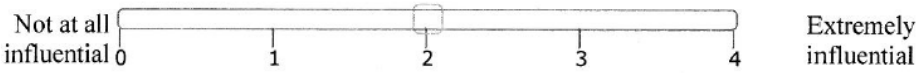
Question 3.25

How influential is daily rural-urban migration (mainly due to economic and tourism factors) on waste generation rate in the city?



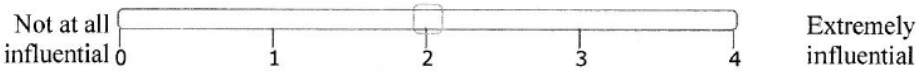
Question 3.26

How influential are the individual views on good waste management practices on their waste behaviour?

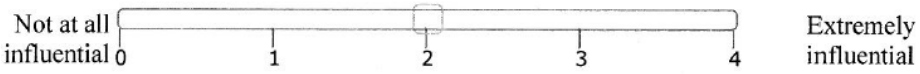


Question 3.27

How influential are the changes in local waste management system on public willingness in improving their waste behaviour?



Question 3.28
How influential are the changes in waste management change the waste behaviour of the public?



Question 3.29
For question no 3.29, please classify the following social factors as VISIBLE or INVISIBLE in the context of solid waste management according to the description given below:

- **Visible factors** in waste management are defined as factors that arc measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes, published for awareness and available for relevant access by public.
- **Invisible factors** are defined as factors that are not considered at all in any of waste management processes, however, have influence the social behavioral and philosophical perceptions on solid waste management and practice.

	Visible	Invisible
Seasonal events		

(Local seasonal events refer to the specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not officially be recognized by the government)

Religion
(System of faith and worship to personal God)

Cultural
(Social behaviour, belief, traditions of particular group of people)

Ethnicity
(A particular group of people with same races, religion, origin that may have different culture from other groups of people of a country)

Local/national events
(Local and national events refer to special days of celebration includes national holidays, commemoration events and also racial or ethnic affiliation which are officially recognized by the government)

Discrimination
(A practice of unfair treatment of a group of people to other people, mainly with regards to the socio-economic status)

Socio-demographic indicators
(Changes in particular demographic components which are measured periodically)

Resource consumption patterns
(*Changes of natural resources use for human activities within particular period of time)*

Shared norms
(Shared social norms are rules of behaviour that are considered acceptable in group of society)

Rural-urban daily migration
(Movement of people from rural to urban areas on daily basis, mainly due to the economic and tourism factors)

Philosophical change
(The evolving thoughts and feelings on a particular issues that reflected in the changing in behaviour)

Attitude-behaviour gap
(Difference of individual values or understanding on particular issues does not correlate with their actions)

Resistance to change

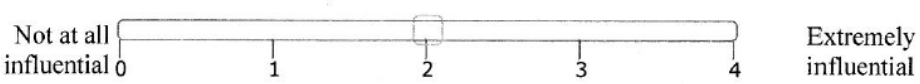
(Actions taken by individuals or group of people when they perceive or interpret change as a threat to them)

Section 4: Technology

For question 4.1 to 4.5, please rate how influential are the subfactors related to technology on the implementation of local SWM system.

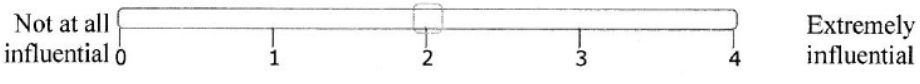
Question 4.1

How influential are the skilled workers and experts in waste management on improving the local SWM



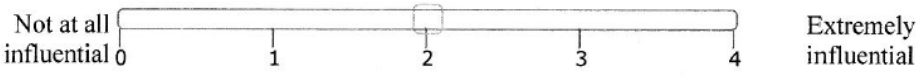
Question 4.2

How influential is the application of suitable technology on the implementation of SWM?



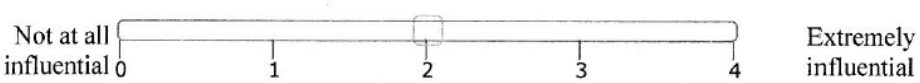
Question 4.3

How influential are the availability of SWM facilities on the SWM system?



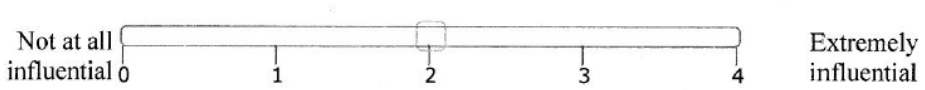
Question 4.4

How influential is the application of the latest technology on the implementation of SWM system?



Question 4.5

How influential are the research and development activities on the implementation of SWM systems?



Question 4.6

For question no 4.6, please classify the following technology factors as VISIBLE or INVISIBLE in the context of solid waste management according to the description given below:

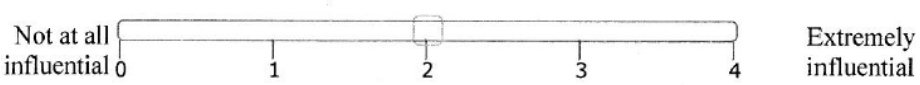
- **Visible factors** in waste management are defined as factors that arc measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes, published for awareness and available for relevant access by public.
- **Invisible factors** are defined as factors that are not considered at all in any of waste management processes, however, have influence the social behavioral and philosophical perceptions on solid waste management and practice.

	Visible	Invisible
Skilled workers and experts *(Workers with specific knowledge, skills and ability to perform best in their work, while experts are someone who widely recognized as a reliable source of technique or skill)*		
Application of suitable technology *(Application of the appropriate technology that are best designed for efficient operation)*		
Facilities availability *(Adequate number of facilities are developed for specific use of the people)*		
Rate of technology change *(Development of the related technology over certain period of time)*		
Research and development activities *(New innovative research that change the utilization, performance, management and practices)*		

Section 5: Legal

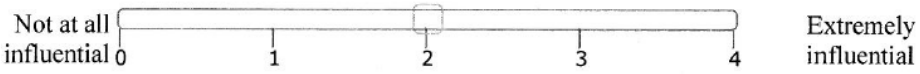
For question 5.1 to 5.5, please rate how influential are the subfactors related to legal on the implementation of local SWM system.
Question 5.1

How influential are the international SWM directives on the implementation of SWM system?



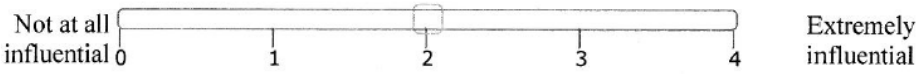
Question 5.2

How influential are the SWM policies on the implementation of SWM system?



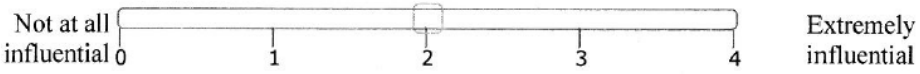
Question 5.3

How influential are the producers responsibility on taking sustainable approach for their products with regards to the implementation of SWM system?



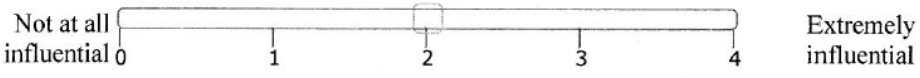
Question 5.4

How influential are the consumer awareness on proper management of post-consumer waste on the implementation of SWM system?



Question 5.5

How influential are the SWM law in the implementation of SWM system?



Question 5.6

For question no 5.6, please classify the following legal factors as VISIBLE or INVISIBLE in the context of solid waste management according to the description given below:

- **Visible factors** in waste management are defined as factors that arc measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes,

published for awareness and available for relevant access by public.

- **Invisible factors** are defined as factors that are not considered at all in any of waste management processes, however, have influence the social behavioral and philosophical perceptions on solid waste management and practice.

Visible Invisible

International directives
(Environmental guidelines and instructions drafted by international organizations to create uniformity in actions)

Local policy
(Policy that sets guidelines that determine the decision and actions on relevant matter)

Producers responsibility
(Approach taken by the producers in managing waste as by products)

Consumer accountability
(Responsibility of consumers in buying, consume and managing the waste from the products)

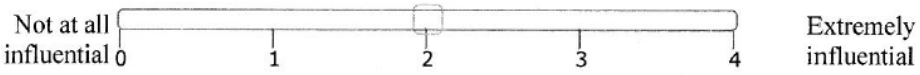
Relevant SWM law
(Compliance and enforcement of the law towards environmental protection and social considerations)

Section 6: Economy

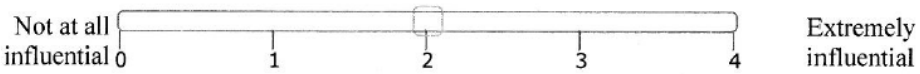
For question 6.1 to 6.7, please rate how influential are the subfactors related to economy on the implementation of local SWM system.

Question 6.1

How influential are the awareness of potential income from waste on the public waste behaviour?

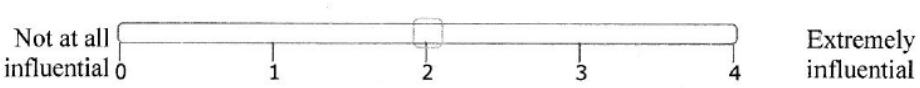


Question 6.2
How influential are the trade restriction on selected waste as secondary resources in regards to the implementation of SWM system?



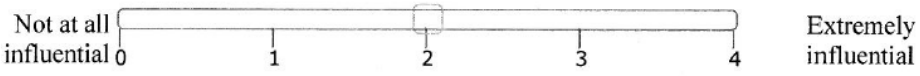
Question 6.3

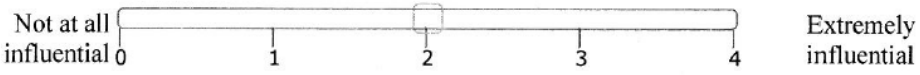
How influential are the restrictions applied onto non-registered and informal sector on the market growth of resource recovery?



Question 6.4

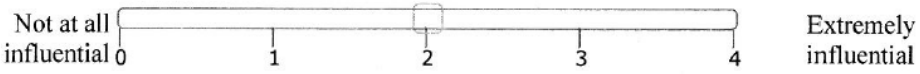
How influential are the financial assistance on facilities development in regards to the implementation of SWM system?





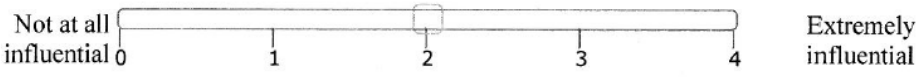
Question 6.5

How influential are the implementation of tax on waste trade on the implementation of SWM system?



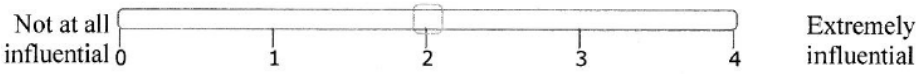
Question 6.6

How influential are the changes in economic growth patterns on the waste generation rate?



Question 6.7

How influential are the suitable incentives offered on waste reduction initiatives in regards to the public waste behaviour?



Question 6.8

For question no 6.8, please classify the following economy factors as VISIBLE or INVISIBLE in the context of solid waste management according to the description given below:

- **Visible factors** in waste management are defined as factors that arc measurable by specific indicators or scale, quantifiable by measuring methods, considered in decision making and implementation processes, published for awareness and available for relevant access by public.

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	Visible	Invisible
Potential income from waste *(Monetary benefits gain from waste)*		
Trade restrictions on waste *(Limitation on trade activities to selected waste)*		
Third sector restrictions *(Limitation on trade activities to non-formal business organizations)*		
Availability of funds *(Financial assistance offered on particular projects or initiatives)*		
Interest and tax *(Application of interest and tax on goods and services)*		
Economic growth patterns *(Changes in the amount of goods and services produced per head of the population over a period of time)*		
Incentives *(Rewards offered on appropriate actions)*		

Section 7: Participant details

Before finishing this survey, please fil1 in some information about you. All information collected will be kept confidential.

Question 7.1

Are you?
Male Female

Question 7.2

Where did your waste management experiences mostly come from?

- o Afghanistan
- o Albania
- o Algeria
- o Africa Samoa
- o Andorra
- o Anguilla
- o Antartica
- o Antigua and Barbuda
- o Argentina
- o Armenia
- o Aruba
- o Australia
- o Austria
- o Azerbaijan
- o Bahamas
- o BahrainBangladesh
- o Barbados
- o Belarus
- o Belgium
- o Belize
- o Benin
- o Bermuda
- o Bhutan
- o Bolivia
- o Bosnia and Herzegovina
- o Botswana
- o Bouvet Island
- o Brazil
- o British India Ocean Territory
- o Brunei
- o Bulgaria
- o Burkina Faso
- o Burundi
- o Cambodia

- Cameroon
- CanadaC
- Cape Verde
- Cayman lslands
- Central African Republic
- Chad
- Chile
- China
- Christmas Island
- Cocos (Keeling) Islands
- Colombia
- Comoros
- Congo
- Cook Islands
- Costa Rica
- Cote D'lvorie (Ivory Coast)
- Croatia (Hrvatska)
- Cuba
- Cyprus
- Czech Republic
- Democratic Republic of Congo (Zaire)
- Denmark
- Djibouti
- Dominica
- Dominican Republic
- East Timor
- Ecuador
- Egypt
- El Salvador
- Equatorial Guinea
- Eritrea
- Estonia
- Ethiopia
- Falkland lslands (Malvinas)
- Faroe Islands
- Fiji
- Finland

- France
- France, Metropolitan
- French Guinea
- French Polynesia
- French Southern Territories
- Gabon
- Gambia
- Georgia
- Germany
- Ghana
- Gibraltar
- Greece
- Greenland
- Grenada
- Guadeloupe
- Guam
- Guatemala
- Guinea
- Guinea-Bissau
- Guyana
- Haiti
- Heard And McDonald Islands
- Honduras
- Hong Kong
- Hungary
- Iceland
- India
- Indonesia
- Iran
- Iraq
- Ireland
- Israel
- Italy
- Jamaica
- Japan
- Jordan
- Kazakhstan

- Kenya
- Kiribati
- Kuwait
- Kyrgyzstan
- Laos
- Latvia
- Lebanon
- Lesotho
- Liberia
- Libya
- Liechtenstein
- Lithuania
- Luxembourg
- Macau
- Macedonia
- Madagascar
- Malawi
- Malaysia
- Maldives
- Mali
- Malta
- Marshall lslands
- Martinique
- Mauritania
- Mauritius
- Mayotte
- Mexico
- Micronesia
- Moldova
- Monaco
- Mongolia
- Montserrat
- Morocco
- Mozambique
- Myanmar (Burma)
- Namibia
- Nauru

- Nepal
- Netherlands
- Netherlands Antilles
- New Caledonia
- New Zealand
- Nicaragua
- Niger
- Nigeria
- Niue
- Norfolk Island
- North Korea
- Northern Mariana Islands
- Norway
- Oman
- Pakistan
- Palau
- Panama
- Papua New Guinea
- Paraguay
- Peru
- Philippines
- Pitcaim
- Poland
- Portugal
- Puerto Rico
- Qatar
- Reunion
- Romania
- Russia
- Rwanda
- Saint Helena
- Saint Kitts And Levis
- Saint Lucia
- Saint Pierre And Miguelon
- Saint Vincent And The Grenddines
- San Marino
- Sao Tome And Principe
- Saudi Arabia

- Senegal
- Seychelles
- Sierra Leone
- Singapore
- Slovak Republic
- Slovenia
- Solomon lslands
- Somalia
- South Africa
- South Georgia And South Sandwich lslands
- South Korea
- Spain
- Sri Lanka
- Sudan
- Suriname
- Svalbard And Jan Mayen
- Swaziland
- Sweden
- Switzerland
- Syria
- Taiwan
- Tajikistan
- Tanzania
- Thailand
- Togo
- Tokelau
- Tonga
- Trinidad And Tobago
- Tunisia
- Turkey
- Turkmenistan
- Turks and Caicos lslands
- Tuvalu
- Uganda
- Ukraine
- United Arab Emirates
- United Kingdom

- 0 United States
- 0 United States Minor Outlying Islands
- 0 Uruguay
- 0 Uzbekistan
- 0 Vatican City (Holy See)
- 0 Venezuela
- 0 Vietnam
- 0 Virgin Islands (British)
- 0 Virgin Islands (US)
- 0 Wallis And Futuna Islands
- 0 Western Sahara
- 0 Western Samoa
- 0 Yemen
- 0 Yugoslavia
- 0 Zambia
- 0 Zimbabwe

Question 7.3

How long you have been working in your experts areas? You can answer more than one of the options given.

Experts field	Less than a year	Between 1 – 5 years	Between 5 to 10 years	Between 10-20 years	More than 20 years	No experience
Private consultant	0	0	0	0	0	0
Private SWM companies	0	0	0	0	0	0
Regulatory	0	0	0	0	0	0
Local authorities	0	0	0	0	0	0
National government	0	0	0	0	0	0
Academics	0	0	0	0	0	0
Third sector	0	0	0	0	0	0
Politics	0	0	0	0	0	0

Charity and community	0	0	0	0	0	0

Question 7.4

What is your age group?

- O Below 18 years old
- O Between 25 to 44 years old
- O Between 45 to 64 years old
- O Above 65 years old

Question 7.5

As a follow up to this survey, would you be willing to participate in the second round of this survey?

Yes	No
O	O

Thank you for taking time to participate in this survey.

END OF SURVEY

Appendix B: Statistical analysis for Chapter 4

Appendix B1: Chi-Square results for association of political factors

Factor	Developed countries		Developing countries		Chi square	P value
	Visible	Invisible	Visible	Invisible		
Government stability	17 20.8	35 31.2	11 7.2	7 10.8	4.500	0.03
Corruption	14 14.1	38 37.9	5 4.9	13 13.1	0.005	0.94
Accountability of leaders	17 17.1	35 34.9	6 5.9	12 12.1	0.002	0.96
Local government plan	51 51.3	1* 0.7	18 17.7	0.3* 0	n/a	1.00
Government priorities	47 46.8	5 5.2	16 16.2	2 1.8	n/a	1.00
Influence of politicians	10 11.1	42 40.9	5 3.9	13 14.1	0.580	0.45
Bureaucracy	20 23.0	32 29.0	11 8.0	7 10.0	2.780	0.09

Appendix B2: Chi-Square results for association of environmental factors

Factor	Developed countries		Developing countries		Chi square	P value
	Visible	Invisible	Visible	Invisible		
Environmental guidelines	48 49.0	4* 3.0	18 17.0	0* 1.0	n/a	0.57
Environmental targets	48 47.5	4* 4.5	16 16.5	2* 1.5	n/a	0.64
Climate change	24 22.3	28 29.7	6 7.7	12 10.3	0.897	0.34
Geographical landform	27 27.5	10 9.5	25 24.5	8 8.5	0.071	0.79
Local weather	22 24.5	11 8.5	30 27.5	7 9.5	4.421	0.04
Environmental awareness	27 29.0	25 23.0	12 10.0	6 8.0	1.178	0.28

Appendix B3: Chi-Square results for association of social factor

Factor	Developed countries		Developing countries		Chi square	P value
	Visible	Invisible	Visible	Invisible		
Seasonal variations	35 33.4	17 18.6	10 11.6	8 6.4	0.804	0.37
Religion	6 5.9	46 46.1	2* 2.1	16 15.9	n/a	1.00
Cultural	10 13.4	42 38.6	8 4.6	10 13.4	4.450	0.04
Ethnicity	13 11.9	39 40.1	3 4.1	15 13.9	0.527	0.46
Local/national events	35 35.7	17 16.3	13 12.3	5 5.7	0.150	0.70
Discrimination	5 4.5	47 47.5	1* 1.5	17 16.6	n/a	1.00
Socio-economic indicators	41 39.4	11 12.6	12 13.6	6 4.4	1.079	0.29
Resource consumption patterns	31 33.4	21 18.6	14 11.6	4* 6.4	n/a	0.25
Shared norms	19 18.6	33 33.4	6 6.4	12 11.6	0.06	0.80
Rural-urban daily migration	27 27.5	25 24.5	10 9.5	8 8.5	0.07	0.79
Philosophical change	8 8.2	44 43.8	3* 2.8	15 15.2	n/a	1.00
Attitude-behaviour change	10 13.4	42 38.6	8 4.6	10 13.4	4.450	0.03
Resistance to change	12 14.1	7 4.9	40 37.9	11 13.1	1.691	0.19

Appendix B4: Chi-Square results for association of technological factors

Factor	Developed countries		Developing countries		Chi square	P value
	Visible	Invisible	Visible	Invisible		
Skilled workers and experts	32 34.2	20 17.8	14 11.8	4* 6.2	n/a	0.26
Application of suitable technology	44 43.1	8 8.9	14 14.9	4* 3.1	n/a	0.49
Facilities availability	50 49.0	2* 3.0	16 17.0	2* 1.0	n/a	0.49
Rate of technology change	27 26.0	25 26.0	8 9.0	10 9.0	0.299	0.58
R&D Activities	31 31.2	21 20.8	11 10.8	7 7.2	4.421	0.03

Appendix B5: Chi-Square results for association of legal factors

Factor	Developed countries		Developing countries		Chi square	P value
	Visible	Invisible	Visible	Invisible		
International directives	44 40.9	8 11.1	11 14.1	7 3.9	4.387	0.03
Local policy	50 49.8	2* 2.2	17 17.2	1* 0.8	n/a	1.00
Producers responsibility	31 31.9	21 20.1	12 11.1	6 6.9	0.281	0.59
Consumer accountability	12 15.6	40 36.4	9 5.4	9 12.6	4.615	0.03
Relevant SWM law	51 50.5	1* 1.5	17 17.5	1* 0.5	n/a	0.45

Appendix B6: Chi-Square results for association of economic factors

Factor	Developed countries		Developing countries		Chi square	P value
	Visible	Invisible	Visible	Invisible		
Potential income from waste	40 38.6	12 13.4	12 13.4	6 4.6	0.736	0.39
Trade restrictions on waste	36 32.7	16 19.3	8 11.3	10 6.7	4.519	0.03
Third sector restrictions	18 18.6	34 33.4	7 6.4	11 11	0.106	0.74
Availability of funds	43 43.8	9 8.2	16 15.2	2 2.8	0.388	0.53
Interest and tax	44 42.3	8 9.7	13 14.7	5 3.3	1.358	0.24
Economic growth patterns	31 31.9	21 20.1	12 11.1	6 6.9	0.281	0.59
Incentives	42 42.3	10 9.7	15 14.7	3 3.3	0.058	0.809

Appendix C : Statistical analysis for Chapter 5

Appendix C1. T-test results for association of political factors

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Corruption	Equal variances assumed	.646	68	**.520**	.25214	.39031	-.52672	1.03100
	Equal variances not assumed	.647	29.716	**.523**	.25214	.38963	-.54390	1.04818
Accountability of leaders	Equal variances assumed	1.717	68	**.090**	.53419	.31105	-.08649	1.15487
	Equal variances not assumed	1.710	29.402	**.098**	.53419	.31237	-.10430	1.17267
Local government plan	Equal variances assumed	-1.301	68	**.018**	-.28846	.22166	-.73077	.15385
	Equal variances not assumed	-1.443	36.350	**.018**	-.28846	.19993	-.69380	.11688
Government priority	Equal variances assumed	.227	68	**.821**	.04701	.20668	-.36542	.45944
	Equal variances not assumed	.214	26.791	**.832**	.04701	.21957	-.40368	.49770
Influence of politician	Equal variances assumed	1.503	68	**.137**	.59615	.39660	-.19525	1.38756
	Equal variances not assumed	1.550	31.349	**.131**	.59615	.38456	-.18780	1.38011
Bureaucracy	Equal variances assumed	-.658	68	**.512**	-.30769	.46733	-1.24023	.62484
	Equal variances not assumed	-.736	37.057	**.466**	-.30769	.41787	-1.15433	.53895
Government stability	Equal variances assumed	1.078	68	**.025**	.43590	.40444	-.37116	1.24295
	Equal variances not assumed	1.084	29.946	**.027**	.43590	.40200	-.38515	1.25694

Appendix C2. T-test results for association of environmental factors

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Environmental guide	Equal variances assumed	-.799	68	**.427**	-.40812	.51082	-1.42744	.61121
	Equal variances not assumed	-.853	33.544	**.400**	-.40812	.47857	-1.38118	.56494
Climate change	Equal variances assumed	1.896	68	**.062**	.92949	.49023	-.04876	1.90773
	Equal variances not assumed	1.724	25.453	**.097**	.92949	.53902	-.17964	2.03862
Environmental target	Equal variances assumed	-1.017	68	**.313**	-.22650	.22268	-.67084	.21785
	Equal variances not assumed	-.950	26.476	**.351**	-.22650	.23839	-.71609	.26310
Geeographical landforms	Equal variances assumed	.334	68	**.740**	.22436	.67259	-1.11777	1.56649
	Equal variances not assumed	.345	31.548	**.732**	.22436	.65001	-1.10041	1.54912
Local weather	Equal variances assumed	3.790	68	**.000**	2.33761	.61680	1.10680	3.56841
	Equal variances not assumed	3.614	27.342	**.001**	2.33761	.64684	1.01118	3.66404
Environmental awareness	Equal variances assumed	.197	68	**.844**	.04915	.24939	-.44851	.54680
	Equal variances not assumed	.171	23.925	**.865**	.04915	.28698	-.54324	.64153

Appendix C3. T-test results for association of social factors

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Seasonal variations	Equal variances assumed	.834	68	**.407**	.90812	1.08923	-1.26540	3.08164
	Equal variances not assumed	.758	25.441	**.455**	.90812	1.19804	-1.55712	3.37336
Religion	Equal variances assumed	-.448	68	**.656**	-.13889	.31026	-.75801	.48023
	Equal variances not assumed	-.448	29.706	**.657**	-.13889	.30978	-.77180	.49402
Cultural	Equal variances assumed	.103	68	**.018**	.07051	.68329	-1.29297	1.43400
	Equal variances not assumed	.106	31.054	**.016**	.07051	.66587	-1.28744	1.42847
Ethnicity	Equal variances assumed	-.977	68	**.332**	-.70513	.72196	-2.14577	.73551
	Equal variances not assumed	-.928	27.176	**.362**	-.70513	.76003	-2.26411	.85386
Local national event	Equal variances assumed	1.197	68	**.235**	1.34188	1.12095	-.89494	3.57870
	Equal variances not assumed	1.262	32.698	**.216**	1.34188	1.06358	-.82276	3.50652
Discrimination	Equal variances assumed	.797	68	**.428**	.23932	.30037	-.36006	.83869
	Equal variances not assumed	.815	30.884	**.421**	.23932	.29357	-.35951	.83814
Socio demographic indicator	Equal variances assumed	-.845	68	**.401**	-.76709	.90768	-2.57834	1.04415
	Equal variances not assumed	-.898	33.272	**.375**	-.76709	.85379	-2.50360	.96941
Resource consumption	Equal variances assumed	-.149	68	**.882**	-.03205	.21507	-.46122	.39711
	Equal variances not assumed	-.162	34.989	**.872**	-.03205	.19745	-.43290	.36880
Shared norms	Equal variances assumed	-1.479	68	**.144**	-.37393	.25285	-.87848	.13062
	Equal variances not assumed	-1.287	23.972	**.210**	-.37393	.29051	-.97355	.22568
Rural urban migration	Equal variances assumed	.854	68	**.396**	.23291	.27270	-.31126	.77707
	Equal variances not assumed	.794	26.287	**.434**	.23291	.29333	-.36973	.83554
Philosophical change	Equal variances assumed	-.206	68	**.838**	-.04060	.19749	-.43469	.35349
	Equal variances not assumed	-.205	29.471	**.839**	-.04060	.19807	-.44541	.36421
Attitude behavior gap	Equal variances assumed	.161	68	**.873**	.03846	.23897	-.43839	.51531
	Equal variances not assumed	.165	31.033	**.870**	.03846	.23296	-.43664	.51356
Resistance to change	Equal variances assumed	-.118	68	**.906**	-.02350	.19852	-.41965	.37264
	Equal variances not assumed	-.124	32.236	**.902**	-.02350	.18973	-.40986	.36285

Appendix C4. T-test results for association of technological factors

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Skilled workers and experts	Equal variances assumed	-.728	68	**.469**	-.14316	.19667	-.53561	.24928
	Equal variances not assumed	-.633	23.940	**.533**	-.14316	.22619	-.61007	.32374
Application of suitable technology	Equal variances assumed	-.542	68	**.590**	-.12821	.23665	-.60044	.34403
	Equal variances not assumed	-.462	23.359	**.648**	-.12821	.27752	-.70182	.44541
Facilities availability	Equal variances assumed	-2.865	68	**.006**	-.52778	.18423	-.89540	-.16015
	Equal variances not assumed	-2.041	19.465	**.055**	-.52778	.25862	-1.06821	.01265
Rate of technology change	Equal variances assumed	-.081	68	**.936**	-.02137	.26351	-.54719	.50446
	Equal variances not assumed	-.074	25.682	**.941**	-.02137	.28794	-.61360	.57086
Research and development	Equal variances assumed	.624	68	**.045**	.17094	.27398	-.37577	.71765
	Equal variances not assumed	.651	32.063	**.040**	.17094	.26256	-.36384	.70572

Appendix C5.T-test results for association of legal factors

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
International directives	Equal variances assumed	-1.300	68	**.198**	-.41880	.32214	-1.06161	.22401
	Equal variances not assumed	-1.194	25.803	**.243**	-.41880	.35087	-1.14029	.30268
Local policy	Equal variances assumed	.066	68	**.947**	.01496	.22565	-.43532	.46523
	Equal variances not assumed	.066	29.324	**.948**	.01496	.22695	-.44898	.47890
Producer responsibility	Equal variances assumed	.830	68	**.410**	.23291	.28065	-.32712	.79294
	Equal variances not assumed	.814	28.674	**.422**	.23291	.28596	-.35223	.81804
Consumer accountability	Equal variances assumed	-.041	68	**.967**	-.01068	.26067	-.53085	.50948
	Equal variances not assumed	-.040	27.940	**.969**	-.01068	.26975	-.56329	.54192
Relevant SWM law	Equal variances assumed	-1.117	68	**.028**	-.23718	.21240	-.66101	.18665
	Equal variances not assumed	-1.044	26.516	**.020**	-.23718	.22716	-.70368	.22932

Appendix C6. T-test results for association of economic factors

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Potential income from waste	Equal variances assumed	.864	68	.391	.23718	.27451	-.31060	.78496
	Equal variances not assumed	.850	28.787	.402	.23718	.27906	-.33374	.80810
Trade restrictions on waste	Equal variances assumed	-.129	68	.898	-.03205	.24830	-.52752	.46342
	Equal variances not assumed	-.152	42.007	.880	-.03205	.21039	-.45664	.39254
Third sector restrictions	Equal variances assumed	1.627	68	.108	.39744	.24422	-.08990	.88477
	Equal variances not assumed	1.610	29.077	.118	.39744	.24682	-.10732	.90219
Availability of funds	Equal variances assumed	.236	68	.014	.05342	.22640	-.39835	.50519
	Equal variances not assumed	.223	26.953	.025	.05342	.23959	-.43822	.54506
Interest and tax	Equal variances assumed	-1.675	68	.099	-.43162	.25769	-.94584	.08260
	Equal variances not assumed	-1.478	24.417	.152	-.43162	.29196	-1.03366	.17042
Economic growth patterns	Equal variances assumed	-.283	68	.778	-.06624	.23399	-.53316	.40069
	Equal variances not assumed	-.278	28.746	.783	-.06624	.23807	-.55333	.42085
Incentives	Equal variances assumed	1.052	68	.296	.29487	.28027	-.26440	.85414
	Equal variances not assumed	1.040	29.021	.307	.29487	.28357	-.28508	.87482

Appendix D : Journal and conference proceedings published

Appendix D1 **:**
Paper title : Mukhtar, E.M., Williams, I.D., Shaw, P.J., Ongondo, F.O., 2016. A tale of two cities: The emergence of urban waste systems in a developed and a developing city. Recycling 1, 254–270. https://doi.org/10.3390/recycling1020254

Appendix D2 **:**
Paper title: Mukhtar, E.M., Williams, I.D., Shaw, P.J., 2018. Visibility of fundamental solid waste management factors in developing countries. Detritus 1, 162–173. https://doi.org/10.26403/detritus/2018.16

Appendix D3:
Paper title: Mukhtar, E.M., Williams, I.D., Shaw, P.J., Ongondo, F.O., 2015. Evolution of waste management systems in developed and developing cities, in: 15th International Waste Management and Landfill Symposium. CISA Publisher, 5-9 October 2015, Sardinia, Italy.

Appendix D4**:**
Paper title : Mukhtar, E.M., Williams, I.D., Shaw, P.J., 2017. Visible and invisible factors of solid waste management in developing countries, in: 16th International Waste Management and Landfill Symposium. CISA Publisher, 2-6 October 2017, Sardinia, Italy.

Appendix D1 :
Paper title : Mukhtar, E.M., Williams, I.D., Shaw, P.J., Ongondo, F.O., 2016. A tale of two cities: The emergence of urban waste systems in a developed and a developing city. Recycling 1, 254–270. https://doi.org/10.3390/recycling1020254

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Article

A Tale of Two Cities: The Emergence of Urban Waste Systems in a Developed and a Developing City

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Abstract: Developing cities have historically looked to developed cities as exemplary models for waste management systems and practices without considering the consequent resource requirements or the key characteristics of the local setting. However, direct adoption of developed cities' approaches without proper consideration of the local circumstances may lead to unsustainable future waste management in developing cities. This study evaluates waste management in London and Kuala Lumpur, representing developed and developing cities, focusing on the integration of policy changes, socio-economic background and waste data trends on a multi-decadal scale. This analysis reveals the gradual implementation of initiatives, the challenges faced and the attempted solutions that were applied differently in both cities. Conceptual models of waste management status in different scenarios for both cities were developed. These models highlight that societal behaviour shifts from minimal waste generation (wasteless) to throw-away society (wasteful) and a drive to achieve sustainable waste behaviour with integration of resource recovery and waste minimization (wasting less). A detailed understanding of the evolution of waste management systems towards fulfilling public needs alongside rapid urbanization can provide new perspectives on future waste scenarios, especially in developing cities. Ultimately, reliable and accurate data are crucial to avoid inaccuracies in planning for future waste management.

Keywords: urbanization; urban waste management; waste management evolution; policy; sustainability; developing cities; developed cities

1. Introduction

Urbanization, rapid economic growth and increasing urban populations have resulted in a marked escalation in quantities of waste generated, heterogeneity and complexity [1,2]. Inadequate waste management has impacted adversely on public health [3] and has caused environmental degradation and resource depletion [4]. The challenge of designing localised waste management strategies that are economically viable, environmentally effective and socially acceptable continues to be of major concern to municipal authorities [5,6].

There are clear differences in waste management systems between developed and developing cities. For instance, waste management practices in developed cities currently focus on optimization strategies for resource conservation [7,8] whilst approaches to waste management in developing cities are often underdeveloped [9], operationally inefficient, and inadequately managed, with limited knowledge and expertise to hand [1,10]. These distinct shortcomings have led to an urgent need for developing cities to seek advice towards shaping waste management systems that are workable and acceptable in local settings.

Integrated waste management can be applied in both developed and developing cities depending on local circumstances and factors that have influenced preceding initiatives [11]. Developing cities have historically looked to developed cities as exemplary models for waste management systems and techniques. However, when trying to select a suitable, durable and sustainable approach to waste management, it is important for decision-makers to (i) understand the local scenario; (ii) evaluate the adaptability of management systems and practices from developed cities; and (iii) consider the consequent resource and logistical requirements, including human and technical resources. Previous studies have addressed the evolution of waste management systems from the viewpoints of societal background [12], policy design [13], technological development and system innovations [14] and the experiences of a single country or city [6,15–19]. To facilitate the improvement of future systems, there is a need to compare the evolution of waste management systems between developed and developing cities in a comprehensive manner, particularly relationships between socio-economic developments, strategy/policy changes and waste arisings.

This study reviews the history of urban waste management in developed and developing cities, focusing on the integration of policy changes, socio-economic background and waste data trends. In this context, we specifically appraise historical evidence over a 44-year period (1970–2014) for London and Kuala Lumpur, representing developed and developing cities, respectively. These cities were selected because:

- After more than 300 years of British colonial rule, there has been a strong British influence on administrative systems in Malaysia.
- Malaysia has been a member of the Commonwealth since 1957, status which has facilitated the maintenance of a British-modelled government administration.
- Development in Kuala Lumpur has followed, with a substantial time-lag, a similar trajectory to London in terms of its population and development.

Through long-term historical comparison, the development of waste management systems may be evaluated as a means to question whether developed cities can influence positively the adoption of waste management systems in developing cities. Evolution of their waste management systems is thus examined in terms of waste generation, composition, collection systems, disposal methods, recycling and the overarching waste strategies implemented. We consider how changes in societal circumstances and behaviour are associated with indicators of waste management systems over time and provide insights into how future waste management systems may evolve, especially in developing cities.

2. Materials and Methods

Whilst there are various definitions of urban waste, the simplest version makes reference to non-liquid waste materials that have been discarded or are unwanted and need to be disposed from domestic, trade, commercial, industrial, agriculture as well as public services [20–22].

In the UK, waste is defined in the Environmental Protection Regulations (1991) according to the European Union (EU) Directive 91/156/EEC as "any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard" [23]. Annex 1 in Directive 91/156/EEC contains a list of 16 different categories of waste, mainly used to determine whether or not a substance or object has been discarded. In Malaysia, the general terms of waste are defined in the Solid Waste Management and Public Cleansing Act (2007) as:

(a) any scrap material or other unwanted surplus substance or rejected products arisings. from the application of any process;
(b) any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled; or
(c) any other material that according to this Act or any other written law is required by the authority to be disposed of, but does not include scheduled wastes as prescribed under the Environmental

Quality Act 1974 (Act 127), sewage as defined in the Water Services Industry Act 2006 (Act 655) or radioactive waste as defined in the Atomic Energy Licensing Act 1984 (Act 304)" [24].

In this study, three key indicators have been selected to illustrate pertinent changes and trends; population growth, economic growth and waste arisings. The study focuses on the period 1970–2014. Population growth rate is the increase in a country's population during a period of time, and includes the number of births and deaths and the number of people migrating to and from a country [25]. Economic growth is evaluated by annual Gross Domestic Product (GDP), i.e., market value of products and services in a country. Data on population growth and GDP for both cities were mainly gathered from the World Bank's global development indicators [26]. Table 1 shows the sources of data used in this study.

Table 1. Sources of data used as basis for waste arisings, trends and composition changes in Malaysia and the United Kingdom from 1970 to 2014.

Country/City	Data Characteristics	Years	Reference
Malaysia	Waste arisings	1970–1980	[27]
		1990	[28]
		2000–2010	[29]
		2014	[29]
Kuala Lumpur	Waste arisings	1970–2014	[29]
	Waste composition	1970–2000	[27]
		2010	[30]
		2014	[29]
United Kingdom	Waste arisings	1970	[31]
		1980	[32]
		1990	[33]
		2000	[34]
		2010	[35]
		2014	[36]
London	Waste arisings	1970	Estimated value *
		1980	Estimated value *
		1990	[37]
		2000	[38]
		2010	[39]
		2014	[40]
	Waste composition	1970	[31]
		1980	[22]
		1990	[14]
		2000	[41]
		2010	[38]
		2014	[42]

* Estimation is based on 1990–2010 trend where London's waste contributed approximately 13.7% of total UK waste.

Standardization of the data is impractical; some required data were unavailable, some have questionable accuracy, and there have been changes in the type of waste included in or defined as solid waste over time. For instance, the definition and classification of solid waste changed over the period depending on its necessity in the local waste scenario. In order to provide better comparisons, data for waste generation used in this study were grouped into the same timeline. The number of accessible historical databases on waste management in Malaysia is limited and there is a lack of organised documentation to record such data, often resulting in outdated and possibly inaccurate databases [43].

3. Results

3.1. Overview of Historical Waste Management

Waste generation trends and composition can provide information required for future planning [44]. Historians consider that environmental knowledge and developed strategies about earlier civilisations can be gained by examining waste profiles and trends over time [16,45]. As cities became modernized, higher amounts of waste of increasingly complex composition were produced from diverse sources. As national GDP increases, per capita waste generation also increases, suggesting higher waste generation in the future [46]. Table 2 summarizes the population growth and waste arisings for London and Kuala Lumpur over 44 years. After independence in 1957, Kuala Lumpur benefited from economic prosperity that significantly improved standards of living. The expansion of the manufacturing sector stimulated Malaysia's economic growth, but the consequences of economic activities on the environment triggered public anxiety about waste arisings and their means of disposal throughout the 1980s.

Table 2. Population trends and waste arisings for Kuala Lumpur and London (1970s–2014). (Data sources shown in Table 1).

Years	1970s	1980s	1990s	2000s	2010s	2014
MALAYSIA						
Population (10^6)	10.91	13.83	18.21	23.42	28.28	30.60
GDP (billion USD)	4.28	24.94	44.02	93.79	247.5	338.10
Annual waste generation (10^6 tonnes)	0.11	0.32	5.57	5.69	10.26	11.43
National recycling rate (%)	NA	NA	NA	3.00	5.00	5.00
Per capita waste (kg/capita/day)	0.03	0.06	0.84	0.67	0.99	1.02
KUALA LUMPUR						
Population (10^6)	0.88	0.92	1.12	1.31	1.62	1.73
Annual waste generation (10^6 tonnes)	0.04	0.11	0.21	1.00	1.27	1.52
Per capita waste (kg/capita/day)	0.11	0.34	0.52	1.93	2.34	2.41
Daily generation (tonnes/day)	98.9	310.5	586.8	2754	3800	4168
UNITED KINGDOM						
Population (10^6)	55.928	56.352	57.808	59.954	61.773	64.560
GDP (billion USD)	130.6	567.1	1067	1549	2408	2989
Annual waste generation (10^6 tonnes)	18.00	22.50	27.10	36.10	32.00	26.8
National recycling rate (%)	6.00	6.00	6.00	17.80	43.20	44.90
Per capita waste (kg/capita/day)	0.88	1.10	1.36	1.58	1.39	1.39
LONDON						
Population (10^6)	7.529	6.806	6.890	7.215	7.470	8.540
Annual waste generation (10^6 tonnes)	2.47 *	3.08 *	3.82	4.40	4.90	3.63
Per capita waste (kg/capita/day)	0.90	1.24	1.52	1.67	1.80	1.16
Daily generation (tonnes/day)	6767	8438	10,466	12,055	13,425	9945

* Data estimated on 13.7% of total UK waste.

London was the first city to establish formal door-to-door waste collections by 1900; a similar system exists today. With more complex challenges to manage waste in London, the inherited systems have failed to meet the consequences of economic growth and population expansion [47]. The overall system evolved initially in response to the high fraction of coal ash in municipal waste that had potential market value [48]. The dust-yard operations reached their peak by the mid-19th century when coal ash prices dropped gradually and changed the waste characterization and composition [48].

3.2. Trends in Waste Generation, Population and Economic Growth

Generally, waste generation and its management have a direct association with socio-economic development and human health [12,49], degree of urbanization, standard of living, and a nation's prosperity [50,51]. The Malaysian economy has undergone a transformation over the last four decades, driven by the increased trade, higher domestic demand and financial integration. The economic activities during the 1970s, under the New Economic Policy (NEP), led to a continued increase in waste generation through the 1980s. Hence, it is conceivable that much of the growth in waste arisings can be attributed to GDP growth and population concentration in urban areas. Kuala Lumpur's population has doubled from 1970 to 2014. There is an indicative increase of 24% in population growth from 2000s to 2010s alongside high economic growth with a 163% increase in GDP within the same period. However, waste generation increased faster than population growth in the city, with a notable increase in the 1990s–2000s, which marked a period when extensive data collection on waste was properly recorded by the government. The increase in waste generation as recorded from the 1990s to 2000s was mainly due to the initiatives taken by the Ministry of Local Government, the authority responsible for establishing a reliable waste database at the national level; this period also saw the implementation of interim contracts for solid waste management that were initially awarded to private companies in 1998. With the implementation of the interim contract, data collection was more systematic and centralized, more accurately reflecting current waste generation, specifically for Kuala Lumpur. Under these circumstances, the earliest regulations imposed included the Street Drainage and Building Act 1974, Town and Country Planning Act 1976 and Environmental Quality Act 1974, with specific clauses on waste management within the acts [52]. Per capita waste generation in Kuala Lumpur increased from 0.11 kg in 1970 to 2.41 kg in 2014, a 20-fold increase in 44 years. The average household size in urban areas decreased over the study period with 6.1 persons in 1970 and 4.3 persons in 2010 [53]. Alongside the household size decrease, per capita waste generation tended to increase, mainly driven by household-level waste such as mail and newspapers, which are not affected by a reduction in the size of the household [54]. Organic matter contributed the highest percentage of material in household waste composition [55]. Kuala Lumpur's population is expected to reach 4.2 million with average daily waste generation of 9207 tonnes in 2023 [27,55]. The trends of population growth and waste generation for Kuala Lumpur and London are as shown in Figures 1 and 2.

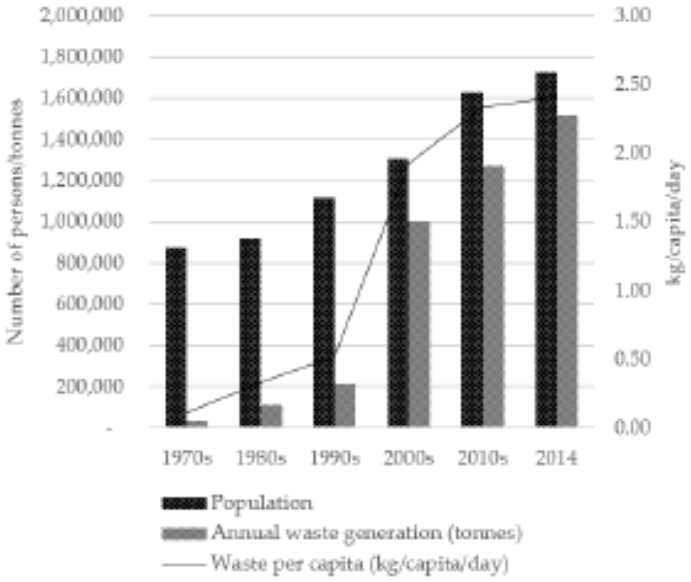

Figure 1. Trends in population, waste generation and per capita waste in Kuala Lumpur. (Data sources shown in Table 1).

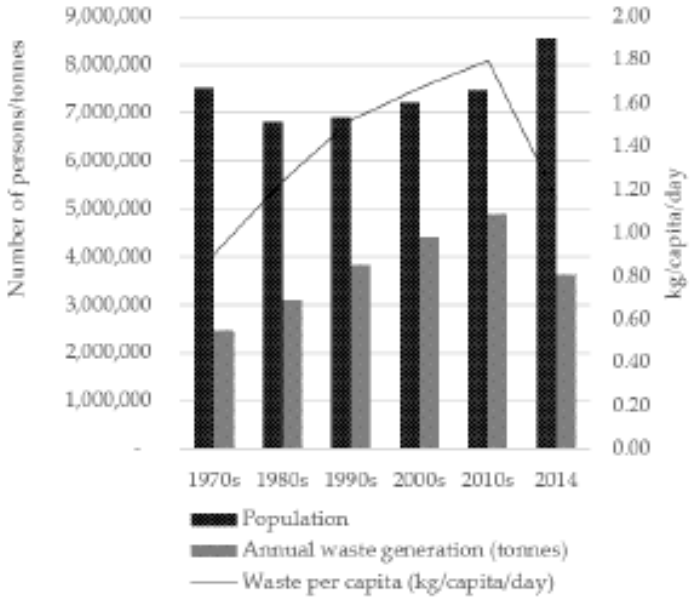

Figure 2. Trends in population, waste generation and per capita waste in London. (Data sources shown in Table 1).

Towards the new millennium, UK waste management was mainly influenced by the EU Landfill Directive of 1999 which aimed to mitigate impacts on human health and the environment caused by landfilling of waste [34]. This resulted in a significant increase (133%) in landfill tax, from £24 per tonne in 2007 to £56 per tonne in 2011 [56]. Efforts in waste minimization and reduction are reflected in the reduction of waste generated and an increase in the recycling rate from 6% to 45% from the 1970s to 2014. Alongside the 25% reduction in waste generation from 2010 to 2014, the UK's recycling rate increased steadily from 17.8% in the early 2000s to 44.9% in 2014. However, the reduction in waste arisings was also partially caused by the economic crisis and downturn around late 2007–2012 [57] which saw a fall in consumer spending and a decline in production of consumer goods [56]. In London, population decline was reported in the 1970s–1980s as a result of the city's redevelopment in which housing estates were rebuilt as commercial centres, thus forcing city centre residents to move outwards [58]. London's decline in population reversed slowly in early 2000. However, as residential numbers in outer London increased, more daily commuters travelled to the city centre for business and work. The increase in the number of daily commuters in addition to tourists has no doubt contributed to increased waste generation within central areas of the city.

3.3. Waste Collection, Treatment and Disposal Methods

Since there is no reported evidence of a formal waste management system before independence from the UK in 1957, waste disposal methods in Malaysia were probably by burning, burying or disposal into water bodies. Not until the late 1970s was collection, treatment and disposal of waste in Kuala Lumpur under the authority of the Kuala Lumpur City Hall (KLCH). Gradually, the upgrading of facilities for waste treatment and disposal in Kuala Lumpur city was completed in line with the increase in waste generation and concern for the adverse environmental impacts of poor waste management on public health [2]. With the mixture of dwelling types, waste collection was aligned to suit disposal behaviour in terms of the type of container used and the source of waste generated. Operational costs for waste management subsequently increased and became the most challenging issue for the authority. Although there were no direct payments collected from households for waste collection and disposal, the cost has been included in the local tax contribution. KLCH allocated 66% of the council tax revenue for waste management services paid to the interim contractors and for tipping

fees, which was not sufficient for investment in high technology facilities. Taman Beringin Landfill, which commenced operation in 1991, was the only waste disposal site for domestic and commercial waste located within the city. Due to the quantities of waste generated as the city grew rapidly in the late 1990s, the expected lifespan of the landfill was reduced and it was closed in 2005. Taman Beringin Transfer Station was developed in 2002 as an integrated solution for waste disposal and land scarcity in Kuala Lumpur.

Incineration is the preferred disposal method for Malaysia but the high capital investment costs are not affordable for most Malaysian cities. A few small-scale incinerators were built on a trial basis, mostly adopting technology from Europe with customised design to suit local waste characteristics, especially for high moisture content waste. All reportedly failed, mainly due to flawed design or inadequate capacity that caused high operation and maintenance costs [59,60]. The government has proposed a large-scale incineration plant in Kuala Lumpur to reduce dependency on landfill, however, the plan was strongly rejected by the public in view of the potential harm to the environment and human health [59]. The government's intention to build an incinerator arguably provides an indication of the unsuccessful implementation of previous waste minimisation and recycling efforts.

In London, early garbage removal trucks were simply open-bodied dump trucks pulled by a team of horses. They became motorized in the early part of the 20th century and the first closed-body trucks (to eliminate odours) with a dumping lever mechanism were introduced in the 1920s in Britain. Transport and collection costs are the most significant elements to be considered in the financial matters of waste management. Waste treatment facilities were first operated in London in 1874 with novel "waste destructors" in which waste was burned. Almost a hundred years later, in 1971, the London Ecopark incinerator was launched to handle more than a quarter of London's waste while generating electricity. However, waste problems in the city continue to escalate, and new innovations initiated such as the vacuum system using underground pipes that became operational in Wembley City in December 2008. In this system, sorted recyclables and waste were automatically transported through enclosed vacuum pipes to central collection points and stored for collection [61]. The breakthrough of innovative systems may lead to improvement of conventional waste collection system towards more sustainable waste management system in megacities like London.

3.4. Waste Composition

In Kuala Lumpur, waste composition has changed little over the studied period. Like some other developing countries, organic waste is the major component (45%–60%) of the total waste generated (see Table 3). Paper, plastic, metal and glass are the common recyclables found in the waste stream. Early waste management in Malaysia generally involved dealing with relatively homogenous organic waste and major components of recyclable items [29]. The change in the composition indicates the change of lifestyle and consumer patterns during the period. The changes also were also contributed to by the enforcement of the Solid Waste Management Act (2007) whereby initiatives towards improving waste management systems and practices were implemented that reflected an increase in the recycling rate.

Realizing the potential to generate energy from organic waste, the Malaysian Government introduced organic waste separation at source in 2005 with the intention to develop high technology facilities in the future, including thermal treatment and anaerobic digestion. Residents' actions were not, however, aligned with the Government's initiatives, as the facilities developed did not complement the awareness campaign, thus leading to a continued increase in organic matter in the waste stream. Limited knowledge of plastic recycling and a lack of suitable recycling facilities for plastics resulted in a significant increase in the non-recovered plastic fraction in the waste stream. In addition, due to its durability, cheapness and convenience, plastics are primary materials for packaging that are easily discarded after single use.

One of the local activities that contribute to the high volume of single use plastic is the presence of night markets. In Kuala Lumpur, night markets are popular due to the variety of stalls and

abundance of daily essentials for sale. They consist of stalls selling a range of goods and foods that are "ready-to-eat" or prepared-on-demand food, which is to be eaten on-site, or takeaways and mainly use single-use plastics for packaging.

Table 3. Waste composition (%) for London and Kuala Lumpur (1970–2014). (Data sources shown in Table 1).

Years	1970s	1980s	1990s	2000s	2010s	2014
LONDON						
Fine dust and cinder	27.4	19.0	-	-	-	-
Organic	19.3	21.0	38.1	36.7	32.0	34.0
Paper	32.5	30.0	23.8	24.6	23.0	36.0
Metals	7.1	9.0	3.2	3.8	4.0	4.0
Rags/Textiles	2.2	3.0	2.5	2.4	3.0	1.0
Glass	7.9	9.0	7.9	6.7	7.0	12.0
Plastic	1.0	3.0	5.2	10.3	10.0	6.0
WEEE	-	-	-	0.8	2.0	-
Others	2.6	6.0	19.3	14.7	19.0	7.0
KUALA LUMPUR						
Organic	63.7	78.1	40.8	43.2	43.5	32.3
Paper	11.7	11.5	30.0	23.7	22.7	31.6
Metals	6.4	3.2	4.6	4.2	3.3	2.7
Textiles	1.3	3.2	2.5	1.5	0.9	-
Glass	2.5	0.6	3.0	3.2	2.6	4.9
Plastics	7.0	0.6	9.8	11.2	25.2	8.3
Wood	6.5	2.6	3.2	0.7	-	-
Others	0.9	0.2	6.1	12.3	1.8	20.2

Coal was the main source of heat and energy in the 18th century to late 20th century in most parts of the UK. Coal ash from households formed the major portion of waste composition in London and, after collection, it was sent to the dust-yards to be reused as a soil conditioner [48]. High levels of coal burning during cold weather and coal-fired power station operations in London during the 1950s led to the Great Smog of 1952 [62]. The general trends of United Kingdom waste from the 1930s to the 1980s highlights the appearance of plastic in waste in the 1960s as well as a reduction in ash in the early 1970s as a result of a smoke control policy [63]. Materials such as plastics and paper subsequently started to dominate waste composition, mainly driven by the packaging of goods and food. Waste electrical and electronic equipment (WEEE) appeared in the waste stream in the new millennium due to the rapid emergence of technology, its increasingly affordable price and limited lifespan, exacerbated by the short-term obsolescence of many electrical and electronic consumer goods. The United Kingdom disposed of almost 1 million tonnes of WEEE in 2003 with 70% comprising large household appliances [64]. The proportion of organic waste increased steadily from 19% in the 1960s to 32% in 2010. Biodegradable waste has been recently diverted from landfill due to concern about methane gas released to the atmosphere and its contribution to climate change. Therefore, resource recovery from the waste stream became a preferred option and there is a move towards supporting the circular economy framework in the future.

3.5. *Waste Minimisation Strategy and Recycling Policies*

A timeline illustrating the evolution of waste management systems in both cities (Figure 3) reveals the gradual implementation of waste management initiatives, the challenges faced and the attempted solutions. This analysis in turn indicates how waste management systems have evolved towards fulfilling public needs alongside sometimes rapid economic development and population expansion. In Malaysia, waste management became a responsibility of federal authorities when the Environmental

Quality Act (EQA) was formulated in 1974, which later migrated to the Local Government Act in 1976. The implementation of waste management in Kuala Lumpur was initiated with the Action Plan for Beautiful and Clean (ABC) Malaysia in 1998, which focused on recycling and strengthening local authority roles in waste management. Recycling and waste minimisation were seen as mechanisms to deal with escalating waste generation. A national recycling campaign commenced in 1993 but it failed to achieve the target recycling rate due to low participation by the public and inadequate provision of recycling facilities [27]. The National Strategic Plan for Solid Waste Management was established in 2005 with inspiration from the ABC Plan in 1998 in which the government continues to promote waste minimisation and recycling as the preferred solutions for waste management.

More recycling facilities and centres were developed around the city that offer cash incentives in exchange for recyclables, which created a "spoon-feed" recycling habit among the public and depended on each household's willingness to bring items to the nearest recycling centre [65]. Recycling has thus become attractive to the public for personal economic gain rather than for environmental reasons. This situation has indicated a false start to sustainable recycling practice in the city, where it is anticipated that the biggest challenge to implement separation at source is to shift from the incentive-driven recycling to voluntary practice.

In Kuala Lumpur, a significant contribution to recycling is made by the informal sector via recovery of usable materials from waste stream whilst in London, recycling systems are more uniform and administered formally by the municipalities. Informal systems—often involving scavengers or informal waste collectors—can be more efficient and dynamic in developing cities and some successful transitions from the informal to the formal sector have occurred [66]. During the 1980s and 1990s, scavengers were mainly local people from lower income levels in society and their activities focused on recovering materials from landfills. Also, municipal waste collection crews carried out collection of recyclables from households, a practice often known as "tailgate recycling" that is not allowed by law, but, sales of recyclables provide extra income to the crew [28].

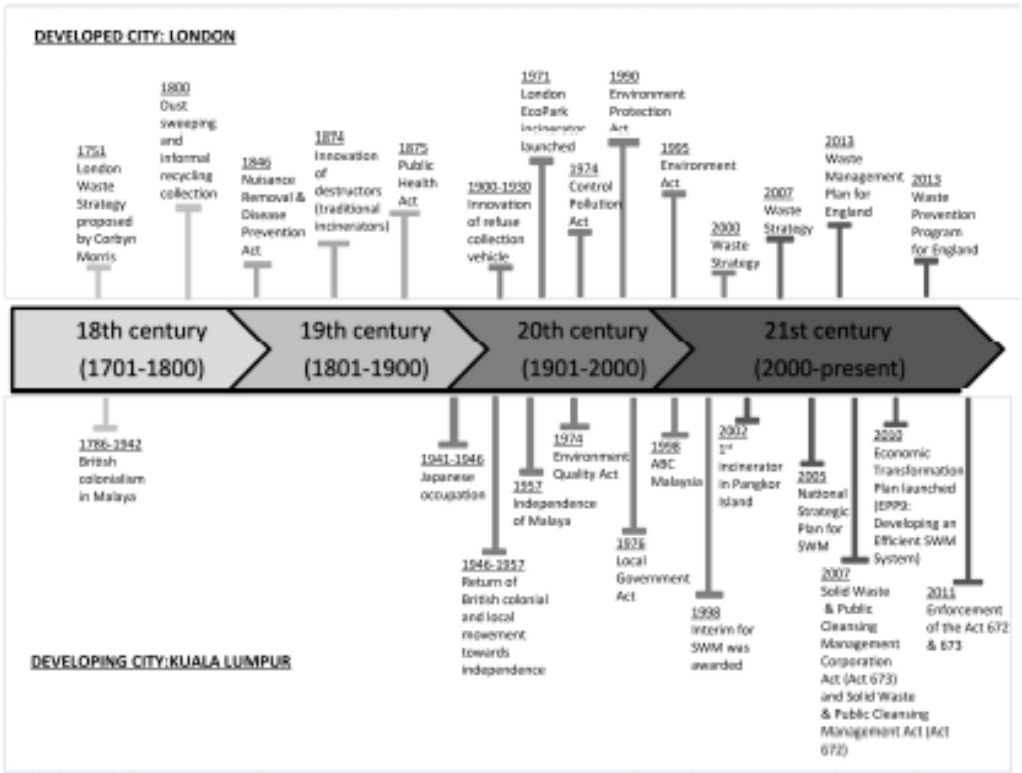

Figure 3. The evolution of waste management policies for London and Kuala Lumpur.

Scavenging by municipal crews, however, reduced the efficiency of waste collection thus increasing the operational cost to the municipal authority. Scavenging also led to the loss of control of tracking recycling activities and data collection as the informal recycling industries grew more rapidly than expected. Consequently, although the recycling rate in Malaysia was almost certainly higher than officially reported, it is still unknown on an accurate basis.

In the 1990s, there was an ingress of foreign labour from neighbouring countries to address labour shortages in the manufacturing sector. Foreign labour then started to dominate waste collection activities, particularly via informal recycling activities. The informal recycling sector became aggressive due to poverty and a lack of regulation and a lack of guidelines for more sustainable recycling programmes. The informal recycling is generally considered to be more efficient than the formal sector due to skilful manual sorting by workers who manage to extract waste according to its value. Informal recycling businesses operate without licences and operate using unregulated work procedures with cheap labour, thus creating broad marginal profit on its activities [67].

Environmental and solid waste management (SWM) policies in Malaysia have evolved from simple informal policies to national level strategies and legislation [68]. This transition was from general waste policies in the Environmental Quality Act (1974) to the implementation of the Solid Waste Management and Public Cleansing Act (2007) in 2011 which demonstrated the government's commitment towards achieving an effective and sustainable waste management system. Along with this transition, other strategies and plans have been implemented, some of which were influenced by other countries' experiences, whilst others were designed in response to local scenarios. The evolution of waste management in Kuala Lumpur had improved residents' social serenity, economic stability and environmental efficiency [69]. However, a series of failures in waste strategies occurred, mainly due to lack of awareness and participation from the public as well as the limited funds allocated for development of plans for waste management. In fact, due to political intervention and conflicts of interest between the federal and state governments in the late 2000s, the long-delayed Solid Waste Management and Public Cleansing Act was rejected by opposition states, pushing the ultimate goal towards achieving sustainable waste management even further from realisation.

The development of recycling systems in London can be seen as a long-term continuum from the early dust-yard operations until recycling operations were stimulated by EU directives towards the end of the 20th century. Consequently, the waste industry has changed from treating waste as a homogenous material for disposal to developing specialist systems for recovery of different components in the waste stream; the collection, sorting, dissembling and delivery of materials has had to be developed in such a way as to align with this change. The UK was relatively shifting its focus from waste to resource management, alongside other industrialised countries such as the United States of America, Canada, Germany, Austria and the Scandinavian countries, where average recycling rates of 30%–50% [14].

4. Discussion

4.1. Conceptual Models from Waste to Resource Management

As society has evolved and the global population has expanded, the consumption of natural resources has changed rapidly. Before the Industrial Revolution, there was a scarcity of resources and little waste was discarded without some form of recovery. The behaviour of such a society can be considered "wasteless" in that few materials were disposed and resource efficiency was high. Because populations were relatively poor, consumption was low, recovery of materials was high and little waste was produced. Zero-waste operations in the dust-yards of London in the 18th century are good examples of behaviour in a wasteless society. Along with modernization and urbanization, the lifestyle in London has become more challenging in terms of balancing economic stability with improvement to the quality of life. Strong economic stability and higher living standards have shaped society into a throw-away or "wasteful" society, wherein an abundance of resources has allowed the manufacture of

easily-available and affordable products, and recovery of materials was deemed financially unattractive. Subsequently, large amounts of waste were generated that required disposal and this eventually placed significant burdens on the environment. This situation is regarded as unsustainable as the potential environmental degradation has increased as a consequence of over-consumption of natural resources and increases in waste generation. A stepwise shift up the waste hierarchy turns to recycling as the preferred option to recover secondary value from resources.

Moving towards the future, where depletion of natural resources is predicted, it is crucial to shift the present society's waste behaviour, from being wasteful to "wasting less". Anticipating increased future waste arisings, a society that wastes less will have access to resources from reuse/recycling/composting, though it is predicted that resource consumption will be higher due to increased demand for goods. Shifting from waste management to sustainable resource management clearly is the desired way to manage waste in the future in all countries.

Sustainability in waste management can be defined as efficient resource consumption that reduces the amount of waste produced and contributes to sustainable economic development, environmental protection and social equity and harmony. On the basis of this study, we have created conceptual models to represent the evolution of waste management in developed and developing cities, representing by Kuala Lumpur and London (Figure 4). The lowest point of the curve in the figure indicates maximum resource utilization with low recovery rate. Upon reaching this point, at which the waste management practice is at its worst, initiatives to improve the system have to be implemented to avoid deleterious environmental consequences. London had experienced a slow societal behavioural shift and was considered to be a wasteful society for long period due to the incapability of the existing waste management system that was inherited from the earlier waste management system in the 18th century to serve the rapid population growth and massive amount of waste generated from economic activities. As the population is projected to be expanded in the future, it is crucial for London to shift the societal behaviour into wasting less to mitigating the adverse environmental impacts resulting from poor waste management systems. By comparison with London's waste management status over time, Kuala Lumpur might maintain its waste management status if the current society's waste behaviour continues in the future. Current societal waste behaviour in Kuala Lumpur can be considered as wasteful regardless of various initiatives for waste recovery and minimization implemented either by the government or the public. The absence of regional directives on waste management and a lack of enforcement of waste management policies are inevitably hindering progress towards achieving sustainable waste management. There is nonetheless concern about the marked increase in waste generation over the last decade in addition to the rapid increase of population in the city. We would expect London to have moved beyond being a wasteful society and to have started implementing initiatives towards becoming a society that wastes less as a result of EU Directives and national initiatives towards sustainable practice and behaviours relating to waste management. Undeniably, various factors have influenced initiatives striving for sustainable waste management systems, however, in each unique waste scenario, the interactions and strengths of the factors might be different. There is a need for further study on the interconnections of these factors in localised waste scenarios and these have to be elucidated in a local context in order to help planners design practical and workable local waste plans. Detailed analysis is recommended in terms of how local factors can contribute to accelerating the process of improving the waste management system.

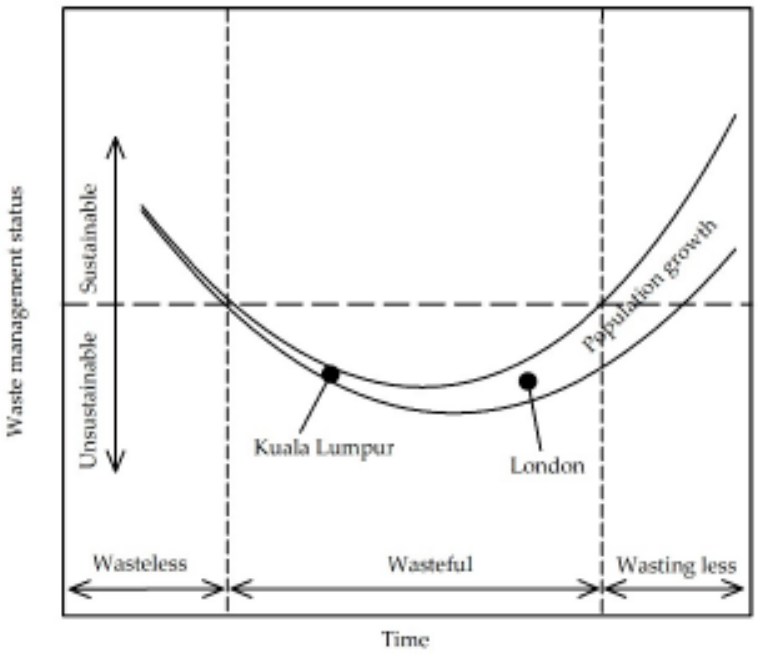

Figure 4. A conceptual model representing the evolution of waste management in developed and developing cities. Population growth is represented by the increasing gap between the curved solid lines. The horizontal dashed line represents the threshold between sustainable and unsustainable waste management practice. Periods of waste management characterized by "wasteless", "wasteful" and "wasting less" status are delineated by vertical dotted lines. The indicative current positions of Kuala Lumpur and London on the route from wasteless to wasting less status are shown.

4.2. *Developing Cities Adopting Practices from Developed Cities*

Developing cities' waste regulations are often prototypes that emerge from past regulations for developed cities. However, such prototypes often do not necessarily work well or fit suitably with local scenarios. Prior to a decision to adopt such regulations, social, economic, environmental and local political factors need to be considered carefully. Straight adoption of technologies that work well in developed cities may not work effectively in developing cities for various reasons, including poor fit with local waste characteristics and quantities, infrastructure, collection and transport systems, temperature, climate, culture, household or business practices and the local economy. Even customisation of technologies to suit local conditions may not ensure the success of its operation. Developing cities such as Kuala Lumpur often cannot afford trials and research, in terms of finance and time, and hence adaptation of methods and systems from developed cities' experiences and success can be seen as a "fast track" option to deal with waste generated from the city areas. As Kuala Lumpur is planning to build many incinerators as a solution for waste disposal, failures from previous small-scale incinerators across the country may shed some light on anticipated challenges in terms of operational costs, social rejection, environmental impacts and eventual likelihood of success—or failure.

4.3. *Economic Influences on Waste Arisings*

As economic prosperity increased, living standards in Kuala Lumpur were raised, increasing purchasing power and waste generation along. Kuala Lumpur has developed economically for the past 50 years with the amount of waste generated escalating much more rapidly than economic growth. It has been spending the majority of earmarked municipal funds on waste management and disposal and relatively little on development of facilities. Likewise, in London, when the benefits of formal

of local circumstances rather than by default via direct adoption from other cities' experiences. The "big picture" for waste management needs to be addressed at national and global levels. Stakeholders need to ensure their functionality to support the system. The public is the biggest stakeholder; they need to understand the connections between their daily lifestyles, resource consumption and the quality of the environment that they live in presently and for the future. An appropriate waste management database is undeniably crucial to help planners for future projections. In developing cities where data are estimated, possible inaccuracies may lead to misinterpretation of the current scenario and could result in incorrect projections or inhibit the realisation of sustainable waste management. Careful historical analysis allied to good quality data, a detailed understanding of key technical and localised factors, and recognition of a city's status on our conceptual model could assist the more rapid emergence of realistic, practically attainable and potentially sustainable waste management infrastructure, service provision and behaviour change systems in developed and developing countries.

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VISIBILITY OF FUNDAMENTAL SOLID WASTE MANAGEMENT FACTORS IN DEVELOPING COUNTRIES

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ABSTRACT

The development of solid waste management (SWM) has been closely related to factors that influenced waste practices in the past and have shaped contemporary waste management systems. Multiple influencing factors need to be considered if SWM is to be effective. We have identified non-measurable or "invisible" factors that are not easily quantifiable or routinely measured but may influence local waste management practices and behaviour. Although the degree of influence of invisible factors is varied and sometimes vague in terms of impact, they serve as a starting point to design more effective waste management strategies. The aim of this study was to identify factors in solid waste management and classify them into two broad categories: "visible" (usually measurable by specific indicators or scales, quantifiable, considered in decision-making and implementation processes, and publically accessible) and "invisible" (not usually measured or quantified but still likely to influence waste generation, behaviour and operational practices, and perceptions about waste). A PESTLE (Political, Environmental, Social, Technological, Legal and Economic) analysis was employed as the basis for categorization. We identified 43 fundamental factors that were divided into the six different PESTLE categories. Experts in waste management were consulted via a Delphi survey and were found to consider 34 (79%) of these 43 fundamental factors to be visible and 9 (21%) invisible. This study highlights the need to adopt new perspectives regarding the role of these fundamental factors in SWM and to understand better the nature and extent of their influence on progress towards cost-effective, efficient, locally-optimised and sustainable waste management systems.

1. INTRODUCTION

Waste generation is connected to the socio-economic status of nations. In developing countries, the management of waste is becoming more complex as a result of rapid urbanization and the increasingly heterogeneous nature of consumer products. Increasing population level, rapid urbanization, increasing economic activity and an increase in society's living standards in major cities in developing countries have led to substantial growth in waste generation. Large increases in global waste generation may be attributed to developing countries, driven by a combination of high urbanization rates and rapid economic development (Le Courtois, 2012). Specific socio-economic conditions prevail in developing countries, including rapid population growth, rural-urban migration, lack of funds and low-skilled cheap labour. SWM systems in emerging economies often lack facilities, and suffer insufficient service coverage, improper disposal and treatment methods that can lead to major environmental and social problems.

Mukhtar et al. (2016), in a review of the history of urban waste management, clearly showed that direct adoption of developed cities' approaches without proper consideration of the local circumstances may lead to unsustainable future waste management in developing cities. The significance of factors in SWM in developing countries has been assessed with regard to: socio-economic impacts on waste generation (Bandara et al., 2007), recycling (Johari et al., 2014), waste to resource initiatives (Storey et al., 2015), the collection of municipal waste (Coffey and Coad, 2010) and disposal of waste (Zurbrügg and Schertenleib, 1998). The roles of specific factors are not always well-defined nor their influence measured. The impact of these factors, when apparent, can be validated from historical evidence. Multiple factors affect the development of SWM, including legislative, environment, social, technical, health, market demand and economic aspects. These key factors need to be identified and their role(s) understood to ascertain

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whether proposed waste management plans are duly tailored to local requirements and are viable in environmental, social and economic terms (Mukhtar et al., 2015). The fundamental factors relevant to waste management systems can vary due to the differences between individual cities' characteristics (Contreras et al., 2010). Some factors are usually measurable by specific indicators or scales, quantifiable, considered in decision-making and implementation processes, and publically accessible (e.g. demographic indicators): these factors may be termed "visible". In contrast, there are "invisible" factors that are not usually measured or quantified but still likely to influence waste generation, behaviour and operational practices, and perceptions about waste. These factors potentially influence the need for development of a waste management system but are qualitative (e.g. behaviour, understanding and awareness) and may be important if local conditions are to be recognised and addressed in the design and implementation of waste management systems.

Various factors in SWM play different fundamental roles in waste management practices (Barr, 2007; Periathamby et al., 2009b; Wilson, 2007). Previous research studies have addressed the significance of factors in SWM, including: policy and strategy (Rudden, 2007; Taherzadeh and Rajendran, 2014; Wilson et al., 2011), age and aging communities (Pickerin and Shaw, 2015), community behaviour and interactions (Shaw, 2008), the socio-economic impacts on waste generation (Bandara et al., 2007), recycling (Johari et al., 2014), waste to resource initiatives (Storey et al., 2015), the collection of municipal waste (Coffey and Coad, 2010) and disposal of waste (Zurbrügg and Schertenleib, 1998). Although the degree of influence of invisible factors is perhaps varied and sometimes unclear in terms of impact, in principle they serve as a starting point to design more effective waste management strategies or policies based on tangible local trends or evidence, rather than adopting best practices from elsewhere which may not address local characteristics, customs, uniqueness or waste composition (Mukhtar et al., 2016).

In some cases, invisible factors' roles in shaping waste management in developing countries may be more important than in developed countries, depending on the combination and roles of other factors under the local circumstances. Due to the influence of these factors in specific situations and at local scale, invisible factors that worked well in one locality may appear to be not important at all in other areas and therefore direct adoption may not lead to similar outcomes. The complexity of a city/region's waste management system requirements need to be: (i) recognised, (ii) analysed and (iii) turned into infrastructure, service provision and information campaigns that lead to behaviour change. For example, cities with diverse ethnic groups in the community might consider the differences in culture and lifestyles of each ethnic group in terms of waste practices, resource consumption and awareness on proper waste management practices. In less diverse settings, any differences in waste-related behaviour among different ethnic groups may not appear to be important and may not need to be considered in waste management plans and systems. It is possible that approaches to setting up waste collection systems, selecting suitable treatment methods and public awareness-raising campaigns need to take visible and invisible factors into consideration in order to reach desirable results. In this paper, we first aim to identify fundamental factors in waste management through a review of multidisciplinary literature and classify these factors into PESTLE (Political, Environmental, Social, Technological, Legal and Economic) categories. The second aim of this study is to classify further these fundamental factors into two broad categories, "visible" and "invisible" by employing a Delphi study. Results will provide clear classification of visible and invisible factors in developing countries and how these factors can be connected within the local setting that can accelerate the development of SWM systems.

2. METHODS

This study comprised two phases. The first stage was a literature review to gather and collate a list of fundamental factors that are reported to be relevant to and important in SWM; factors were then classified according to the PESTLE system (section 2.1). To identify factors, the literature relating to SWM was characterized and critically evaluated (Pérez-Belis et al., 2015). Scholarly articles were searched and subsequently reviewed based on the title, abstract and keywords to evaluate the suitability of the factors highlighted in the documents. The factors as collated and classified were then presented to a consultative group, members of which were asked to specify whether they consider each factor to be "visible" or "invisible" in current waste management practices (section 2.2).

2.1 PESTLE classification of factors in solid waste management

Important factors in waste management development were first identified via a literature review. The literature review was intended to identify factors on a qualitative basis. The factors were grouped according to the PESTLE classification (e.g. Zhang et al., 2011; Kolios and Read, 2013; Srdjevic et al., 2012; Zalengera et al., 2014) to create an analytical framework. Those factors identified were not intended to represent an exhaustive list but to generate a set of factors for subsequent consideration by the consultative group in the Delphi study (section 2.2).

2.2 Delphi survey

The Delphi method was employed to establish views on fundamental factors in SWM from a group of identified international experts. The Delphi method is a systematic and interactive research technique to obtain the judgement of independent experts on a specific topic. Selection of appropriate experts for the Delphi panel is critical to the quality of the study (Hsu and Sandford, 2007). Candidate participants were selected using the authors' extensive knowledge of international waste management professionals supplemented by an online search to identify persons with expert knowledge, including members of editorial panels from waste management-related journals, academics in higher education and established professionals from

selected waste management companies and municipal authorities. The structure of the Delphi questionnaires followed the key factors and PESTLE categorization (section 2.1).

Respondents were presented with the list of factors within PESTLE categories (Tables 1-6) and asked to classify each factor as either "visible" or "invisible". The questionnaire specified the meaning of each of these terms, vis-à-vis:

- Visible factors are usually measurable by specific indicators or scales, quantifiable, considered in decision-making and implementation processes, and publically accessible.
- Invisible factors are not usually measured or quantified but still likely to influence waste generation, behaviour and operational practices, and perceptions about waste.

Respondents were also asked to provide information regarding their own role, expertise and experience in SWM. The Delphi questionnaire was administered by iSurvey, a survey generation and research tool for distributing online questionnaires used by the University of Southampton (https://www.isurvey.soton.ac.uk/).

3. RESULTS AND DISCUSSION

3.1 PESTLE classification of factors in solid waste management

The 43 factors are identified and briefly described in Tables 1-6. Differences in the numbers of factors in each PESTLE class were noted. We note that the observations to hand (Tables 1-6) do not represent an exhaustive list of factors or a quantitative profile. The specific purpose (section 2.1) is to inform and guide the subsequent Delphi survey (section 2.2). In particular, this analysis provides the structural framework for the Delphi study and the definitions of each factor (Tables 1-6).

3.2 Delphi survey: respondent profile

The respondent group comprised professionals from academia, private SWM consultants and companies, regulatory, local authorities and national government, charity organizations, business and trade and politics. Participants were classified according to their current location and its associated economic status (Table 7). The classification of countries by gross net income (GNI) is considered appropriate, but does not necessarily reflect the status of development in countries within the same classification.

3.3 Delphi survey: classification of factors as visible and invisible

Experts were asked to classify 43 factors (Tables 1-6) as visible or invisible. For about 80% of these factors, more than 50% of the respondents judged them to be visible. Each group of factors is considered in relation to PESTLE categories (sections 3.3.1 to 3.3.6).

3.3.1 Political factors

Political factors, as classified by respondents, varied in terms of being considered visible or invisible (Figure 1). The local government plan was considered visible by

TABLE 1: Political factors in SWM: the ability and roles of government to affect management and regulation.

Factor	Description	References
Government stability	Strong government can hold its power and control over the country with minimal external influence	Plata-Díaz et al. (2014); Wilson et al. (2001)
Corruption	Fraudulent conduct for personal benefits, typically related to bribery	Taherzadeh and Rajendran (2014); Jones et al. (2010)
Accountability of leaders	Responsible and trusted leaders	Jones et al. (2010); Rudden (2007)
Local government plan	The plan for future development of the local area	Rudden (2007); Wilson et al. (2001)
Government priorities	Focus and attention on specific issues by the government	Moh and Abd Manaf (2016)
Influence of politicians	Effect of politicians' behaviour and character on specific issues	Taherzadeh and Rajendran (2014)
Bureaucracy	Excessively complicated administrative procedure	Godfrey and Scott (2011)

TABLE 2: Environmental factors in SWM: the ability of environmental elements and resources to influence waste management behaviour and directions.

Factor	Description	References
Environmental guidelines	Local/national guidelines that set specific environmental standards	Li (2007)
Environmental targets	Specific goals on environmental standards to be achieved within certain period of time	Li (2007)
Climate change	Changes in global and regional climate patterns resulted from unsustainable human activities	Zaman (2013); Johnson et al. (2011)
Geographical landform	Different features of the part of the earth which makes the terrain	Li (2007)
Local weather	Specific weather conditions at a particular place and time	Emery et al. (2003)
Environmental awareness	Awareness on the adverse impacts onto the environment resulted from unsustainable human activities	Triguero et al. (2016); De Feo and De Gisi (2010)

TABLE 3: Social factors in SWM: the functionality of humans and their responses towards changes in waste management.

Factor	Description	References
Seasonal variations	Specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not be officially recognized by the government	Gómez et al. (2009); Emery et al. (2003)
Religion	System of faith and worship	Taherzadeh and Rajendran (2014); Mohamad et al. (2012); Mohamad et al. (2011)
Cultural	Social behaviour, belief, traditions of particular group of people	Thyberg and Tonjes (2015); Martin et al. (2006)
Ethnicity	A particular group of people with same races, religious and origin that may have different culture from other groups of people of a country	Perry and Williams (2007)
Local/national events	Special days of celebration include national holidays, commemoration and also racial or ethnic affiliation which are officially recognized by the government	Gibson and Wong (2011)
Discrimination	Unfair treatment of individuals or groups of people	Ma and Hipel (2016); Sembiring and Nitivattananon (2010)
Socio-economic indicators	Changes in particular demographic components which are measured periodically	Triguero et al. (2016); Pickerin and Shaw (2015); Contreras et al. (2010); Wilson et al. (2001)
Resource consumption patterns	Changes of natural resources use for human activities within particular period of time	Taherzadeh and Rajendran (2014)
Shared norms	Rules of behaviour that are considered acceptable in group of society	Binder and Mosler (2007)
Rural-urban daily migration	Movement of people from rural to urban areas on a daily basis, mainly due to the economic and tourism activities	Henry et al. (2006)
Philosophical change	The evolving thoughts and feelings on particular issues that reflected in the changing in behaviour	Wilson et al. (2001)
Attitude-behaviour relationship	The relationship between an individual's values or intentions and their actions	Triguero et al. (2016); Taherzadeh and Rajendran (2014) ; Barr (2007)
Resistance to change	Response(s) of individuals or groups of people when they perceive or interpret change as a threat to them	Taherzadeh and Rajendran (2014)

TABLE 4: Technological factors in SWM: the ability to apply suitable technology towards the improvement of waste management.

Factor	Description	References
Skilled workers; experts	Workers with specific knowledge, skills and ability to perform best in their work; those who are widely recognized as a reliable source of technique and skills	Periathamby et al. (2009a)
Application of suitable technology	Application of the appropriate technology that is best designed for efficient operation	Taherzadeh and Rajendran (2014) Contreras et al. (2010) Wilson et al. (2001)
Facilities availability	Adequate number of facilities are developed for specific deployment	Taherzadeh and Rajendran (2014)
Rate of technology change	Development of waste management-related technology over time	Zaman (2013)
R&D Activities	New or innovative research that changes facilities, management and practices	Periathamby et al. (2009a)

TABLE 5: Legal factors in SWM: the attributes and obligations of local authority and as institutions responsible to comply with waste management guidelines..

Factor	Description	References
International directives	Environmental guidelines and instructions drafted by international organizations to create uniformity and consistency	Contreras et al. (2010) Rudden (2007)
Local policy	Policy that sets guidelines that determine the decision and actions	Taherzadeh and Rajendran (2014)
Producer responsibility	Approach taken by the producers in managing waste	Triguero et al. (2016)
Consumer accountability	Responsibility of consumers in buying and consuming, and managing waste arisings	Triguero et al. (2016)
Relevant SWM law	Compliance and enforcement of the law	Contreras et al. (2010) Bai and Sutanto (2002)

TABLE 6: Economic factors in SWM: the ability of economic status to determine the marketability of recovered materials and waste products.

Factor	Description	References
Potential income from waste	Monetary benefits from waste	Taherzadeh and Rajendran (2014)
Trade restrictions on waste	Limitation on trade activities to selected waste	Ray (2008)
Third sector restrictions	Limitation on trade activities to informal business and/or charitable organizations	Williams et al. (2012)
Availability of funds	Financial assistance available for projects or initiatives	Taherzadeh and Rajendran (2014) Wilson et al. (2001)
Interest and tax	Application of interest and tax on goods and services	Jones et al. (2010)
Economic growth patterns	Changes in the amount of goods and services produced per head of the population over a period of time	Johnson et al. (2011)
Incentives	Rewards offered for appropriate or desired actions	Jones et al. (2010)

all respondents; the majority view was that government priorities, government stability and bureaucracy were visible. The accountability of leaders was viewed as visible and invisible by a similar proportion of respondents, whilst the majority of respondents considered corruption and the influence of politicians to be invisible factors (Figure 1). These observations (Figure 1) illustrate the importance of government in setting the focus and direction in future development of waste management. The experts consulted in the Delphi survey highlighted the visibility of both local government plans and government priorities in relation to waste management. It can be argued that in developing countries, there is a relatively high dependency on government to facilitate proper waste management services and facilities. Most respondents (70%) considered bureaucracy to be a visible factor in waste management (Figure 1). Bureaucracy, whilst often a visible factor, can exert negative impacts if, for example, administration procedures are excessively complicated; unnecessary procedures and approval processes can cause delays in decision-making and implementation.

Government stability was considered by most respondents (61%) to be visible (Figure 1). Changes of government can clearly influence plans and their implementation at local to national scale. Stable government and related institutions allow establishment and maintenance of good relationships between politicians and authorities, ensuring better co-ordination of efforts in planning and development of efficient waste management services. Less stable government can generate uncertainty within the governmental institutions and disrupt decision-making and executing of waste management plans.

TABLE 7: Classification of Delphi survey participants' current location and national economic status.[1]Economic status determined by the gross net income (GNI) per capita per year (World Bank, n.d.); [2]GNI per capita of <$1,025; [3]GNI per capita $1,026 to $4,035; [4]GNI per capita $4,036 to $12,475.

Participants' location	Economic status[1]
Mozambique	Low income[2]
Tanzania	Low income[2]
Togo	Low income[2]
South Africa	Upper-middle income[4]
India	Lower-middle income[3]
Indonesia	Lower-middle income[3]
Malaysia	Upper-middle income[4]
Vietnam	Lower-middle income[3]
Argentina	Upper-middle income[4]
Brazil	Upper-middle income[4]
Peru	Upper-middle income[4]

The accountability of the leaders was classified by 53% of respondents as invisible. Measuring the qualities of leaders is inherently subjective. Changes to waste management cannot be readily or reliably attributed to the contributions of individual leaders; efforts of government authorities in improving waste management are generally cumulative, arising from multiple contributions from many individuals. There may, however, be some attribution of broad-scale outcomes to leaders who have taken a key role in developing a waste management strategy, most likely at a local scale. Although fewer respondents considered corruption to be visible than did bureaucracy, these two factors may be interlinked; excessive bureaucracy can precipitate corruption. It is arguable that corruption, antagonistic politics and bureaucratic procrastination commonly exist in developing countries' government systems, which influence the decision-making and stakeholders' involvement in relation to SWM policy and practice. Corruption is more likely to occur when partnerships and relationships are poorly designed or defined; the efficiency of the networking then becomes inefficient (Taherzadeh and Rajendran, 2014).

With regard to politicians influencing decision-making and implementation of waste management systems, most respondents (69%) considered this to be an invisible factor (Figure 1). Influences of politicians can be notable, however. For example, following Malaysia's General Election in 2008, the change in political leadership led to the challenge for the federal government to implement finally the Solid Waste Management Act 2007. Following the result of the election, a contrast in political relations emerged between (i) states in the same political coalition as the federal government and (ii) states ruled by the opposition party and

not aligned with the federal government. Changes of leadership in some of the states had caused the non-uniformity standards of waste services that led to problems in some areas.

3.3.2 Environmental factors

Many of the environmental factors (Table 2) are considered to be visible by survey respondents. Environmental guidelines and environmental targets were highlighted as visible by the majority of respondents. Clear guidelines and targets on environmental aspects are vital for improving SWM: guidelines should provide procedures and methodologies for monitoring and enforcing the regulations; targets must be achievable and realistic to drive initiatives towards improvements. The importance of geographical landform on the development of SWM systems is also considered visible by most (70%) respondents. Vehicle-based collection in less accessible areas in developing countries may inhibit expansion of service areas in less reachable, mainly rural areas: some facilities, social and economic activities depend on the suitability of transport infrastructure. Spatial variation in this regard requires understanding of the local situation in order to plan for a workable and efficient waste management system. The quality and coverage areas of waste collection services in some of developing countries differ between urban and rural areas, which may explain the observed split between respondents considering geographical landform visible and invisible (Figure 2).

Environmental awareness was seen by most respondents as a visible factor (Figure 2): awareness underpins waste behaviour that can contribute to more sustainable SWM. The importance of having a population that is well-educated regarding environmental and waste management issues is thus highlighted and confirmed as commonly recognised and incorporated in SWM systems and approaches. This outcome is notable: enhancing awareness of good waste practices and sustainability has been stated as a key challenge in SWM in developing countries (Ferronato et al., 2017; McAllister, 2015; Storey et al., 2015). With environmental awareness commonly viewed as visible (Figure 2), there is potential to increase further awareness among public in developing countries to further progress initiatives towards sustainability in SWM.

Notably, Delphi respondents indicated that climate change is more commonly invisible than visible (Figure 2); less than one third of respondents regarded climate change as a visible factor in SWM. This observation is somewhat at odds with the general recognition of climate change as a major and global environmental problem for the waste sector (Turner, 2016). Omissions of climate change from visible factors in SWM policy and practice renders the impacts of SWM on climate invisible and can lead to decision-making that fails to reduce or even propagates waste-related climate change impacts.

3.3.3 Social factors

Respondents' views of social factors in SWM as visible or invisible markedly varied across the factors considered (Figure 3). Resource consumption patterns were regarded as visible by the majority of respondents; economic prosperity is commonly associated with demand for products and materials for consumption which in turn leads to higher demands on effective SWM systems. Experts mainly have considered that consumption patterns are already incorporated in SWM planning and system design. We note that preventing or inhibiting high rates of consumption and avoiding "throw-away" mentality could reduce waste generation by enhancing reuse (Williams and Shaw, 2017). Local/national events were considered to be visible in SWM by most respondents (Figure 3). Celebration of local and national events draws communities together, but can lead to notable quantities of waste that need to be dealt with, requiring additional resources. Seasonal variations were also considered to be visible by most respondents. Such celebrations are typically ethnic, cultural and religious events that occur within specific communities; the associated waste is often generated at a household level. For example, during the Ramadhan and Eid-ul-Fitr celebrations, food waste is generated in higher than usual quantities. Muslims tend to buy more food than their normal require-

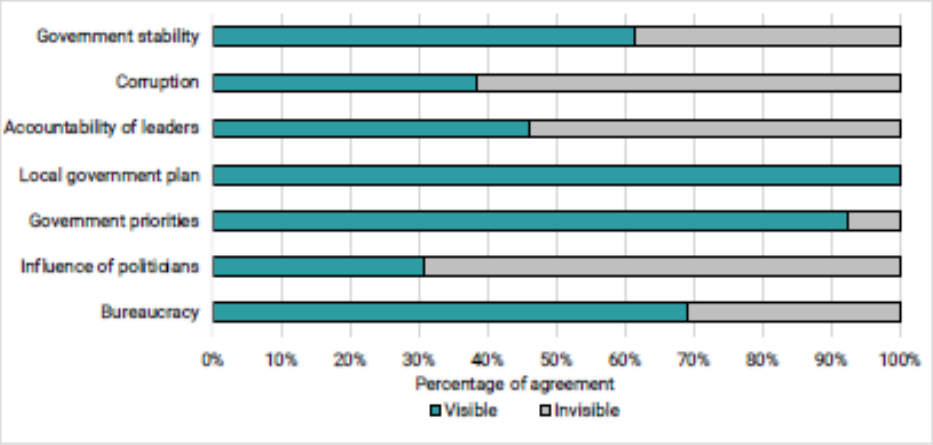

FIGURE 1: Proportions of Delphi survey participants classifying political factors (Table 1) as visible or invisible.

ment for self-consumption and guests; however, with limited time for consumption, food may not be efficiently consumed and ultimately ends up as waste. Changes in waste collection frequency, additional vehicles and workforce are needed in consequence. Likewise, Christmas and Easter celebrations can lead to increases in household waste comprising large proportions of recyclables, such as packaging, wrapping papers, greetings cards, glass bottles and food waste.

Most of the responses from the Delphi respondents identified rural-urban daily migration as a visible factor in SWM (Figure 3). Unequal economic growth distribution between rural and urban areas leads to daily commuting, mainly driven by the economic opportunities and access to education, health, commerce and trade, for example. Although daily migration is already taken into account in many respondents' views, these activities influence the quantities and locations of waste generated in a city and confound estimates of likely waste arisings on a per capita basis. Understanding the influence of daily migration on waste characteristics, generation trends and patterns is non-trivial but nonetheless informs and guides SWM policy and practice in most of the locations represented by the Delphi survey participants (Table 7).

There were five factors classified as equally visible and invisible: cultural, socio-demographic, attitude-behaviour gap, resistance to change, and shared norms. Religion and discrimination were considered to be invisible by most respondents (Figure 3). These factors thus appear to be incorporated in SWM policy and practice on an inconsistent basis. Religion is seen as influential force to transform public practices and behaviour in waste management (Mohamad et al., 2011; Taherzadeh and Rajendran, 2014). Discussions on the influence of religion in waste management, however, are limited and often included within broader sets of socio-demographic indicators (Mohamad et al., 2012). Religion is perhaps not widely considered in SWM systems despite the potential of religious organizations to assist in transforming the public's waste behaviour. Likewise, cultural factors and ethnicity may present opportunities to transform waste management behaviour through social groups and communities, although the visibility of these factors varies between settings according to the Delphi survey responses in this study (Figure 3). We note that factors are not necessarily mutually exclusive: ethnicity may, for example, be associated with cultural and religious factors and their related behaviour and values regarding resource consumption and waste management. We note that although culture, religion and ethnicity may well be closely associated, cultural factors are more commonly recognised and incorporated in SWM (Figure 3).

Discrimination was viewed as a visible factor in SWM by around 1 in 6 Delphi respondents. This is perhaps a weakness in many settings: urbanization and economic growth lead potentially to inequality, harassment and exclusion due to individuals' low social status. The few studies on this issue have highlighted, for example, discrimination of female SWM workers in developing countries (Ma and Hipel, 2016; Nunn, 2012), informal recyclers (Mull, 2005; Sembiring and Nitivattananon, 2010) and racism and social status of communities (Baabereyir, 2009). The intrusion of political agenda in solid waste management hindered the occurrence of social injustice which make discrimination factor is least considered.

3.3.4 Technological factors

Most, but not all, Delphi respondents considered all technological factors to be visible (Figure 4). This outcome highlights the importance of available and suitable facilities for waste management activities that lead to positive waste management behaviour among the public and improve operational efficiency. A lack of suitable facilities can contribute to stagnation or decline of local SWM efficiency, whilst availability of appropriate facilities can motivate public participation. Suitable facilities for SWM also permit resource recovery from the waste stream and thus contribute to more sustainable resource use.

The needs for skilled workers and experts are commonly regarded as visible factors in SWM in developing countries; pertinent skills and expertise can enhance and improve initiatives for and operations of SWM. In contrast, an inadequate skills base can lead to inaccurate waste

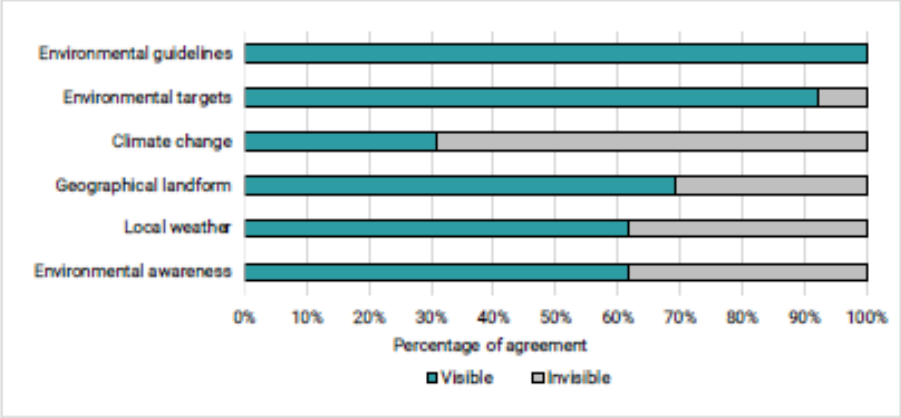

FIGURE 2: Proportions of Delphi survey participants classifying environmental factors (Table 2) as visible or invisible.

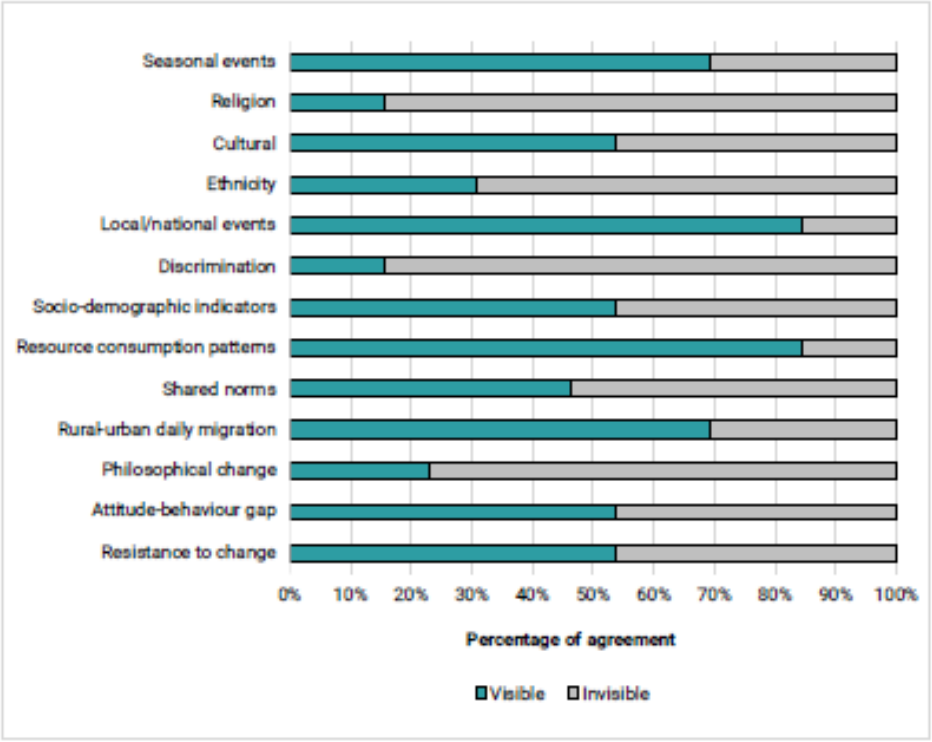

FIGURE 3: Proportions of Delphi survey participants classifying social factors (Table 3) as visible or invisible.

projections and ineffective planning. There are relatively few academic studies that have evaluated the importance of skilled workers and experts in developing sustainable waste management plans (Dinie et al., 2013; Hazra and Goel, 2009; Moh and Abd Manaf, 2014); there is thus a contrast in that knowledge appertaining to skills and expertise is somewhat poor, whilst skills and expertise are commonly incorporated in SWM. We note that waste management involves both technical and non-technical disciplines; therefore, skilled workers can contribute to the efficiency of operational issues. Optimizing the recovery of materials from the waste stream and reducing the maintenance cost of facility operation by proper handling of the waste treatment facilities, for example, relies on a suitably skilled workforce. Most Delphi survey respondents identified application of technology in waste management as a visible factor. Technology can conveniently and efficiently support the SWM systems, for example, when applied to waste treatment operations and recovery of resources from the waste stream. Developing countries, as indicated by the survey respondents, differ in terms of whether changes of technology and research and development are visible. There is a relative lack of financial assistance and allocation of funds for developing technology for SWM in developing countries. The lack of research and development activities in developing countries can lead to the selection of technology that is inappropriate in terms of local weather, waste characteristics, financial capabilities and availability of experts and skilled workers. Consequently, the selected technology may not operate effectively (or at all), thus wasting the resources allocated and causing social indignation.

3.3.5 Legal factors

Legal factors were all significantly classified as visible by the majority of respondents (Figure 5). Relevant SWM law and local policy are both considered visible factors by more than 95% of respondents.

Outcomes in this regard reflect the status of local government plans and government priorities as visible factors in SWM (Figure 1); laws derive in part from political ambitions and purpose. In developing countries existence of local government plans is clearly important and is already incorporated in SWM systems, as is relevant SWM law. Most respondents considered that accountability of consumers is a visible factor; management of post-consumer waste and producer responsibilities are key aspects. International directives were considered to be visible by most respondents; international directives on sustainability of waste management do not always apply and this situation is reflected in the responses received in this instance.

3.3.6 Economic factors

All of the economic factors considered were viewed by most respondents to be visible factors in SWM (Figure 6). Waste trading between developed and developing countries became an alternative solution to disposal for developed countries. This "symbiotic" relationship was appar-

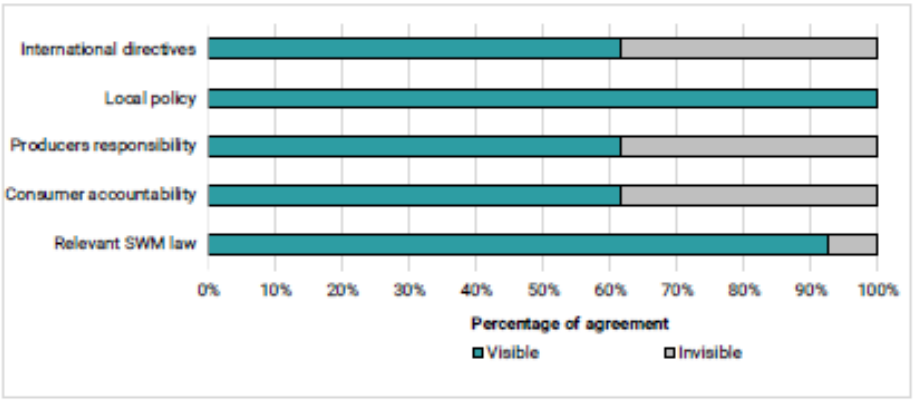

FIGURE 4: Proportions of Delphi survey participants classifying technological factors (Table 4) as visible or invisible.

ently beneficial to both partners; developing countries were generating income from recovery of resources from waste whilst developed countries benefits secured reduced disposal and treatment costs. However, this rapidly led to immoral and unethical practices that resulted in impacts to human health and the environment in developing countries. The strong agreement on the importance of available funds allocated for waste management projects was observed in developing countries with undivided agreement of 100%. Developed countries have more sources of financial support to develop their waste management systems when compared to developing countries (Periathamby et al., 2009b; Wilson, 2007; Wilson et al., 2001). Incentives for the use of selected waste management processes/systems were viewed as motivational tools to reward good practice. The importance of offering incentives to improve further a waste management system was highly recognized and visible, which more than 85% of agreement from developing countries.

A similar pattern of agreement was observed regarding the implementation of tax and interest on waste trading and also the potential income generated from waste due to the public's waste practices. Respondents from developing countries had slightly less concern regarding the importance of these factors in their waste system, which was an unexpected finding given by the rapid growth of business activities relating to waste trade and resource recovery in developing countries like China and Indonesia (Damanhuri and Padmi, 2012; Hui et al., 2006). Emphasis on the investment in facilities and improvements in waste management services can be observed alongside rapid economic growth in developing countries. With a stronger economy, the consumption of the resources increases alongside waste generation and this obviously influences emerging waste management systems. The importance of economic growth is very significant in developing countries with 78% agreement from respondents. Overall, all economic factors were classified as visible, validating the importance of a strong economy to accelerate improvements to SWM systems.

4. CONCLUSIONS

This study highlights fundamental factors in SWM and classifies them into two broad categories; visible and invis-

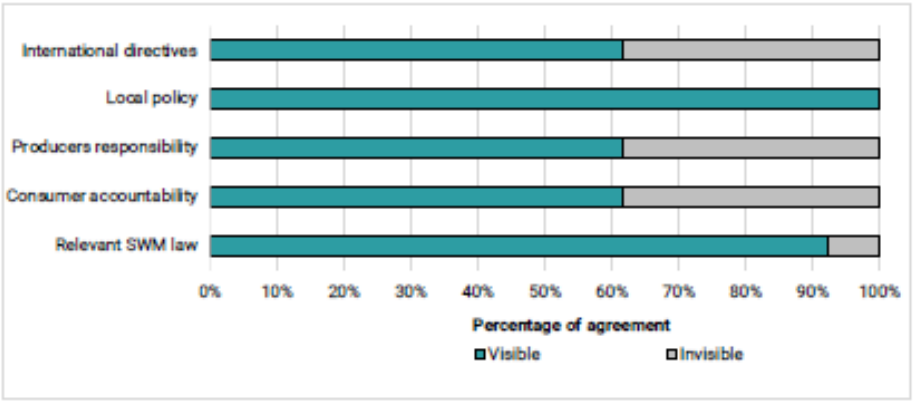

FIGURE 5: Proportions of Delphi survey participants classifying legal factors (Table 5) as visible or invisible.

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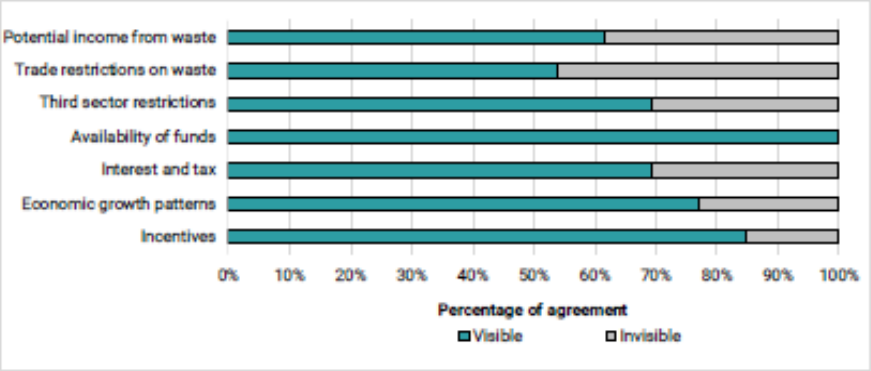

FIGURE 6: Proportions of Delphi survey participants classifying economic factors (Table 6) as visible or invisible.

ible, grouped using a PESTLE framework. From our Delphi survey, we concluded that environmental, technological, legal and economic factors tend to be classified as visible while social and political factors are generally regarded as invisible in developing countries. The recognition of, and emphasis on, invisible factors that are not routinely or commonly considered could potentially enhance the sustainability of a local waste management system. Sustainable waste management requires, for example, appropriate public waste management practices and participation: there may be a need to address social factors (e.g. Table 3; Figure 3) that are deemed invisible if public attitudes and behaviours are to lead to more and better participation in waste management activities and initiatives. Likewise, in terms of governance, there are often overlapping responsibilities and unclear assignment of responsibilities for tasks relating to solid waste management in developing countries. This situation can hinder the effective implementation of SWM improvement initiatives, thus political factors may be more fully considered in the waste management planning in order to accelerate improvements towards effectiveness, efficiency and (economic and environmental) sustainability.

On the basis of this study's outcomes, we propose that understanding the factors that drive the development in waste management systems in developing countries needs to be underpinned by evidence that is not only limited to waste management system, but also involves the characteristics of broader society, government administration and economic status of each country/city. Moreover, fundamental factors elucidated here may have to be considered in the local context to be effective; emphasis should be placed on those factors (if known) that most strongly influence the local conditions. For example, cities with diverse ethnic groups within their community might consider the differences in cultural and lifestyles of each ethnic group in terms of waste behaviour, resource consumption and awareness of waste management practices. In less diverse countries, any differences in waste-related behaviour among different ethnic groups may not appear to be important and may not be an important consideration in waste management plans and systems. It is possible that approaches to setting up waste collection systems, selecting suitable treatment methods and public awareness-raising campaigns need to take visible and invisible factors into consideration in order to reach optimum results.

The strength of influence of factors explored in this study – visible or invisible – remains to be elucidated. There is a prospect that the influence of invisible factors in particular is unique to specific setting of waste management systems at local scale, and that approaches to SWM that are workable in developed countries may not translate with guaranteed success to developing countries due to the differences in socio-cultural, economic and political structures. Even established technologies used in developing countries may not be suitable for other developing countries without modifications underpinned by detailed study and evaluation, and due recognition of both visible and invisible factors. Identification and emphasis of the role of invisible factors potentially helps to accelerate the improvement to success.

We contend that the visibility of factors needs to be evaluated to achieve a meaningful understanding of the factors underpinning the operation and enhancement of SWM. Moreover, there is a need to elucidate the strength of influence that these factors exert on the on a SWM system such that progress towards cost-effective, efficient, locally optimised sustainable waste management systems can be made.

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Appendix D3:

Paper title: Mukhtar, E.M., Williams, I.D., Shaw, P.J., Ongondo, F.O., 2015. Evolution of waste management systems in developed and developing cities, in: 15th International Waste Management and Landfill Symposium. CISA Publisher, 5-9 October 2015, Sardinia, Italy.

EVOLUTION OF WASTE MANAGEMENT SYSTEMS IN DEVELOPED AND DEVELOPING CITIES

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SUMMARY: Developing countries have historically looked to developed cities for technical advice and as exemplary models for waste management systems and techniques without considering the consequent resources requirements or the key characteristics of local circumstances. This paper reviews the history of urban waste management in London and Kuala Lumpur, representing developed and developing cities, respectively, focusing on the integration of policy changes, social-economic background and waste data trends. We discuss how waste management policies and strategies have evolved and the linkages between policy interventions and chronological waste data trends. A detailed understanding of how waste management systems evolve can provide new perspectives and insights; this is important in the current era as waste management is undergoing a paradigm shift, refocusing on sustainable resource management rather than sustainable waste management.

1. INTRODUCTION

Urbanization, rapid economic growth and increasing urban populations have resulted in a significant escalation in quantities of waste generated, heterogeneity and complexity (Guerrero et al. 2013; Periathamby et al. 2009). Rapid economic growth has led to higher income levels and consequently changed people's quality of life and lifestyles. Resource consumption patterns have increased alongside purchasing power and the affordability of essential daily items and services. In many countries, waste management systems have evolved alongside the socio-economic circumstances of a nation. Inadequate waste management has impacted adversely on public health (Saffron et al. 2003) and also caused environmental degradation and resource depletion (Emery et al. 2003). The challenge of designing localised waste management strategies that are economically viable, environmentally effective and socially acceptable continue to be major concern to municipal authorities (McDougall et al. 2001; Hara & Yabar 2012). Developed cities started to initiate their waste management strategies early in the 18th century as awareness of public health issues and the value of resources emerged (Kollikkathara et al. 2009; Louis 2004; Velis et al. 2009). There are clear differences in waste management systems between developed and developing countries; for instance, Wilson (2007) and McDougall et al. (2001) highlight that waste management practises in developed cities now focus on optimization strategies for resource conservation. Approaches to

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S. Margherita di Pula, Cagliari, Italy; 5-9 October 2015

waste management in developing cities are often characterised as highly underdeveloped (Badgie et al. 2012), operationally inefficient, and inadequately managed with limited knowledge and expertise (Zurbrügg & Schertenleib 1998; Guerrero et al. 2013). These distinct gaps have led to an urgent need for developing cities to seek guidance and advice towards shaping waste management systems that are workable and acceptable in local scenarios.

Integrated waste management can be applied in both developed and developing cities depending on local circumstances and preceding factors that influenced the initiatives taken (Asase et al. 2009). Developing countries have historically looked to developed countries as exemplary models for waste management systems and techniques. However, when trying to select a suitable, long-lasting and sustainable approach to waste management, it is important that decision-makers: i) understand the local scenario, ii) evaluate the adaptability of management systems and practices from developed countries, and iii) consider the consequent resource and logistical requirements, including human and technical resources. Previous studies addressed the evolution of waste management systems from the viewpoints of societal background (Louis 2004), policy design (Jenkins et al. 2008), technological development and system innovations (Murray et al. 1998) and single country or city's experiences (Seik 1997; Kollikkathara et al. 2009; Che et al. 2013; Hara & Yabar 2012; Herbert 2007; Shekdar 2009). To facilitate the improvement of future systems, there is a need to compare the simultaneous evolution of waste management systems between developed and developing cities in a comprehensive manner, particularly relationships between socio-economic development, strategy/policy changes and waste arisings.

The purpose of this paper is to review the history of urban waste management in developed and developing cities, focusing on the integration of policy changes, socio-economic background and waste data trends. In this context, we specifically appraise historical evidence over a 50 year period from 1960 to 2010 for London and Kuala Lumpur, representing developed and developing cities, respectively. Evolution of waste management systems are examined in terms of waste generation, composition, collection system, disposal methods, recycling and waste strategies implemented. We discuss how changes in societal circumstances and behaviour correlate with indicators of waste management systems over time and provide insights into how future waste management systems may evolve, especially in developing cities.

2. STUDY CITIES: KUALA LUMPUR AND LONDON

2.1 Background of the city of Kuala Lumpur, Malaysia

Kuala Lumpur developed after its formation at the convergence of the Klang and Gombak rivers in the 1850s and was discovered by the Chinese for tin mining during British occupation. Frank Sweetenham, the Resident General of the British Commission in Malaya[1] had announced the relocation of the central government from Klang to Kuala Lumpur, which marked the beginning of significant British influence in Malaya. After World War II, British Military Administration returned to Kuala Lumpur following the fall of the Japanese from 1942 until 1957 when Malaya finally gained its independence (Lockard 2013; Baker 2006). In 1963, Malaysia formally reformed, consisting of Malaya, Borneo, Sarawak and Singapore.

Kuala Lumpur is the largest city in Malaysia and became the capital of Malaysia in 1963. It was awarded with city status in 1973 and recognized as Federal Territory in 1974 (Omar & Ling 2009). The governmental system are divided into three tiers; the federal, the state and the local government. The rapid growth of the city is due to a combination of industrialization and political

[1] Malaya (or British Malaya) was the name given to a collection of states on the Malay Peninsula and the island of Singapore that fell under British control between the 18th and 20th centuries.

interventions via an expansion of the combined federal and state government services (Evers & Korff 2003). With an area of 243km^2 and an estimated population of 1.6 million in 2010, Kuala Lumpur is ranked as the 49th largest urban area and is growing rapidly in terms of population and economy (Demographia 2015). The city's population rose from 46,718 in 1911 to 316,230 in 1957, driven by the expansion of the tin mining industry in the late of 18th century (Sendut 1965). In the 19th century, Malaysia experienced a significant socio-economic and physical transformation, with the introduction of new policies in 1970s which nourished the further economic growth in the 1980s. At the end of the 20th century, spectacular mega-buildings were constructed and exports of goods increased dramatically, leading to massive urbanization in metropolitan areas, especially in the city of Kuala Lumpur (Teriman et al. 2008). Economic prosperity and strong economic policies encouraged an influx of foreign labour and investors to the city (Wan A Kadir 1997). Along with economic growth, more land was converted into commercial and industrial areas, which coincided with migration from within the city to suburban areas at its fringes (Teriman et al. 2008). Furthermore, relocation of government administration offices to Putrajaya in 2000 made way for Kuala Lumpur to continue centre-stage in national developments with potential mega-projects involving government-linked conglomerates and foreign investors.

2.2 Background of the city of London, United Kingdom

London is one of the world's most influential economic and financial capitals. Historians believed that London first developed as trading port near the Thames River during the Roman occupation in 47 AD. London evolved physically in response to the significant events that impacted the city's structure and demographic patterns, for example, The Great Fire of London (1666) and bombing during World War II that destroyed major residential area in the city (Ween 2012). Despite massive destruction, London grew dynamically to become a major trading and global banking center by the late 16th century. The key to the London's fame is its role at the center of the British Empire (Porter 1998). Apart from economic development, the British Empire expanded its influences globally through the occupation of other countries, mainly for economic and trading purposes rather than military conquest. During the Industrial Revolution in the early 19th century, the development of railways and underground systems shaped the social and economic growth of London (Haywood 1998). In the early 1900s, London continued to sprawl outwards; this raised concerns about land encroachment on neighbouring counties which led the establishment of the Green Belt Act[2] in 1938. The Greater London Plan was then established in 1944 to control population expansion and improve housing conditions as part of the development plan of the city. After World War II, Greater London's population declined from 8.6 million in 1940 to 6.8 million in 1980. However, it began to rise again in 1990 due to the strong economic restructuring and social adjustment. The administration of London today is two-tiered: city-wide - managed by the Greater London Authority (GLA) - and local administration, carried out by 33 smaller authorities. In 2007, London was responsible for 19% of the United Kingdom's annual gross domestic product (GDP) and contained 12% of the total population (Oxford Economics Ltd. 2007). London's current challenges include an ageing and outdated city plan that is struggling to synchronize with ongoing urbanization and population expansion.

[2]The Green Belt Act (Home and Counties) aimed to curb urban sprawl by establishing reserve land and space against harmful development (Thomas 1963).

2.3 Linkages between both cities

2.3.1 British colonialism and its impacts

After being colonised by the British for more than 300 years, it is irrefutable that there has been a strong British influence on the administrative systems in Malaysia (Lockard 2013; Wan A Kadir 1997). The most significant and lasting impact of British colonialism is the development of stable government and democracy, similar to the administrative systems in the UK. A modern Western-centralized government and strong economic development remain as among the great impacts of British rule on Malaya. Modern infrastructure was developed to feed the economic growth. Inspired by the British Education System, English-medium schools were established and these successfully created highly-educated people who were mostly government officers and leaders that led Malaya to independence (Baker 2006).

2.3.2 Commonwealth of Nations

The Commonwealth of Nations was formally formed in 1949 to gather countries that were being ruled or colonised by the British Empire. The highest priority of the Commonwealth was to promote democracy, rule of law, human rights, good governance and social and economic development (The Commenwealth 2015). Malaysia has been an active member of the Commonwealth since 1957 which has facilitated the maintenance of a British-modelled government administration and global diplomatic relations.

2.3.3 City's expansion pattern

During the 18th century London's population and area grew beyond its original boundaries and caused an urban sprawl[3] to neighbouring counties. Administratively, the city expanded into 32 boroughs in which 12 were designated as Inner London and the remainder as Outer London. Similar rapid development in 1980s Kuala Lumpur when residential areas were converted into commercial and tourism centres forced the urban population to move out from the city. Inspired by the London's Green Belt initiative, Kuala Lumpur took similar steps to relocate government administrative offices (to Putrajaya) to reduce overcrowding and increasing demand for space and resources in the city. High density development led to compact urbanisation that caused skyrocketing prices for residential properties, whereby the preferred option was to develop sub-urban housing due to lower land value yet higher demand (Teriman et al. 2009).

3. SOURCE OF DATA

In this study, 3 key indicators have been selected to illustrate changes and trends; population and economic growth which has been correlated with waste arising over the period 1960 to 2010. Population growth rate is the increase in a country's population during a period of time, and includes the number of births and deaths and the number of people migrating to and from a country (The World Bank Group 2001). Economic growth is determined by the performance of annual Gross Domestic Product (GDP) by market value of products and services in a country. Data on population growth and GDP for both cities were mainly gathered from the World Bank's databank on global development indicators (World Bank 2015). Table 1 shows the sources of data used in this study.

Whilst there are various definitions of solid waste, the most common factor is a reference to the

[3]Urban sprawl describes the expansion of urban development and population away from the central to suburban and low density area as a result of urbanization in the city (Banai & Depriest 2014).

materials that have been discarded or are unwanted and need to be disposed of (Pongrácz & Pohjola 2004). In the UK, waste is defined in the Environmental Protection Regulations (1991) according to the European Union (EU) Directive 91/156/EEC as "any substance or object in the categories set out in Annex I[4] which the holder discards or intends or is required to discard" (Department of Environment Food and Affairs 2012).

Table 1. Data used as basis for estimating waste arising, trends and composition changes in Malaysia and the United Kingdom during 1960-2010.

	Years	*Data characteristics*	*References*
Malaysia	1970 - 1980	Waste arising	Periathamby (2001)
	1990		Hassan et al. (2000)
	2000 - 2010		Periathamby (2014)
Kuala Lumpur	1970 - 2010	Waste arising	Periathamby (2014)
	1970 - 2000	Waste composition	Periathamby (2001)
	2010		Mohd Yatim & Arshad (2010)
United Kingdom	1970	Waste arising	Holmes (1981)
	1980		Wasteonline (2004)
	1990		OECD (2002)
	2000		Timlett (2010)
	2010		Audit Commission (2014)
London	1970	Waste arising	Estimation value
	1980		Estimation value
	1990		Greater London Authority (2003)
	2000		Greater London Authority (2011)
	2010		DEFRA (2014)
	1970	Waste composition	Holmes (1981)
	1980		Kadir (1997)
	1990		Murray et al. (1998)
	2000		Poll (2004)
	2010		Greater London Authority (2011)

Likewise in Malaysia, the general terms of waste is defined in the Solid Waste Management and Public Cleansing Act (2007) as:

(a) any scrap material or other unwanted surplus substance or rejected products arising from the application of any process;

(b) any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled; or

(c) any other material that according to this Act or any other written law is required by the authority to be disposed of, but does not include scheduled wastes as prescribed under the Environmental Quality Act 1974 [Act 127], sewage as defined in the Water Services Industry Act 2006 [Act 655] or radioactive waste as defined in the Atomic Energy Licensing Act 1984 [Act 304]" (Malaysia Government 2007)

In this paper, waste generated within municipal boundaries is taken into account. The data was analysed within a period of 50 years, starting from 1960. Standardization of the data is almost impossible with some missing data observed due to unavailability of data. In order to provide better comparisons, data for waste generation was grouped into the same timeline.

[4]Annex 1 in Directive 91/156/EEC contains a list of 16 different categories of waste, mainly be used to determine whether or not a substance or object have been discarded

4. OVERVIEW OF HISTORICAL WASTE MANAGEMENT

Waste generation trends and composition can portray information required for future planning (Beigl et al. 2008). Historians believe that environmental knowledge and developed strategies about earlier civilisations can be gained by examining waste profiles and trends over time (Hounsell 2009; Kollikkathara et al. 2009). As cities become modernized, massive amounts of waste with increasingly complex composition were produced from diverse sources. As national GDP increases, per capita waste generation also increases, suggesting huge waste generation at high GDP in the future (Terazono et al. 2005). Table 2 summarizes the population growth and waste arising for London and Kuala Lumpur over 60 years. After independence, Kuala Lumpur relished the economic prosperity that significantly changed lifestyles. The expansion of the manufacturing sector inspired Malaysia's economic growth; however, consequences of economic activities on the environment triggered public anxiety about waste arising and means of disposal throughout the 1980s.

London was the first city to establish formal door-to-door waste collections by 1900, a similar system to that still applied today. With more complex challenges to manage waste in London, the inherited systems failed to meet the consequences of overwhelming economic growth and population expansion (Parfitt 2010). The overall system evolved in response to the high fraction of coal ash in municipal waste that had potential market value. The Public Health Act was established in 1848 with the aim of improving public health through proper waste management and provision of clean drinking water. The dust-yard operation reached its peak by the mid-19th century when coal ash prices dropped gradually and changed the waste characterization and composition. Uncontrolled growth in waste arising lead to series of environmental problems and public health issues such as a significant cholera outbreak in 1854 and the "Great London Stink" from the River Thames in 1858.

Table 2. Population trends and waste arising for Kuala Lumpur and London (1960-2010).

	1960s	*1970s*	*1980s*	*1990s*	*2000s*	*2010s*
MALAYSIA						
Population (10^6)	8.16	10.91	13.83	18.21	23.42	28.28
GDP *(billion* USD)	2.44	4.28	24.94	44.02	93.79	247.5
Annual waste generation (10^6 tonnes)	NA	0.11	0.32	5.57	5.69	10.26
National recycling rate (%)	NA	NA	NA	NA	3.00	5.00
Waste per capita (kg/capita/day)	NA	0.03	0.06	0.84	0.67	0.99
KUALA LUMPUR						
Population (10^6)	0.32	0.88	0.92	1.12	1.31	1.62
Annual waste generation (10^6 tonnes)	NA	0.04	0.11	0.21	1.00	1.27
Waste per capita (kg/capita/day)	NA	0.11	0.34	0.52	1.93	2.34
Daily generation (tonnes/day)	NA	98.9	310.5	586.8	2,754	3,800
UNITED KINGDOM						
Population (10^6)	52,807	55,928	56,352	57,808	59,954	61,773
GDP (billion USD)	72.33	130.6	567.1	1,067	1,549	2,408
Annual waste generation (10^6 tonnes)	NA	18.00	22.50	27.10	36.10	32.00
National recycling rate (%)	NA	6.00	6.00	6.00	17.80	43.20
Waste per capita (kg/capita/day)	NA	0.32	1.10	1.36	1.58	1.39
LONDON						
Population (10^6)	7,977	7,529	6,806	6,890	7,215	7,470
Annual waste generation (10^6 tonnes)	NA	2.47**	3.08**	3.82	4.40	4.90
Waste per capita (kg/capita/day)	NA	0.33	0.45	0.55	0.61	0.66
Daily generation (tonnes/day)	NA	6,767	8,438	10,466	12,055	13,425

*NA: Not Available

**Data estimated on 13.7% [5] of total UK waste

4.1 Trends in waste generation, population and economic growth

Generally, waste generation and management have a direct correlation with socio-economic development and human health (Melosi 2004; Louis 2004), degree of urbanization, standard of living and a nation's prosperity (Ogbonna et al. 2007; Walsh et al. 2006). From 1970 to 2010, annual waste generation showed a clear trend of growth, with a striking increase during 1980-1990. The economic activities during the 1970s, under the New Economic Policy (NEP), led to a continued increase in waste generation in 1980s. The Malaysian economy has undergone a transformation over the last 5 decades, driven by increased trade, encouraging domestic demand and financial integration. As a result, GDP in Malaysia grew fourfold during 1970-1980 from the previous decade and continued to double until the 2010s. Hence, it is conceivable that much of the growth in waste arisings can be attributed to GDP growth and population concentration in urban areas. Kuala Lumpur's population increased more than fivefold since 1960 with a maximum increase of 24% in the early millennium. However, waste generation increased faster than population growth in the city; with a striking hike in the 1990s (see Figure 1).

Under such circumstances, the earliest regulations imposed included the Street Drainage and Building Act 1974, Town and Country Planning Act 1976 and Environmental Quality Act 1974, with specific clauses on waste management within the acts (Fauziah & Periathamby 2013). Waste per capita generation in Kuala Lumpur increased from 0.11 kg in 1970 to 2.34 kg in 2010, a 20-fold increase in 50 years. The average household size in urban areas decreased over the study period

[5] Estimation is based on 1990-2010 trend where London's waste contributed approximately 13.7% of total UK waste

with 6.1 persons in 1970 to 4.31 persons in 2010 (Department of Statistics Malaysia 2011). According to Burnley (2001), as household size decreases, per capita waste generation increases, mainly driven by household waste such as mail and newspapers. It is estimated that organic matter contributed the highest percentage of material in household waste composition (Saeed et al. 2009). Kuala Lumpur's population is expected to reach 4.2 million with average daily waste generation of 9,207 tonnes in 2023 (Saeed et al. 2009; Periathamby 2001). Without a proper database, waste generation was estimated; not until the early 1990 was waste generation data captured at a national level.

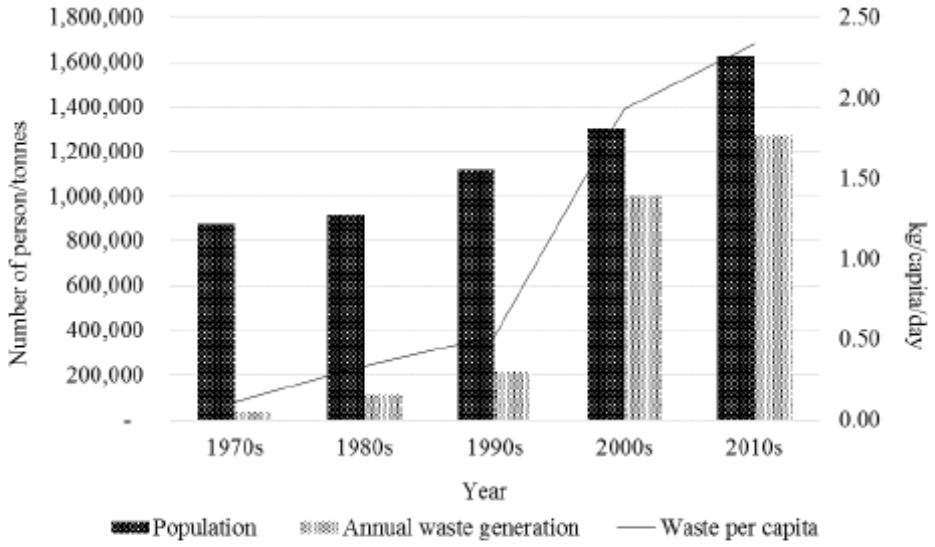

Figure 1. Trends in population, waste generation and waste per capita in Kuala Lumpur.

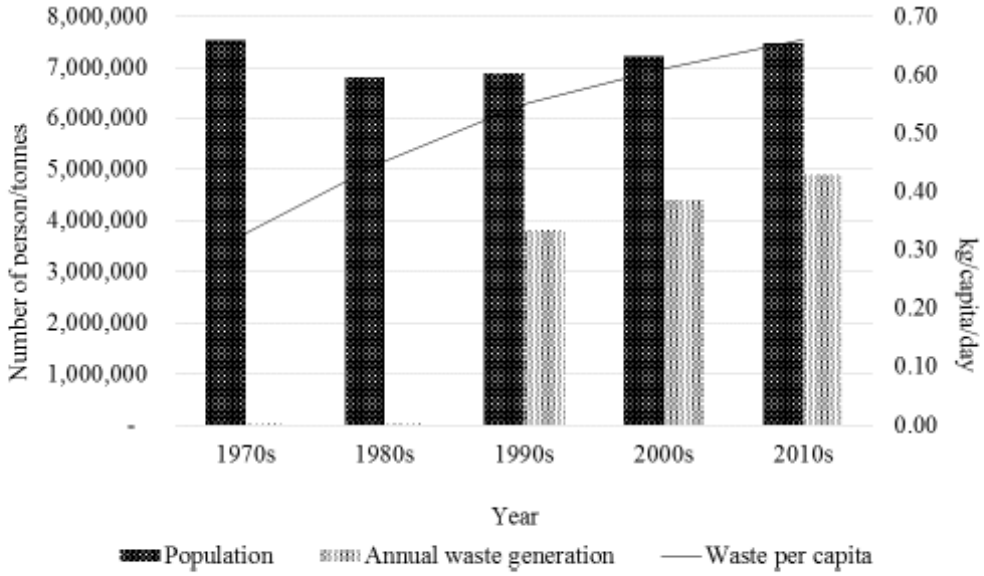

Figure 2. Trends in population, waste generation and waste per capita in London.

Towards the new millennium, UK waste management was mainly influenced by the EU Landfill Directive in 1999 which aimed to prevent and reduce waste, as well as mitigate impacts on human health and the environment caused by landfilling of waste (Timlett 2010). In London, population decline was reported in 1970s-1980s as a result of the city's redevelopment by rebuilding estates into commercial centres thus forcing Londoners to move out from the city (White 2008). Waste arising trends in the UK generally recorded a steady increase from the 1970s to the new millennia (see Figure 2). Along with the implementation of the EU Directive in 1999, aggressive waste minimization and reduction has taken place, reflected in the reduction of waste generation and an increase in recycling rate from 6% to 43%. London's decline in population reversed slowly in early 2000; however, as residential numbers in outer London increased, more daily commuter travel to the city centre for business. The increase in the number of daily commuters in addition to tourists contributed to increased waste generation.

4.2 Waste collection, treatment and disposal methods

Since there is no reported evidence of a proper waste management system before independence, waste disposal methods in Malaysia were probably by burning, burying or deposition into water bodies. Not until the late 1970s was collection, treatment and disposal of waste in Kuala Lumpur under the authority of the Kuala Lumpur City Hall (KLCH). Gradually, upgrading of the facilities was completed in line with the increase in waste generation and concern about the adverse environmental impacts of poor waste management on public health (Periathamby et al. 2009). With the mixture of dwelling types, waste collection was aligned to suit disposal behaviour in terms of the type of container used and source of waste generated. Undeniably, operational costs for waste management increased and became the most challenging issue for the authority. Although there were no direct payments collected from households for waste collection and disposal, the cost has been included in the local tax contribution. KLCH allocated 66% of household assessment fee for waste management services payment to the interim contractors and tipping fees, which is not sufficient for investment in high technology facilities (Ministry of Housing and Local Government 2012). The most common method for waste disposal across the nation is landfilling. In line with the continual increase in waste generation, disposal sites; sanitary landfills and open dumpsites have been developed, usually located far from the city or neighbour city of Kuala Lumpur. Taman Beringin Landfill was the only waste disposal site for domestic and commercial waste located within the city centre and it commenced operation in 1991. Due to the over-forecast of waste generated as the city grew rapidly in the late 1990s, the lifespan of the landfill was shortened and it was closed in 2005. Taman Beringin Transfer Station was developed as an integrated solution for waste disposal and land scarcity in Kuala Lumpur (Ghasimi et al. 2010). The facility commenced its operations in 2002 and provides a modern waste transfer system from the city to a remote landfill located almost 70km from the facility.

Incineration is the preferred disposal method for Malaysia but the high capital investments are not affordable for most developing cities. A few small-scale incinerators were built for research purposes in Malaysia, mostly adopted technology from Europe with customised design to suit local waste characteristics, especially for high moisture content waste. All reportedly failed, mainly due to faulty design or inadequate capacity that caused high operation and maintenance costs (Jereme et al. 2013; Xiang 2012). The government has proposed a mass-scale incineration plant in Kuala Lumpur to reduce dependency on landfill for waste disposal. However, the plan was strongly rejected by the public in view of the potential harm to the environment and human health (Jereme et al. 2013). The government's intention to build an incinerator provides an indicaton of the unsuccessful implementation of previous waste minimisation and recycling efforts.

In London, early garbage removal trucks were simply open-bodied dump trucks pulled by a team of horses. They became motorized in the early part of the 20th century and the first closed-

body trucks to eliminate odours with a dumping lever mechanism were introduced in the 1920s in Britain. Transport and collection costs are most significant elements to be considered in the money matters of waste management. Waste treatment facilities were first operated in London in 1874 with innovative "waste destructors" where waste was burned. Almost a hundred years later, in 1971, the London Ecopark incinerator was launched to handle more than a quarter of London's waste while feeding electricity into the National Grid. However, waste problems in the city keep escalating, and new innovations, such as the development of a vacuum system using underground pipes were under consideration (Ween 2012).

4.3 Waste composition

Coal was the main source of heat and energy in the 18th century to late 20th century in most parts of the UK. Coal ash from household formed the major portion of waste composition in London and after collection, it was sent to the dust-yards to be reused as soil conditioner (Velis et al. 2009). Excessive coal burning during cold weather and coal-fired power station operations in London during the 1950s lead to the Great Smog of 1952[6]. Bridgwater (1986) analysed the general trends of United Kingdom waste from the 1930s to the 1980s, highlighting the appearance of plastic in waste in 1960 as well as a reduction in ash in the early 1970s as a result of a smoke control policy. Materials such as plastics and paper started to dominate waste composition, mainly driven by the packaging of goods. Waste electrical and electronic equipment (WEEE) appeared in the waste stream in the new millennium due to the rapidly emergence of technology, its increasingly affordable price and limited lifespan, driven by in-built obsolescence. The United Kingdom disposed close to 1 million tonnes of WEEE in 2003 with 70% comprising large household appliances (Dalrymple et al. 2007). The share of organic waste increases steadily from 19% in the 1960s to 32% in 2010. Figure 3 shows the composition of waste for London which clearly indicates the transition from the coal ash era to plastic revolution by end of 1980. The implementation of EU Landfil Directive in 1999 changed the focus of waste management in London from disposal to recovery. Biodegradable waste was diverted from landfill due to concern about methane gas released to the atmosphere that contributes to climate change. Therefore, optimization of resource recovery from the waste stream became the popular option and there is a slow move towards supporting the circular economy framework in future.

Figure 4 shows the composition of waste for Kuala Lumpur; the waste composition does not change much over the studied period, with organic waste contributing the largest share. Early waste management in Malaysia generally involved dealing with relatively homogenous waste of organic and major components of recyclable items. Realizing the potential to generate energy from organic waste, the Government introduced organic waste separation at source in 2005 with the vision to develop high technology facilities which include thermal treatment and anaerobic digestion in the future. Yet, the residents were not inspired with the Government initiatives as the facilities development did not complement the awareness campaign, thus leading to a continued increase in organic waste.

[6] Great Smog of 1952 was a severe air pollution event known as modern London's most massive civilian disaster, with 13,000 people had died as a result of the smog (Laskin 2006)

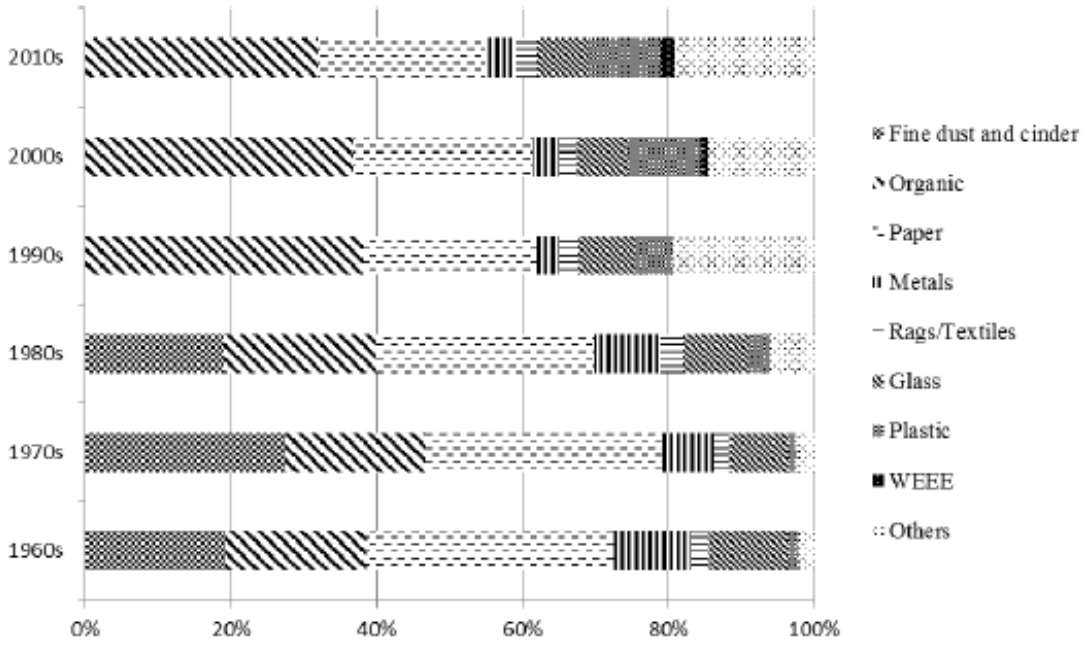

Figure 3. Trends in London waste composition 1960-2010.

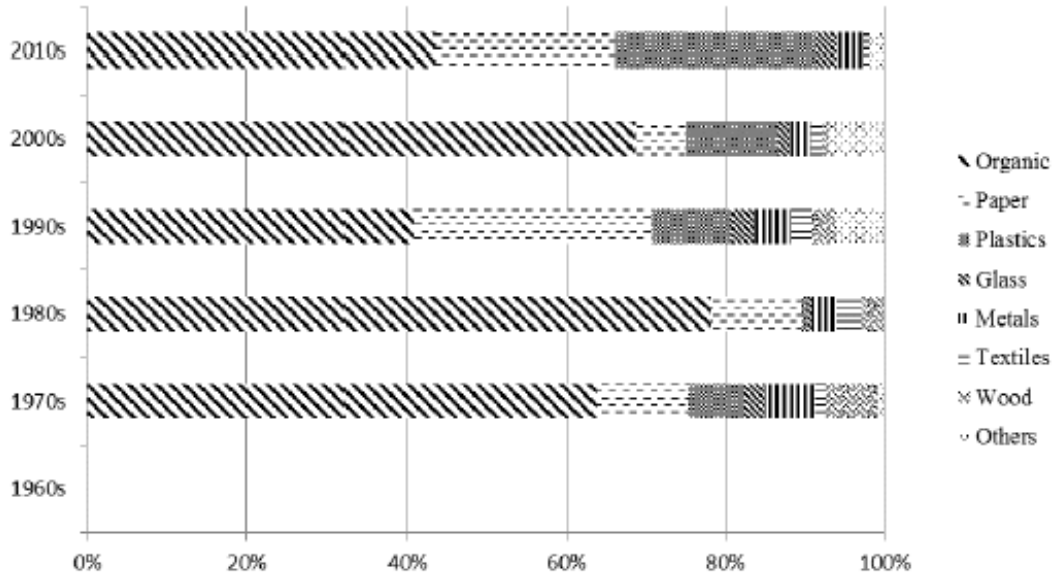

Figure 4. Trends in Kuala Lumpur's waste composition, 1960-2010.

Limited knowledge on plastic recycling and lack of suitable recycling facilities for plastic resulted in the significant increase in the plastic fraction in the waste stream. In addition, due to its durability, cheapness and convenience for daily use, plastics become primary materials for packaging which is easily discarded after single use.

In Kuala Lumpur, night markets have often been preferred by people due to their variety of stalls

and abundance of essential daily needs for sale. They consist of collections of stalls selling a range of goods and foods. Foods available at the night markets are 'ready-to-eat' or prepared-on-demand food which is to be eaten on-site, or takeaways that mainly use single-use plastics for packaging. In general, waste characteristics vary depending on demographic patterns, urbanization rate as well as appropriate focus by the authority to seek the best applicable methods for waste management in the city.

4.4 Waste minimisation strategy and recycling policies

A timeline illustrating the evolution of waste management systems in both cities is shown in Figure 5. The chronological analysis reveals the gradual implementation of waste management initiatives, the challenges faced and the attempted solutions. This analysis in turn indicates how the waste management systems have evolved towards fulfilling public needs alongside rapid economic development and population expansion. In Malaysia, waste management became a federal authority when the Environmental Quality Act (EQA) was formulated in 1974, which later shifted to the Local Government Act in 1976. The aggressive implementation of waste management in Kuala Lumpur was initiated with the Action Plan for Beautiful and Clean (ABC) Malaysia in 1998, which focused on recycling and strengthening local authority roles in waste management. Recycling and waste minimisation were seen as mechanisms to deal with escalating waste generation. A national recycling campaign commenced in 1993, however, it failed to achieve the targeted recycling rate due to the low participation from the public and inadequate recycling facilities provided (Periathamby 2001). The National Strategic Plan of Solid Waste Management was established in 2005 with inspiration from the ABC Plan in 1998, where government continue to promote waste minimisation and recycling as the preferred solution for waste management. In order to further inculcate the recycling habits among public, more recycling facilities and centres were developed around the city and were operated by the KLCH and also private companies. These facilities offer cash incentives in exchange for recyclables, which created a "spoon-feed" recycling habit among public and depended on the household's willingness to bring items to the nearest recycling centre (Zen et al. 2014). Recycling has become attractive to the public for personal economic gain rather than for environmental reasons.In Kuala Lumpur, a significant contribution to recycling is made by the informal sector or scavengers via recovery of usable materials from waste streams. In London, recycling systems are more uniform and administered formally by the municipalities. Informal systems – often known as scavengers or informal waste collectors – are often more efficient and dynamic in developing cities and some successful transitions from the informal to the formal sector have occurred (Nas & Jaffe 2004).

During the 1980s to 1990s, scavengers were mainly local people from the lower income level in society and their activities focused on recovering materials from landfills. Collection of recyclables from households was carried out by both scavengers and municipal waste collection crews, often known as tailgate recycling. Although tailgate recycling is not allowed by law, sales of recyclables provides extra income to the crew (Hassan et al. 2000). Scavenging by municipal crews reduced the efficiency of waste collection thus increasing the operational cost to the authority. In addition, the government started to lose control on tracking recycling activities and data collection as the informal recycling industries grew more rapidly than expected. Consequently, although the recycling rate in the country is almost certainly higher than officially reported, it is still unknown. In the 1990s, there was ingress of foreign labour from neighbouring countries to address labour shortages in manufacturing sector. Foreign labour then started to dominate waste collection activities, particularly via informal recycling activities. The informal recycling sector became aggressive due to poverty and a lack of regulations and guidelines for more sustainable recycling programs. The informal recycling is often to be more efficient due to skillfull manual sorting workers that manage to extract waste according to its value. Along with the recycling initiatives by

the government in the late 1990s, informal recycling was seen to be more efficient, therefore, informal recyclers were licenced by the municipalities for better tracking and control.

Environmental and solid waste management (SWM) policies in Malaysia have evolved from simple informal policies to national level strategies and legislation (Victor & Agamuthu 2013). The transition from general waste policies in the Environmental Quality Act (1974) until official Solid Waste Management and Public Cleansing Act (2007) were implemented in 2011 proved the government's commitment towards achieving an effective and sustainable waste management system. Along with the transitions, plenty of strategies and plans have been implemented; some were influenced by other countries' experiences whilst others were designed in response to local scenarios. Abas & Wee (2014) concluded that the evolution of waste management in Kuala Lumpur had improved social serenity, economic stability and environmental efficiency. However, a series of failures in waste strategies occurred, mainly due to lack of awareness and participation from the public as well as limited funds allocated for development of plans for waste management. In fact, due to political intervention and conflicts of interest between the federal and state governments, the long-delayed Solid Waste Management and Public Cleansing Act was rejected by opposition states, pushing the ultimate goal towards achieving sustainable waste management even far from realization.

The development of recycling systems in London can be seen as a very slow continuation from the early dust-yard operations until recycling operations were kick-started by EU directives towards the end of the 20th century. Consequently, the waste industry has changed from treating waste as a homogenous material for easy disposal to developing specialist systems for recovery of different components in the waste stream; the collection; sorting, dissembling and delivery of materials has had to be developed in such way to fit with this shift. The UK was relatively slow to shift its focus from waste to resource managment, trailing behind other industrialised countries such as the United States of America, Canada, Germany, Austria and the Scandanavian countries, where major cities reported recycling rates of 30-50% whilst London's recycling rate was only 6% (Murray et al. 1998).

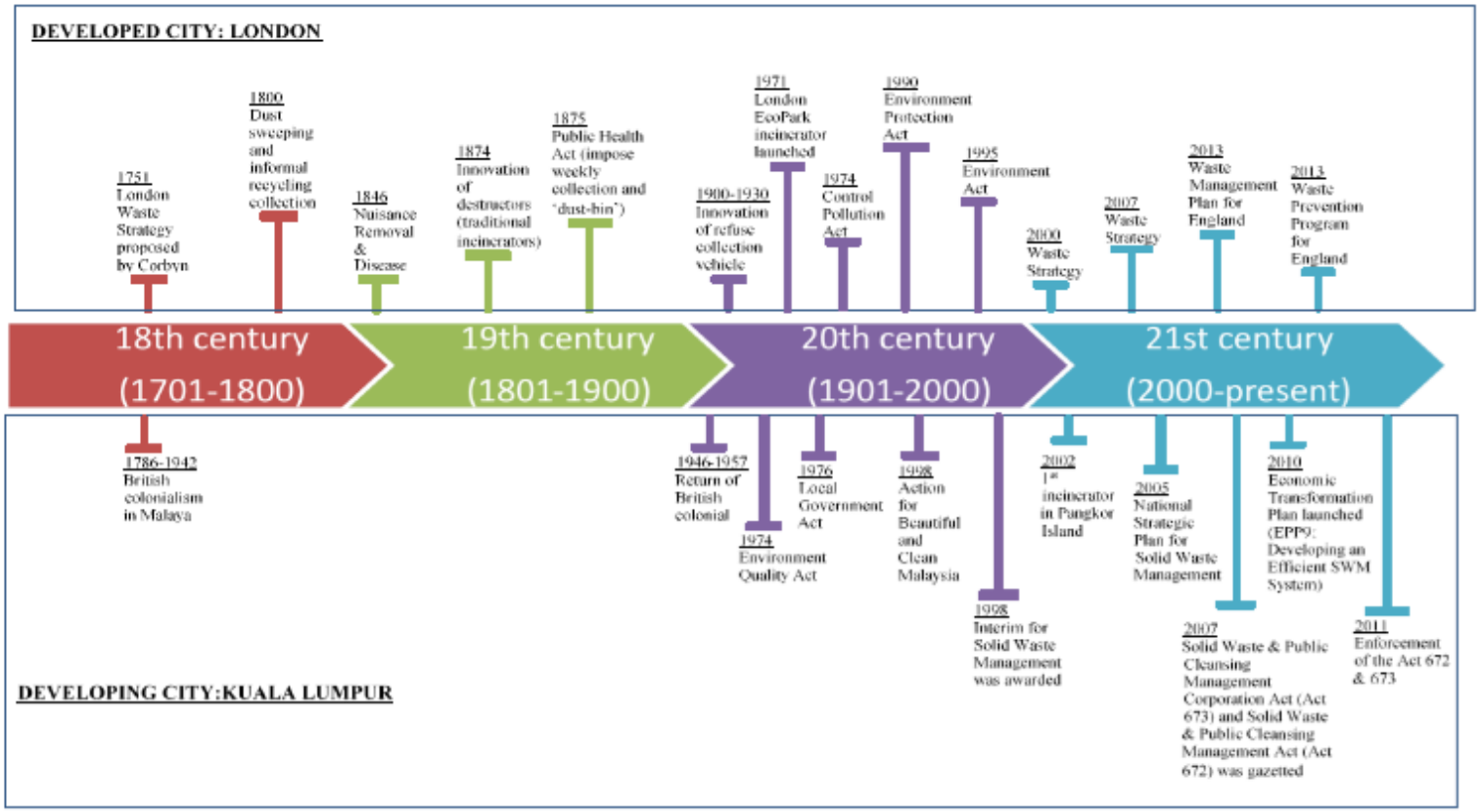

Figure 5. The evolution of waste management policies for London and Kuala Lumpur.

5. A NEW PARADIGM - FROM WASTE TO RESOURCE MANAGEMENT

As society has evolved and the global population has expanded, the consumption of natural resources has changed rapidly. Before the Industrial Revolution, there was a scarcity of resources and waste was hardly seen discarded without some form of recovery. The behaviour of such a society can be considered as "*wasteless*" where few materials were actually disposed. Because there was a scarcity of resources, consumption was low, recovery of materials was high and little waste was produced. Zero-waste operations in the dust-yards of London in the 18th century are good examples of behaviour in a "*wasteless*" society. Along with modernization and urbanization, the lifestyle in London has become more hectic and challenging in terms of balancing economic stability with improvement to quality of life. Strong economic stability merged with higher living standards have shaped society into a throw-away or "*wasteful*" society, where an abundance of resources allowed the manufacture of easily available and affordable products, and recovery of materials was deemed financially unattractive. Subsequently, large amounts of waste were generated that required disposal and this eventually placed significant burdens on the environment. A stepwise shift up the waste hierarchy led to recycling becoming the preferred option to recover secondary value from resources. Moving towards the future, where depletion in natural resources is predicted, it is crucial to shift the present society's waste behaviour, from being wasteful to "*wasting less*". Anticipating increased future waste arisings, a society that wastes less ideally will have access to an abundance of recovered secondary resources from reuse/recycling/composting, though it is predicted that resource consumption will be higher along with increased demands for goods. Shifting from waste management to sustainable resource management clearly is the ideal way to manage waste in the future in all countries.

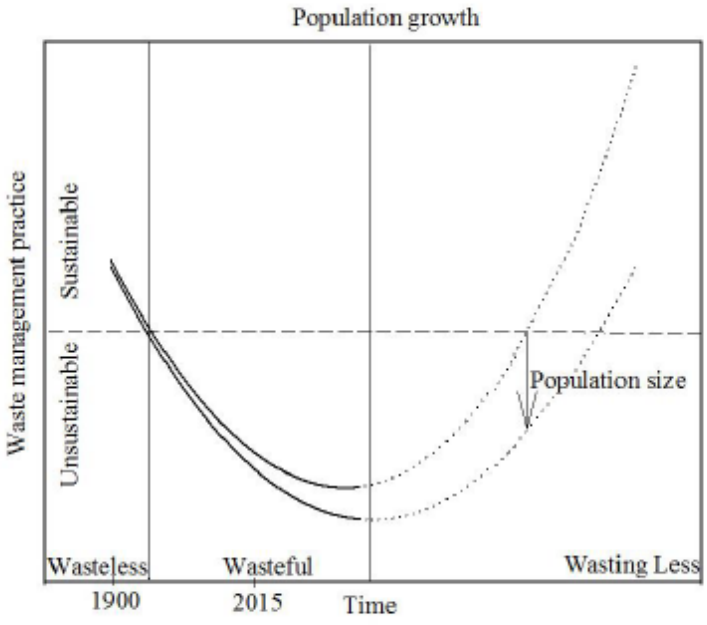

Figure 6. Waste management evolution conceptual model for Kuala Lumpur.

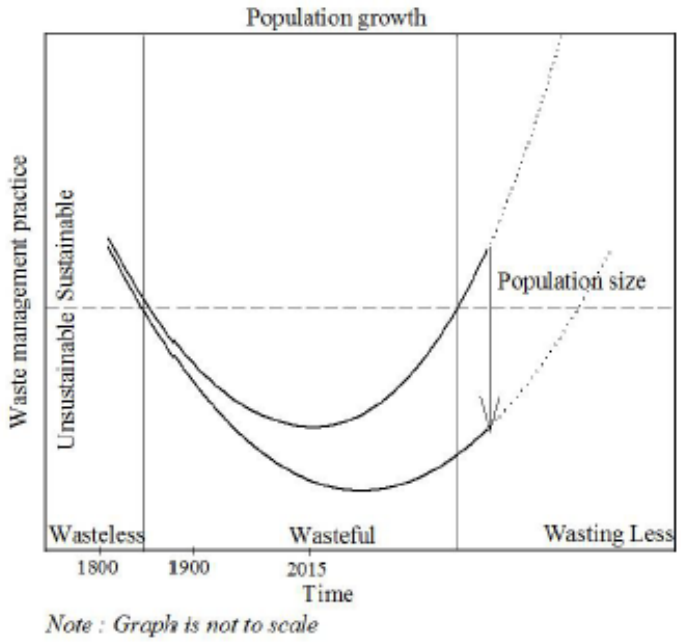

Figure 7. Waste management evolution conceptual model for London.

Figures 6 and 7 show the waste management evolution conceptual models for Kuala Lumpur and London. By comparison with London's waste management status over time, Kuala Lumpur might be able to project its waste management status if the current society's waste behaviour continues in the future. Societal waste behaviour in Kuala Lumpur can be considered as *wasteful* regardless of various initiatives for waste recovery and minimization implemented either by the government or the public. Unlike London, non-existence of regional directives on waste management and a lack of proper enforcement of waste management policies are making progress towards achieving sustainable waste management slow. Although waste arisings and resource use are not as intense as in developed nations, there is concern about the significant increase in waste generation over the last decade in addition to the exponential increase of population in the city. The lowest point of the curve indicated maximum resource utilization with low recovery rate. Upon reaching to this point where the waste management practice is at worst, aggressive implementations to improve the system has to be done to avoid disastrous environmental consequences. Localised factors or drivers had indicatively enhanced the initiatives towards striving for sustainable waste management. Detailed analysis is recommended in terms of how localised factors can contribute to accelerating the process of improving the waste management system.

6. DISCUSSION

6.1 Developing cities adopting practices from developed cities

Developing cities' waste regulations are often prototypes of past regulations from developed cities. However, such prototypes often do not work well or fit suitably with local scenarios. Prior to a decision to adopt such regulations, social, economic, environmental and local political factors should be considered carefully. Straight adoption of technologies that work well in developed cities

may not work effectively in developing cities for various reasons, including poor fit with local waste characteristics and quanities, infrastructure, collection and transport systems, temperature, climate, culture, household/business practicess and the local economy. Even customisation of technologies to suit local conditions may not ensure the success of its operation. Developing cities often cannot afford trials and research, in terms of finance and time, and hence adaptation from developed cities' experiences and success is seen to be a fast-track to deal with urban wastes. As Kuala Lumpur is planning to build many incinerators, failures from previous small-scale incinerators across the country may shed some light on anticipated challenges in terms of operational costs, social rejection, environmental impacts and eventual chance of success/failure.

6.2 Economic influence on waste arisings

As economic prosperity increased, living standards in Kuala Lumpur were raised, increasing purchasing power and waste generation. Kuala Lumpur has economically developed for the past 50 years with amount of waste generated escalating much higher than the economic growth. It has been spending the majority of earmarked municipal funds on waste management and disposal and least on facilities development. Likewise in London, when the benefits of proper waste management outweigh the cost implications, the level of government spending on upgrading facilities and improving waste management system should increase.

6.3 Colonial influence

In general, there is some commonality between London and Kuala Lumpur in terms of application of laws and regulations as well as strategies and approaches to waste management. Although both cities' waste management systems have historically been dominated by end-of pipe solutions, London is moving towards resource management via increased recovery and recycling. Waste management policy in London has been achieved via decades of development and transformation of factors that influenced the kind of systems implemented today, and it is undeniable that EU directives have had a very strong recent influence. Legal, financial, operational, technical, social and to some extent political factors are the main determinants of successful implementation of waste strategies and systems in developed cities; these factors are less developed or more inconsistent in developing cities and hence sustainable waste management systems are still far from realization in these locations. Although the British influence on Kuala Lumpur's waste management system is not obvious, it has taken up experiences and practices of London's waste management and matched with local conditions for better implementation. In future, if Kuala Lumpur is developing towards London's characteristics in terms of demographic patterns, London's experiences in waste management may able to help Kuala Lumpur's authorities to plan for future waste management systems.

6.4 External factors

In developing cities, localised factors that support waste management systems could be discovered with more detailed analysis and evaluation about how these factors react to each other in a local waste scenario. These factors are external forces that drive the city to enhance sustainable waste management initiatives to suit societal lifestyles, resource consumption and expanding economic activities. Factors such as weather and climate significantly impact waste degradation and methods of waste treatment. With minimum funding on waste facilities development and management anticipated in developing cities, it is crucial to have cost-benefit analyses as well as having the custom-made facilities to suit local conditions and scenarios. Waste management policies for both Kuala Lumpur and London have been integrated with other national environmental policies.

However, the policies have derived from different components such as characteristics of the waste, degree of the environmental impacts, and disposal methods as well as tools for waste management activities. The enthusiasm of Kuala Lumpur's authorities to develop waste systems into the most sophisticated and sustainable at low financial cost has driven the authority to study other cities' successes and adopt them to suit local conditions. Although there is no regional directive on waste management, success stories from neighbouring city such as Korea, Japan and Singapore have also provided inspiration for Kuala Lumpur.

7. CONCLUSIONS

The conclusions from this study are:

a) Historical analysis of trends and systems in a developing and developed city has enabled the identification of key milestones in waste management practices, policies and strategies. A developing nation should be able to observe the successes and failures of developed cities' waste management initiatives and learn from them when changing its localised waste systems.
b) The analysis has led to the development of conceptual models of waste management status that may be useful for cities similar to Kuala Lumpur and London. Future improvements may not be require total system changes, rather enhancements of localised factors that support the system may be all that is required in order to make the system more effective and sustainable.
c) Comprehensive waste management policies with full implementation plans need to be properly formulated based on a clear and concise understanding of local circumstances, never from direct adaptation from other city's experiences.
d) The "big picture" for waste management needs to be addressed at national and global levels. Each stakeholder needs to gear up their functionality to support the system. The public is the biggest stakeholder; the public need to be educated to understand the connections between their daily lifestyles, resource consumption and the quality of the environment that they live in presently and for the future.
e) The importance of a proper waste management database is undeniably crucial to help planners for future projections. In developing cities where databases are estimated and may be widely inaccurate, this may lead to misinterpretation of the current scenario and could result in disastrous projections or even make the realization of sustainable waste management almost impossible.

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Appendix D4:

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VISIBLE AND INVISIBLE FACTORS OF SOLID WASTE MANAGEMENT IN DEVELOPING COUNTRIES

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SUMMARY: The development of solid waste management (SWM) has been closely related to factors that influenced waste practices in the past and has shaped contemporary waste management systems. Multiple influencing factors need to be considered if SWM is to be effective. We have identified non-measurable or "invisible" factors that are not easily quantifiable or routinely measured but may influence local waste management practices and behaviour. Although the degree of influence of invisible factors is varied and sometimes vague in terms of impact, they serve as a starting point to design more well-rounded and effective waste management strategies The aim of this study was to identify factors in solid waste management and classify them for the first time into two broad categories, "visible" and "invisible". A PESTLE (Political, Environmental, Social, Technological, Legal and Economic) analysis was employed as the basis for categorization. We identified 43 key factors that were divided into the six different PESTLE categories, of which 34 (79%) were visible factors and 9 factors (21%) were visible. Findings from this study highlight the need to adopt new perspectives in determining which factors play key roles in local waste management but have not been addressed appropriately and may have hindered the initiatives taken in developing SWM systems efficiently.

1. INTRODUCTION

Waste generation is connected to the socio-economic status of nations. In developing countries, the management of waste is becoming more complex as a result of rapid urbanization and the increasingly heterogeneous nature of modern products. Increasing population level, rapid urbanization, significant economic activity and a steady increase in society's living standard in major cities in developing countries has lead to the exponential growth in waste generation. Large increases in global waste generation may be attributed to developing countries, driven by a combination of high urbanization rates and massive economic development (Le Courtois, 2012) . Specific socio-economic conditions prevail in developing countries, including rapid population growth, rural-urban migration, lack of funds and low-skilled cheap labour. SWM systems in merging economies often lack facilities, and suffer insufficient

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service coverage, improper disposal and treatment methods that greatly lead to major environmental and social problems.

Mukhtar et al. (2016), in their global review of the history of urban waste management, clearly showed that direct adoption of developed cities' approaches without proper consideration of the local circumstances may lead to unsustainable future waste management in developing cities. The significance of factors in SWM in developing countries has been assessed according to specific contexts including: socio-economic impacts on waste generation (Bandara et al., 2007), recycling (Johari et al., 2014), waste to resource initiatives (Storey et al., 2015), the collection of municipal waste (Coffey & Coad, 2010) and disposal of waste (Zurbrügg & Schertenleib, 1998). The roles of specific factors are not always well-defined nor their influence measured. The impact of these factors, when apparent, can be validated from historical evidence.

Multiple factors affect the development of waste management systems, including legislative, environment, social, technical, health, market demand and economic aspects. These factors need to be identified and their role understood to ascertain whether proposed waste management plans are duly tailored to local requirements and viable in environmental, social and economic terms (Mukhtar et al., 2015). The key factors relevant to waste management systems can vary due to the differences between individual cities' characteristics (Contreras et al., 2010). Some factors are measurable and known (e.g. demographic indicators) and can contribute to projecting future waste conditions. In contrast, there are factors that potentially influence the need for development of a waste management system but are qualitative (e.g. behaviour, understanding and awareness) and may be important if local conditions are to be recognised and addressed in the design and implementation of waste management systems.

Various factors of solid waste management plays different fundamental roles in waste management practices (Barr, 2007; Periathamby et al., 2009; Wilson, 2007); however, the non-measurable or "invisible" factors that are not easily quantifiable and nor routinely measured but may influence local waste management practices and behaviour. Although the degree of influence of invisible factors is varied and sometimes vague in terms of impact, hypothetically, they serve as a starting point to design more well-rounded and effective waste management strategies (Periathamby et al., 2009) or policies based on tangible local trends or evidence, rather than adopting best practices from elsewhere which may not address local characteristics, customs, uniqueness or waste composition (Mukhtar et al., 2016).

In this study, factors in waste management are classified for the first time into two broad categories; visible and invisible. We define a visible factor as one that is fully considered in waste management which is quantifiable and measurable using available datasets, published and available for public access for fair consideration. We define an invisible factor as one that is non-measurable and non-quantifiable but still influences behavioural, generations and philosophical perceptions on waste and its practices. In some cases, invisible factors' roles in shaping waste management in developing countries are more significant than in developed countries, depending on the combination of other factors in the local waste conditions. Due to the local influence of these factors in specific situations, invisible factors that worked well in one local condition may appear to be not significant at all in other areas and therefore direct adoption cannot occur. The complexity of a city/region's waste management system requirements need to be i) recognised ii) analysed and finally iii) turned into infrastructure, service provision and information campaigns that lead to behaviour change. For example, cities

with diverse ethnic groups in the community might consider the differences in cultural and lifestyles of each ethnic group in terms of waste practices, resource consumption and awareness on proper waste management practices. In less diverse countries, any differences in waste-related behaviour among different ethnic groups may not appear to be important and may not need to be considered in waste management plans and systems. It is possible that approaches to setting up waste collection systems, selecting suitable treatment methods and public awareness-raising campaigns need to take visible and invisible factors into consideration in order to reach optimum results.

The aim of this study is to identify factors of solid waste management in developing countries and classify them into two broad categories, "visible" and "invisible". In this paper, we identify factors in waste management through a review of multidisciplinary literature and structured the factors according to PESTLE (Political, Environment, Social, Technology, Legal and Economic) for clear categorization. Factors from each components of PESTLE will then be classified as visible and invisible by employing a Delphi study. Results will provide clear classification of visible and invisible factors in developing countries and how these factors can be connected within the local waste conditions that can accelerate the development of SWM systems.

2. METHODS

The study comprised two phases. The first stage was a literature review to gather and collate a list of key factors that are reported to be relevant to and important in SWM; factors were then classified according to the PESTLE categories (section 2.1). The factors as collated and classified were then presented to a consultative group, members of which were asked to specify whether they consider each factor to be "visible" or "invisible" in current waste management practices (see section 2.2).

2.1 PESTLE classification of factors in solid waste management

Important factors in waste management development were first identified via a literature review. The literature review was intended to identify factors on a qualitative basis. The factors identified were not intended to represent an exhaustive list but to generate a set of factors for subsequent consideration by the consultative group in the Delphi study (section 2.2). The factors were grouped according to the PESTLE classification system (e.g Zhang et al., 2011; Kolios and Read, 2013; Srdjevic et al., 2012; Zalengera et al., 2014). This approach provides an analytical framework for a complex system and interactions between factors.

2.2 Delphi survey

The Delphi method was employed to establish views on factors in solid waste management from the group of identified experts. The Delphi method is a systematic and interactive research technique to obtain the judgement of independent experts on a specific topic. Experts were selected using an online search, including editorial panels of waste management and related journals and academics in higher education. The structure of the Delphi questionnaires followed the key factors and PESTLE classification (section 2.1).

Respondents were presented with the list of factors within PESTLE classes (Tables 2-7) and asked to classify each factor as either "invisible" or "visible". The questionnaire specified the meaning of each of these terms, vis-à-vis:

- Visible: factors that are measurable, quantifiable, considered in SWM decision-making and implementation, and available in the public domain.
- Invisible: factors that are not currently considered in SWM but have the potential to influence SWM behaviour, perceptions and practice.

Respondents were also asked to provide information regarding their own role, expertise and experience in SWM. The Delphi questionnaire was administered by iSurvey, a survey generation and research tool for distributing online questionnaires used by the University of Southampton (https://www.isurvey.soton.ac.uk/).

3. RESULTS AND DISCUSSION

3.1 PESTLE classification of factors in solid waste management

The 43 factors are identified and briefly described in Tables 1-6. Differences in the numbers of factors in each PESTLE class were noted. We note that the observations to hand (Tables 1-6) do not represent an exhaustive list of factors or a quantitative profile. The specific purpose (section 2.1) is to inform and guide the subsequent Delphi survey (section 2.2). In particular, this analysis provides the structure for the Delphi study (i.e. PESTLE classification) and definitive descriptions of each factor (Tables 1-6).

Table 1. Political factors in solid waste management: the ability and roles of government to affect management and regulation.

Factor	*Description*	*References*
Government stability	Strong government can hold its power and control over the country with minimal external influence	Plata-Díaz et al. (2014); Wilson et al. (2001)
Corruption	Fraudulent conduct for personal benefits, typically related to bribery	Taherzadeh & Rajendran (2014); Jones et al. (2010)
Accountability of leaders	Responsible and trusted leaders	Jones et al. (2010) Rudden (2007)
Local government plan	The plan for future development of the local area	Rudden (2007) Wilson et al. (2001)
Government priorities	Focus and attention on specific issues by the government	Moh & Abd Manaf (2016)
Influence of politicians	Effect of politicians' behaviour and character on specific issues	Taherzadeh & Rajendran (2014)
Bureaucracy	Excessively complicated administrative procedure	Godfrey & Scott (2011)

Table 2. Environmental factors in solid waste management: the ability of environmental elements and resources to influence waste management behaviour and directions.

Factor	*Description*	*References*

Environmental guidelines	Local/national guidelines that set specific environmental standards	Li (2007)
Environmental targets	Specific goals on environmental standards to be achieved within certain period of time	Li (2007)
Climate change	Changes in global and regional climate patterns resulted from unsustainable human activities	Zaman (2013) Johnson et al. (2011)
Geographical landform	Different features of the part of the earth which makes the terrain	Li (2007)
Local weather	Specific weather conditions at a particular place and time	Emery et al. (2003)
Environmental awareness	Awareness on the adverse impacts onto the environment resulted from unsustainable human activities	Triguero et al. (2016) De Feo & De Gisi (2010)

Table 3. Social factors in solid waste management: the functionality of humans and their responses towards changes in waste management.

Factor	*Description*	*References*
Seasonal variations	Specific annual celebrations at particular times of the year to celebrate a change of weather, season, crop harvesting and also racial, religious or ethnic affiliation which may or may not officially recognized by the government	Gómez et al. (2009) Emery et al. (2003)
Religion	System of faith and worship to personal God	Fatimah Mohamad et al., (2011) Mohamad et al., (2012)
Cultural	Social behaviour, belief, traditions of particular group of people	Thyberg & Tonjes (2015) Martin et al. (2006)
Ethnicity	A particular group of people with same races, religious and origin that may have different culture from other groups of people of a country	Perry & Williams (2007)
Local/national events	Special days of celebration include national holidays, commemoration and also racial or ethnic affiliation which are officially recognized by the government	C.Gibson & Wong (2011)
Discrimination	A practice of unfair treatment of a group of people to other people, mainly with regards to the socio-economic status	Ma & Hipel (2016) Sembiring & Nitivattananon (2010)
Socio-economic indicators	Changes in particular demographic components which are measured periodically	Triguero et al. (2016) Pickerin & Shaw (2015)
Resource consumption	Changes of natural resources use	Taherzadeh & Rajendran

patterns	for human activities within particular period of time	(2014)
Shared norms	Rules of behaviour that are considered acceptable in group of society	Binder & Mosler (2007)
Rural-urban daily migration	Movement of people from rural to urban areas on daily basis, mainly due to the economic and tourism factors	Henry et al. (2006)
Philosophical change	The evolving thoughts and feelings on particular issues that reflected in the changing in behaviour	Wilson et al. (2001)
Attitude-behaviour change	Difference of individual values or understanding on particular issues does not correlate with their actions	Triguero et al. (2016) Jones et al. (2010) Barr (2007)
Resistance to change	Actions taken by individuals or group of people when they perceive or interpret change as a threat to them	Taherzadeh & Rajendran (2014)

Table 4. Technological factors in solid waste management: the ability to apply suitable technology towards the improvement of waste management.

Factor	*Description*	*References*
Skilled workers and experts	Workers with specific knowledge, skills and ability to perform best in their work, while experts are someone who widely recognized as a reliable source of technique and skills	Periathamby et al. (2009)
Application of suitable technology	Application of the appropriate technology that are best designed for efficient operation	Taherzadeh & Rajendran (2014) Contreras et al. (2010) Wilson et al. (2001)
Facilities availability	Adequate number of facilities are developed for specific use of the people	Taherzadeh & Rajendran (2014)
Rate of technology change	Development of the related technology over certain period of time	Zaman (2013)
R&D Activities	New innovative research that change	Periathamby et al. (2009)

	the utilization, performance, management and practices	

Table 5. Legal factors in solid waste management: the attributes and obligations of local authority and as institutions responsible to comply with waste management guidelines.

Factor	*Description*	*References*
International directives	Environmental guidelines and instructions drafted by international organizations to create uniformity in actions	Contreras et al. (2010) Rudden (2007)
Local policy	Policy that sets guidelines that determine the decision and actions on relevant matter	Taherzadeh & Rajendran (2014)
Producers responsibility	Approach taken by the producers in managing waste as by products	Triguero et al. (2016)
Consumer accountability	Responsibility of consumers in buying, consume and managing the waste from the products	Triguero et al. (2016)
Relevant SWM law	Compliance and enforcement of the law towards environmental protection and social considerations	Contreras et al. (2010) Bai & Sutanto (2002)

Table 6. Economic factors in solid waste management: the ability of economic status to determine the marketability of recovered materials and waste products.

Factor	*Description*	*References*
Potential income from waste	Monetary benefits from waste	Periathamby et al. (2009)
Trade restrictions on waste	Limitation on trade activities to selected waste	Ray (2008)
Third sector restrictions	Limitation on trade activities to non-formal business organizations	Williams et al. (2012)
Availability of funds	Financial assistance offered on particular projects or initiatives	Taherzadeh & Rajendran (2014) Wilson et al. (2001)
Interest and tax	Application of interest and tax on goods and services	Jones et al. (2010)
Economic growth patterns	Changes in the amount of goods and services produced per head of the population over a period of time	Johnson et al. (2011)
Incentives	Rewards offered on appropriate actions	Jones et al. (2010)

3.2 Delphi survey: respondent profile

The respondent group comprised professionals from academia, private SWM consultants and companies, regulatory, local authorities and national government, charity organizations, business and trade and politics. Participants were classified according to their current location and its associated economic status (Table 7). The classification of countries by gross net income (GNI) is considered appropriate and convenient, but does not necessarily reflect the status of development in countries within the same classification.

Table 7. Classification of Delphi survey participants' current location and national economic status. [1] Economic status determined by the gross net income (GNI) per capita per year (World Bank, n.d.); [2] GNI per capita of <$1,025; [3] GNI per capita $1,026 to $4,035; [4] GNI per capita $4,036 to $12,475.

Participants' location	*Economic status*[1]
Mozambique	Low income[2]
Tanzania	Low income[2]
Togo	Low income[2]
South Africa	Upper-middle income[4]
India	Lower-middle income[3]
Indonesia	Lower-middle income[3]
Malaysia	Upper-middle income[4]
Vietnam	Lower-middle income[3]
Argentina	Upper-middle income[4]
Brazil	Upper-middle income[4]
Peru	Upper-middle income[4]

3.3 Delphi survey: classification of factors as visible and invisible

Experts were asked to classify 43 factors (Tables 1-6) as visible or invisible. For ca. 80% of these factors, more than 50% of the respondents judged them to be visible. Each group of factors is considered in relation to PESTLE categories (sections 3.3.1 to 3.3.6).

3.3.1 Political factors

Political factors, as classified by respondents, varied in terms of being considered visible or invisible (Figure 1). The local government plan was considered visible by all respondents; the strong majority view was that government priorities, government stability and bureaucracy were visible. The accountability of leaders was viewed as visible and invisible by a similar proportion of respondents, whilst the majority of respondents considered corruption and the influence of politicians to be invisible factors (Figure 1).

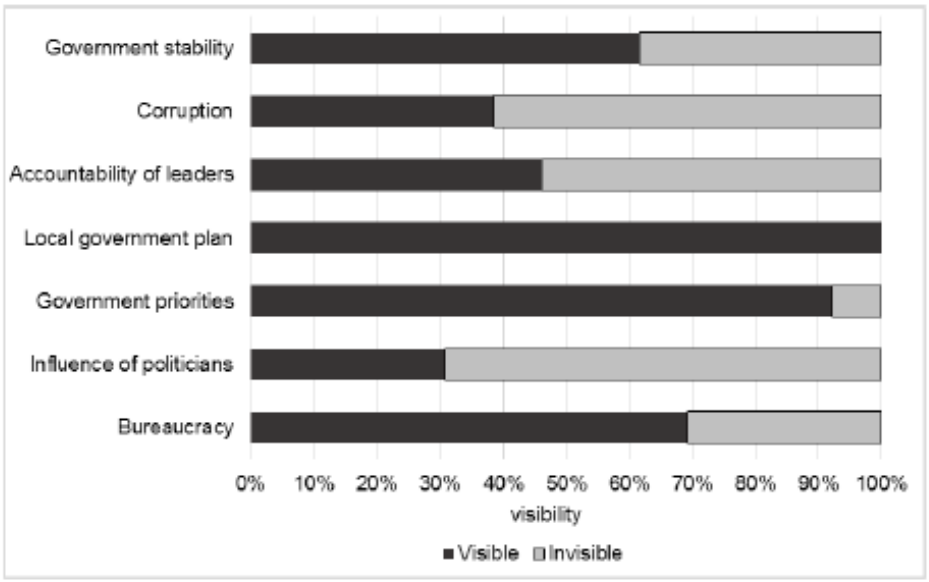

Figure 1. Proportions of Delphi survey participants classifying political factors (Table 2) as visible or invisible.

These observations (Figure 1) illustrate the importance of government in setting the focus and direction in future development of waste management. The experts consulted in the Delphi survey the highlighted the visibility of both local government plans and government priorities in relation to waste management. It can be argued that in developing countries there is a relatively high dependency on government to facilitate proper waste management services and facilities.

Most respondents (70%) considered bureaucracy to be a visible factor in waste management (Figure 1). Bureaucracy, whilst often a visible factor, can exert negative impacts if, for example, administration procedures are excessively complicated; unnecessary procedures and approval processes can cause delays in decision-making and implementation.

Government stability was considered by most respondents (61%) to be visible (Figure 1). Changes of government can clearly influence plans and their implementation at local to national scale. Stable government and related institutions allow establishment and maintenance of good relationships between politicians and authorities, ensuring better co-ordination of efforts in planning and development of efficient waste management services. Less stable government can generate uncertainty within the governmental institutions and disrupt decision-making and executing of waste management plans.

The accountability of the leaders was classified by 53% of respondents as invisible; measuring the qualities of leaders is often subjective. Changes to waste management cannot be readily or reliably attributed to the contributions of individual leaders; efforts of government authorities in improving waste management are generally cumulative, arising from multiple contributions from many individuals. There may, however, be some attribution of broad-scale outcomes to leaders who have taken a key role in developing a waste management strategy, most likely at a local scale.

Although fewer respondents considered corruption to be visible than bureaucracy, these two factors may be interlinked; excessive bureaucracy can precipitate corruption. It is arguable that

corruption, antagonistic politics and bureaucratic procrastination commonly exist in developing countries' government systems, which influence the decision-making and stakeholders' involvement in relation to SWM policy and practice. Corruption is more likely to occur when partnerships and relationships are poorly designed or defined; the efficiency of the networking then becomes inefficient (Taherzadeh and Rajendran, 2014).

With regard to politicians influencing decision-making and implementation of waste management systems, most respondents (69%) considered this to be an invisible factor (Figure 1). Influences of politicians can be notable, however. For example, following Malaysia's General Election in 2008, the change in political leadership led to the biggest challenges for the federal government to implement finally the Solid Waste Management Act 2007.

3.3.2 Environmental factors

Many of the environmental factors (Table 2) are considered to be visible by survey respondents. Environmental guidelines and environmental targets were highlighted as visible by the majority of respondents. Clear guidelines and targets on environmental aspects are vital for improving SWM: guidelines should provide procedures and methodologies for monitoring and enforcing the regulations; targets must be achievable and realistic to drive initiatives towards improvements. The importance of geographical landform on the development of SWM systems is also considered visible by most (70%) respondents. Vehicle-based collection in less accessible areas in developing countries may inhibit expansion of service areas in less reachable, mainly rural areas: some facilities, social and economic activities depend on the quality of transport infrastructure. Spatial variation in this regard requires understanding of the local situation in order to plan for a workable and efficient waste management system. The quality and coverage areas of waste collection services in some of developing countries differ between urban and rural areas, which may explain the observed split between respondents considering geographical landform visible and invisible (Figure 2).

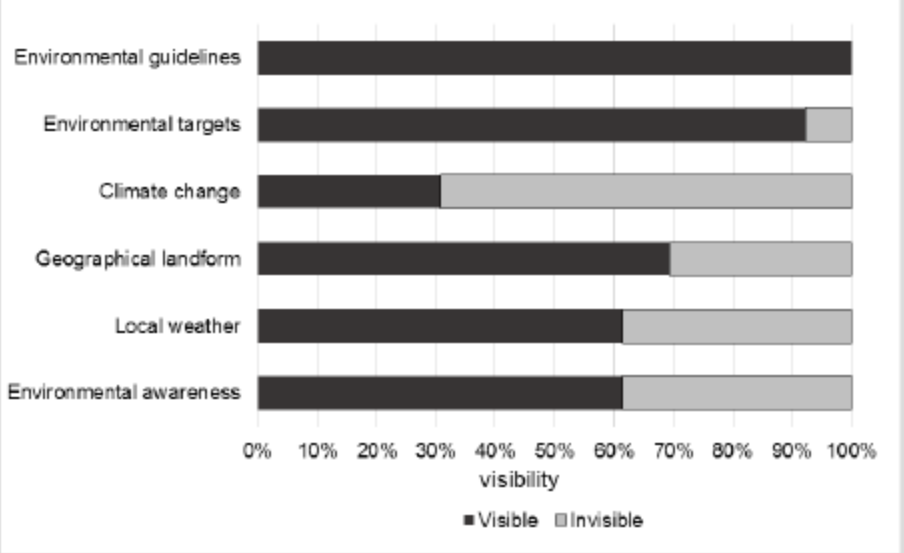

Figure 2. Proportions of Delphi survey participants classifying environmental factors (Table 2) as visible or invisible.

Environmental awareness was seen by most respondents as a visible factor (Figure 2): this underpins waste behaviour that can contribute to more sustainable SWM. The importance of having a population that is well-educated on environmental and waste management issues is thus highlighted and confirmed as commonly recognised and incorporated in SWM systems and approaches. This outcome is notable: enhancing awareness on good waste practices and sustainability has been stated as a key challenge in SWM in developing countries (Ferronato et al., 2017; Mcallister, 2015; Storey et al., 2015). With commonly visible status of environment awareness (Figure 2), there is potential to increase further awareness among public in developing countries to further progress initiatives towards sustainability in SWM.

Notably, Delphi respondents indicated that climate change is more commonly invisible than visible (Figure 2); less than one third of respondents regarded climate changes as a visible factor in SWM. This observation is somewhat at odds with the general recognition of climate change as a major and global environmental problem for the waste sector (Turner, 2016). Omission of climate change from visible factors in SWM policy and practice renders the impacts of SWM on climate invisible and can lead to decision-making that fails to reduce or even propagates waste-related climate change impacts.

3.3.3 Social factors

Respondents' views of social factors in SWM as visible or invisible varied markedly across the factors considered (Figure 3). Resource consumption patterns were regarded as visible by the majority of respondents; economic prosperity is commonly associated with demand for products and materials for consumption which in turn leads to higher demands on SWM systems. Experts mainly has consider that consumption patterns are already incorporated in SWM planning and system design. We note that preventing or inhibiting high rates of consumption and avoiding "throw-away" mentality could reduce waste generation by enhancing reuse, resource recovery and recycling (Williams and Shaw, 2017).

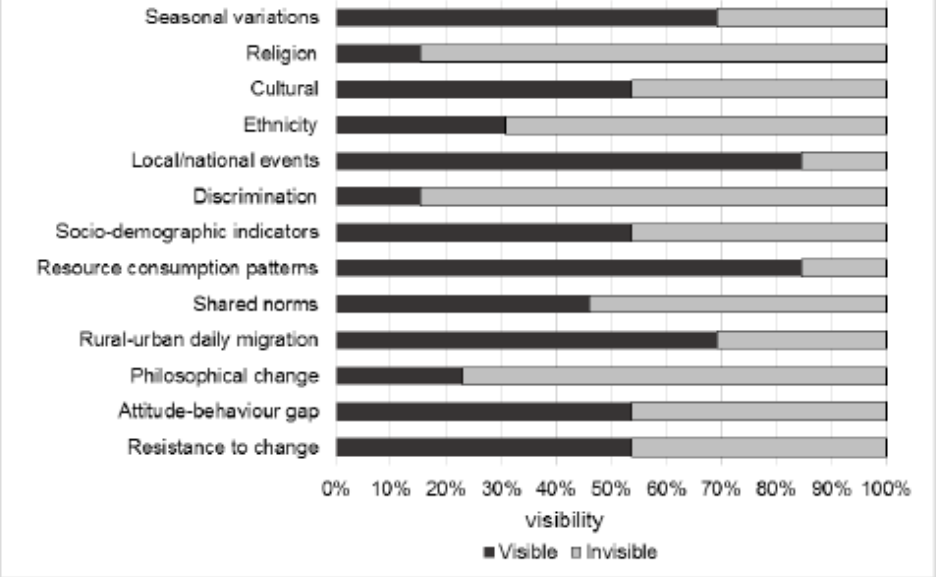

Figure 3. Proportions of Delphi survey participants classifying social factors (Table 3) as visible or invisible.

Local / national events were considered to be visible in SWM by most respondents (Figure 3). Celebration of local and national events draws communities together, but can lead to notable quantities of waste that need to be dealt with, requiring additional resources. Seasonal variations were also considered to be visible by most respondents: such events typically celebrate ethnic, cultural and religious events that occur within niche communities; the associated waste is often generated at a household level. For example, during the Ramadhan and Eid-ul-Fitr celebrations, food waste is generated in higher than usual quantities. Muslims tend to buy more food than their normal requirement for self consumption and guests; however, with limited time for consumption, food are not being efficiently consumed and ultimately end up as waste. Changes in waste collection frequency, additional vehicles and workforce are needed in consequence. Likewise, Christmas and Easter celebrations can lead to increases in household waste comprising large proportions of recyclables, such as packaging, wrapping papers, greetings cards, glass bottles and food waste.

Most of the responses from the Delphi respondents identified rural-urban daily migration as a visible factor in SWM (Figure 3). Unequal economic growth distribution between rural and urban areas leads to daily commuting, mainly driven by the economic opportunities and access to education, health, commerce and trade, for example. Although daily migration is already taken into account in many respondents' views, these activities influence the quantities and locations of waste generated in a city and confound estimates of likely waste arisings on a per capita basis. Understanding the influence of daily migration on waste characteristics, generation trends and patterns, is non-trivial but nonetheless informs and guides SWM policy and practice in most of the locations represented by the Delphi survey participants (Table 7).

There were five factors classified as equally visible and invisible: cultural, socio-demographic, attitude-behaviour gap, resistance to change and shared norms. Religion and

discrimination were considered to be invisible by most respondents (Figure 3). These factors thus appear to be incorporated in SWM policy and practice on an inconsistent basis. Religion is seen as influential force to transform public practices and behaviour on waste management (Fatimah Mohamad et al., 2011; Taherzadeh and Rajendran, 2014). Discussions on the influence of religion in waste management, however, are limited and often included within broader sets of socio-demographic indicators (Mohamad et al., 2012). Religion is perhaps not widely considered in SWM systems despite the potential of religious organizations to assist in transforming the public's waste behaviour. Likewise, cultural factors and ethnicity may present opportunities to transform waste management behaviour through social groups and communities, although the visibility of these factors varies between settings according to the Delphi survey responses in this study (Figure 3). We note that factors are not necessarily mutually exclusive: ethnicity may, for example, be associated with cultural and religious factors and their related behaviour and values regarding resource consumption and waste management. We note that although culture, religion and ethnicity may well be closely associated, cultural factors are more commonly recognised and incorporated in SWM (Figure 3).

Discrimination was viewed as a visible factor in SWM by around 1 in 6 Delphi respondents. This is perhaps a weakness in many settings: urbanization and economic growth lead to inequality, harassment and exclusion due to individuals' low social status. The few studies on this issue have highlighted, for example, discrimination of female SWM workers in developing countries (Ma and Hipel, 2016; Nunn, 2012), informal recyclers (Mull, 2005; Sembiring and Nitivattananon, 2010) and racism and social status of communities (Baabereyir, 2009). The intrusion of political agenda in solid waste management hindered the occurrence of social injustice which make discrimination factor is least considered.

3.3.4 Technological factors

Most, but not all, Delphi respondents considered all technological factors to be visible (Figure 4). This outcome highlights the importance of available and suitable facilities for waste management activities that lead to positive waste management behaviour among the public and improve operational efficiency. Conversely, a lack of suitable facilities can contribute to stagnation or decline of local SWM; availability of appropriate facilities can motivate public participation. Suitable facilities for SWM also permit resource recovery from the waste stream and thus contribute to more sustainable resource use.

The needs for skilled workers and experts are commonly regarded as visible factors in SWM in developing countries; pertinent skills and expertise can enhance and improve initiatives for and operations of SWM. In contrast, an inadequate skills base can lead to inaccurate waste projections and ineffective planning. There are relatively few academic studies that have evaluated the importance of skilled workers and experts in developing sustainable waste management plans (Dinie et al., 2013; Hazra & Goel, 2009; Moh & Abd Manaf, 2014); there is thus a contrast in that knowledge appertaining to skills and expertise is somewhat poor, whilst skills and expertise are commonly incorporated in SWM. We note that waste management involves both technical and non-technical disciplines; therefore, skilled workers can contribute to the efficiency of operational issues. Optimizing the recovery of materials from the waste stream and reducing the maintenance cost of facility operation by proper handling of the waste treatment facilities, for example, relies on a suitably skilled workforce.

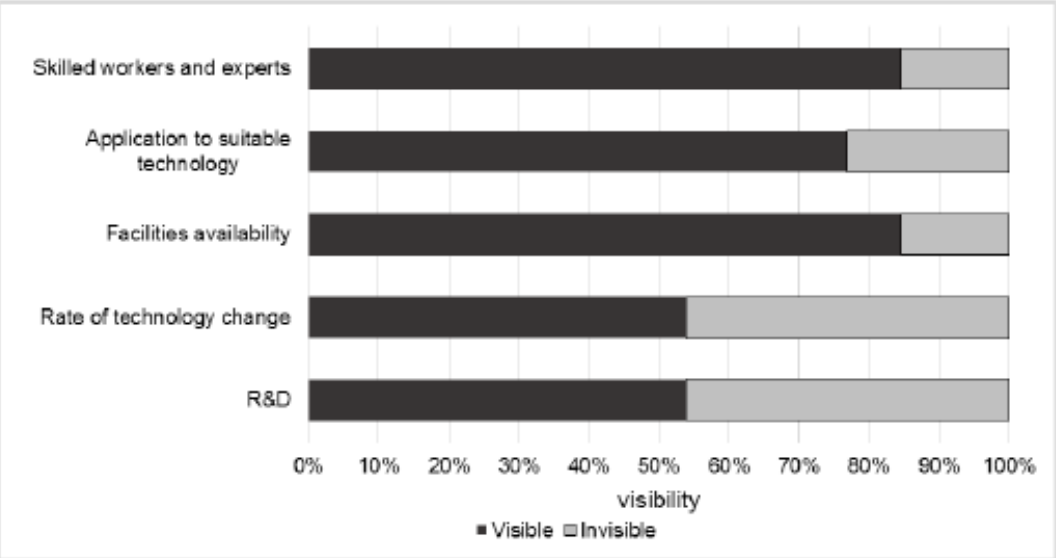

Figure 4. Proportions of Delphi survey participants classifying technological factors (Table 4) as visible or invisible.

Most Delphi survey respondents identified application of technology in waste management as a visible factor. Technology can conveniently and efficiently support the SWM systems, for example, when applied to waste treatment operations and recovery of resources from the waste stream. Developing countries, as indicated by the survey respondents, differ in terms of whether changes of technology and research and development are visible. There is a relative lack of financial assistance and allocation of funds for developing technology for SWM in developing countries. The lack of research and development activities in developing countries can lead to the selection of inappropriate technology in terms of local weather, waste characteristics, financial capabilities and availability of experts and skilled workers. Consequently, the selected technology may not operate effectively (or at all), thus wasting the resources allocated and causing social indignation.

3.3.5 Legal factors

Legal factors were all classified as visible in developing countries by the majority of respondents (Figure 5). Relevant SWM law and local policy are both considered visible factors by more than 95% of respondents. Outcomes in this regard reflect the status of local government plans and government priorities as visible factors in SWM (Figure 1); laws derive from political ambitions and purpose. In developing countries existence of local government plans is clearly important and is already incorporated in SWM systems, as is relevant SWM law.

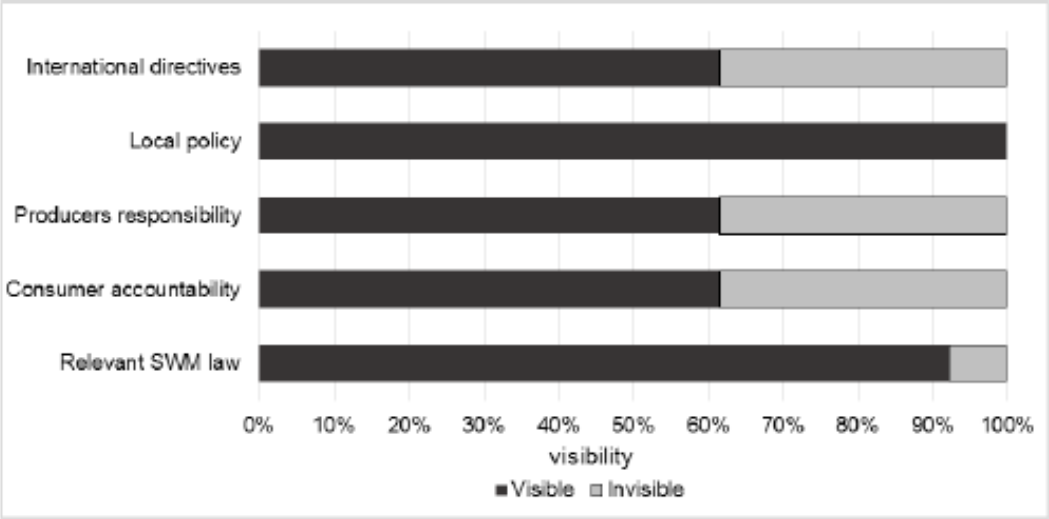

Figure 5. Proportions of Delphi survey participants classifying legal factors (Table 5) as visible or invisible.

Most respondents considered that accountability of consumers is a visible factor; management of post-consumer waste and producer responsibilities are key aspects. International directives were considered to be visible by most respondents; international directives on sustainability of waste management do not always apply and this situation is reflected in the responses received in this instance.

3.3.6 Economic factors

All of the economic factors considered were viewed by most respondents to be visible factors in SWM (Figure 6). Waste trading between developed and developing countries became an alternative solution to disposal for developed countries. This symbiotic relationship was apparently beneficial to both partners; developing countries were generating income from recovery of resources from waste whilst developed countries benefits secured reduced disposal and treatment costs. However, this rapidly led to immoral and unethical practices that resulted in damaging human health and environmental impacts in developing countries.

The strong agreement on the importance of available funds allocated for waste management projects was observed in developing countries with undivided agreement of 100%. Developed countries have more sources of financial support to develop their waste management systems when compared to developing countries (Periathamby et al., 2009; Wilson, 2007; Wilson et al., 2001). Incentives for the use of selected waste management processes/systems were viewed as motivational tools to reward good practice. The importance of offering incentives to further improve a waste management system was highly recognized, which more than 85% of agreement from developing countries.

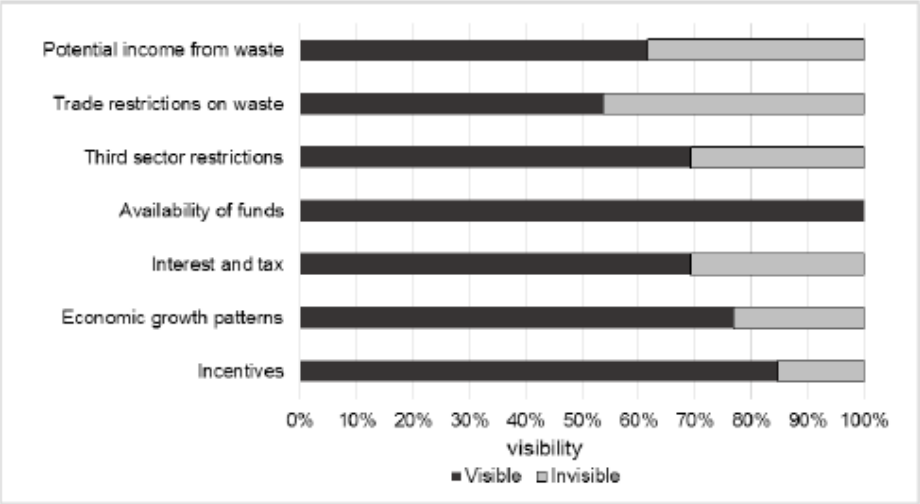

Figure 6. Proportions of Delphi survey participants classifying economic factors (Table 6) as visible or invisible.

A similar pattern of agreement was observed about the implementation of tax and interest on waste trading and also the potential income generated from waste on the public waste practices. Respondents from developing countries had slightly less concern on the importance of these factors in their waste system, which was an unexpected finding given by the rapid growth of business activities relating to waste trade and resource recovery in developing countries like China and Indonesia (Damanhuri, 2009; Hui et al., 2006). Great emphasis on the investment on facilities and improvements in waste management services can be observed alongside rapid economic growth in developing countries. With a stronger economy, the consumption of the resources increases alongside waste generation and this obviously influences emerging waste management systems. The importance of economic growth is very significant in developing countries with 78% agreement from respondents. Overall, all economic factors were classified as visible in both types of country, validating the importance of a strong economy to accelerate improvements to solid waste management systems.

4. CONCLUSIONS

This study highlights influential factors in solid waste management and classifies them for the first time into two broad categories; visible and invisible. The factors were grouped using a PESTLE analysis for clear categorization. From our Delphi survey, we concluded that environment, technology, legal and economy factors are strongly classified as visible factors while social and political are generally regarded as invisible factors in developing countries. The effectiveness and efficiency of solid waste management systems in developing countries are affected much more than by technological or financial issues. In this context, effectiveness and efficiency are multi-dimensional issues that include the interconnection of other factors that are workable within local conditions. The recognition of, and emphasis on, invisible factors that are not routinely or commonly considered can further enhance the sustainability of a local waste

management system. As proposed sustainable waste management practices require changes to public waste management practices and behaviour, there is a need to address the social factors in terms of attitude and behaviour of the public to be more vigilant of adverse impacts resulting from poor waste management practices. There is often overlapping of responsibilities and no clear assignment of responsibilities for tasks relating to solid waste management in developing countries. This situation hinders the effective implementation of improvement initiatives, thus there is a call for political factors to be considered in the waste management planning to further accelerate improvements towards effectiveness, efficiency and (economic and environmental) sustainability.

The national priorities of development in developing countries are different from developed countries and this influences waste management systems. The changes of solid waste management systems have been closely related to factors that have different fundamental roles in the local waste system. Factors in waste management can enhance the implementation of local plans and improvement initiatives. Understanding the factors that drive developments in waste management systems in the past and factors that significantly influence and impact current systems is vitally important if there is to be a move towards achieving sustainable waste management systems. This can be achieved by historical studies of local systems to understand the underpinning factors that significantly influenced the development and shaped the present waste management system. Evidence is not limited to waste management systems only, but also involves the characteristics of the society, government administration and economic status of each country/city. Factors elucidated here have to be interpreted in the local context to be effective. Emphasizing the right factors that significantly influence the local conditions can maximise the efficiency of the efforts with highest impact to the system. The influence of invisible factors is unique to each local waste management system and direct adaptation from other countries' experiences may not be workable. In some cases, invisible factors' roles in shaping waste management in developing countries are more significant than in developed countries, depending on the combination of other factors in the local conditions. Similar approaches that are workable in developed countries are not realistic in developing countries due to the inherent socio-cultural, economic and political structures. Even established technologies used in developing countries may not be suitable for other developing countries without modifications that underpin with detail study and evaluation. Hence the objective of setting the targets may not materialise due to differences in the approach or technology. Identification and emphasis the role of invisible factors potentially helps to accelerate the improvement to success.

Factors in waste management change dynamically alongside urbanization and the pace of change varies from one country to another. The visibility of factors needs to be re-evaluated regularly to get an accurate situation that lead to meaningful future projections. Different combinations of factors influence the development of waste management systems and addressing and understanding the factors that presently influence the local conditions are the best to move forward towards a sustainable waste management system.

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