detritus | Multidisciplinary Journal for Waste Resources & Residues

CISA

VISIBILITY OF FUNDAMENTAL SOLID WASTE MANAGEMENT FACTORS IN DEVELOPING COUNTRIES

Erni M. Mukhtar, Ian D. Williams * and Peter J. Shaw

Centre for Environmental Science, Faculty of Engineering & the Environment, University of Southampton, Highfield, Southampton SO17 1BJ, United Kingdom

Article Info:
Received:
15 January 2018
Revised:
05 March 2018
Accepted:
20 March 2018
Available online:
31 March 2018

Keywords:
Solid waste management
Visible factors
Invisible factors
Developing countries
PESTLE
Delphi study

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

* Corresponding author:
Ian D. Williams
email: i.d.Williams@soton.ac.uk

https://doi.org/10.26403/detritus/2018.16

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-

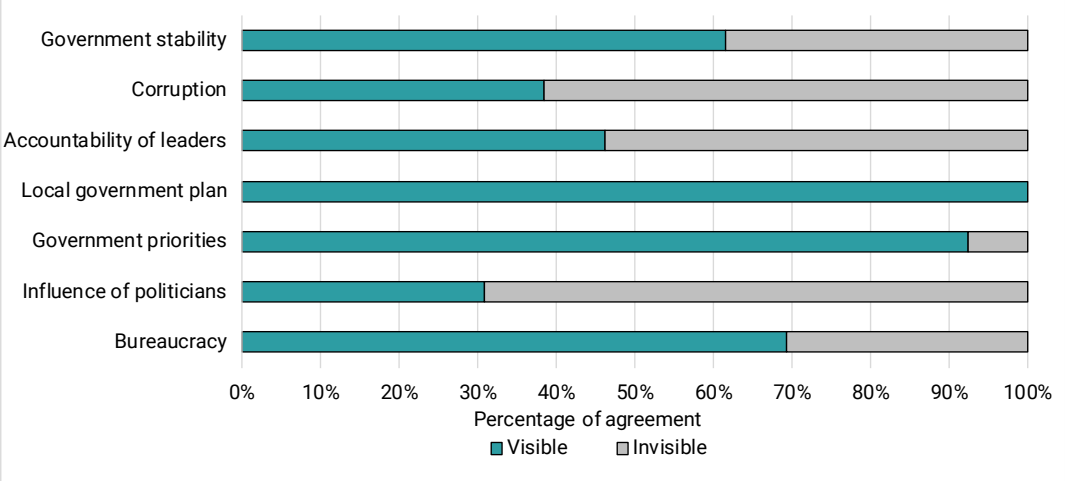

FIGURE 1: Proportions of Delphi survey participants classifying political factors (Table 1) as visible or invisible.

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

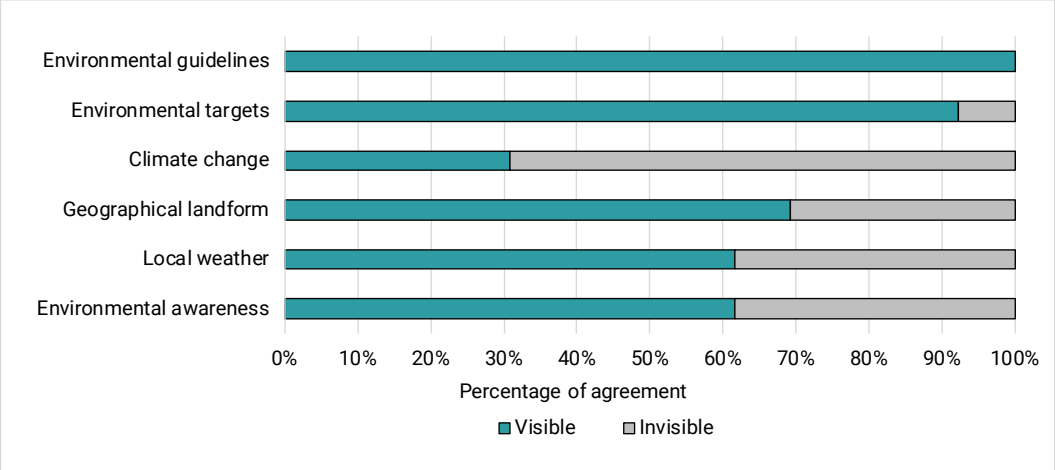

FIGURE 2: Proportions of Delphi survey participants classifying environmental factors (Table 2) as visible or invisible.

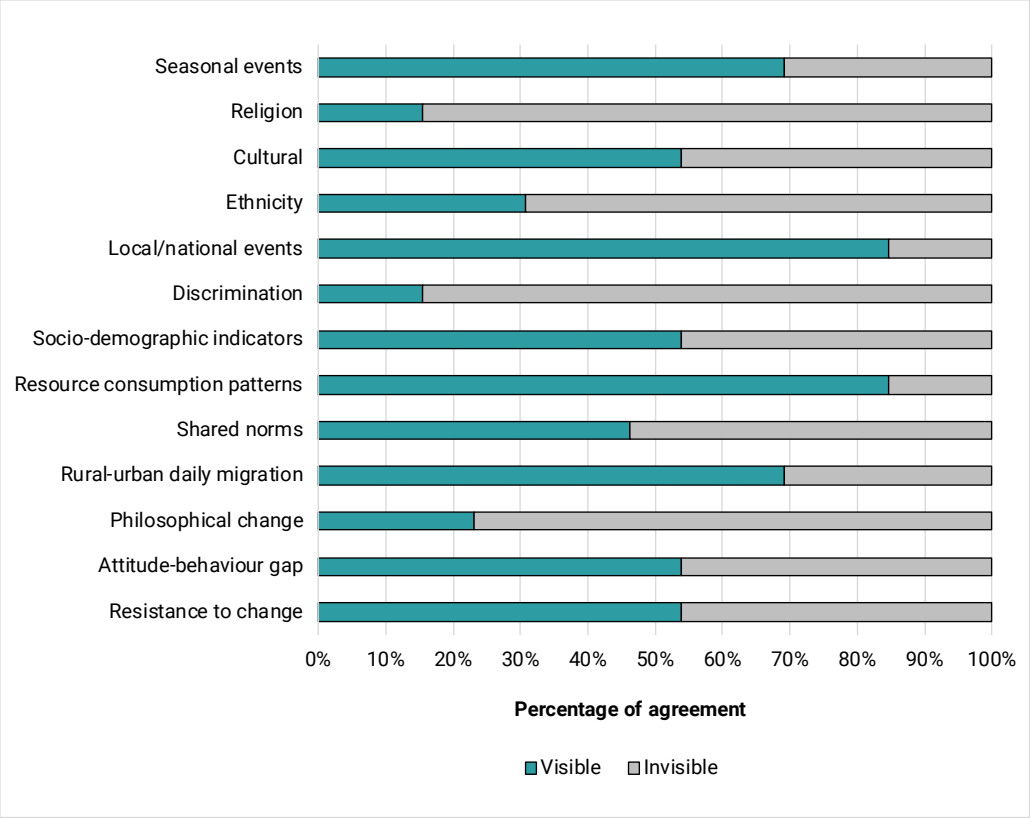

FIGURE 3: Proportions of Delphi survey participants classifying social factors (Table 3) as visible or invisible.

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-

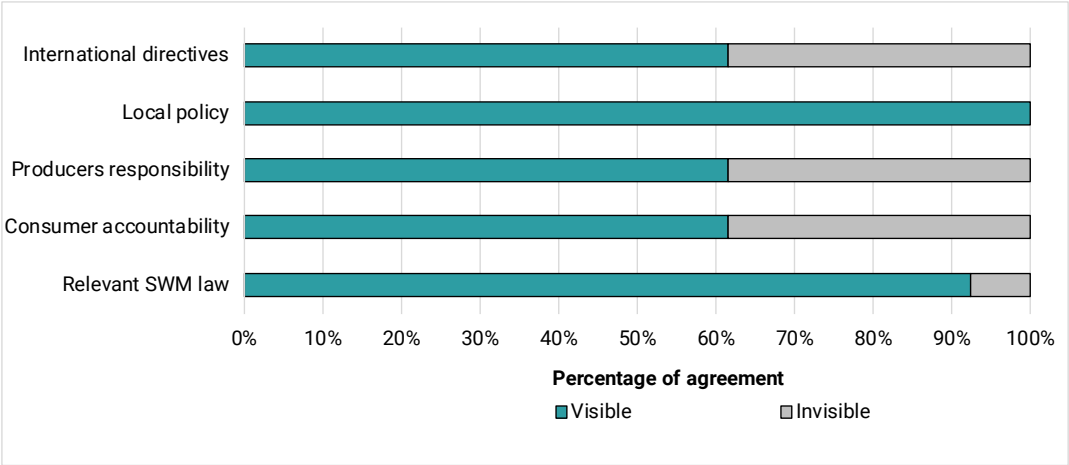

FIGURE 4: Proportions of Delphi survey participants classifying technological factors (Table 4) as visible or invisible.

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-

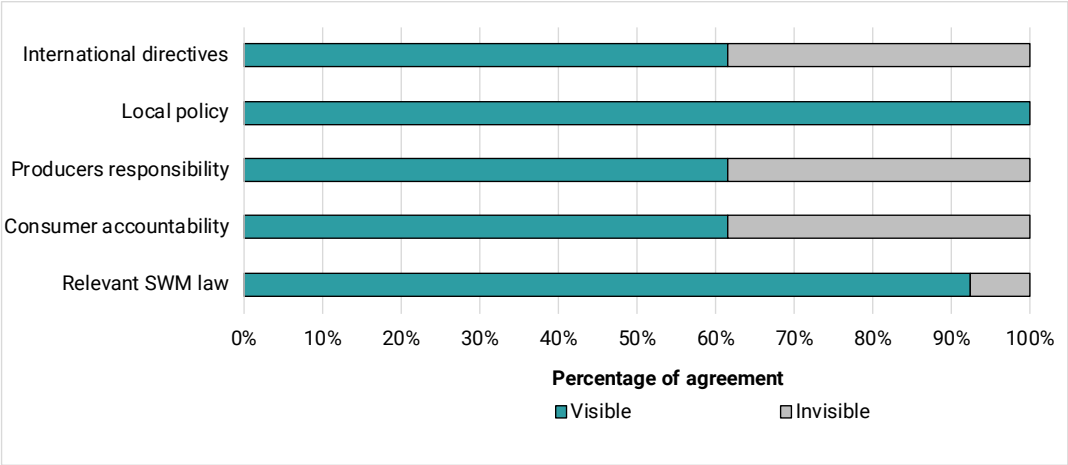

FIGURE 5: Proportions of Delphi survey participants classifying legal factors (Table 5) as visible or invisible.

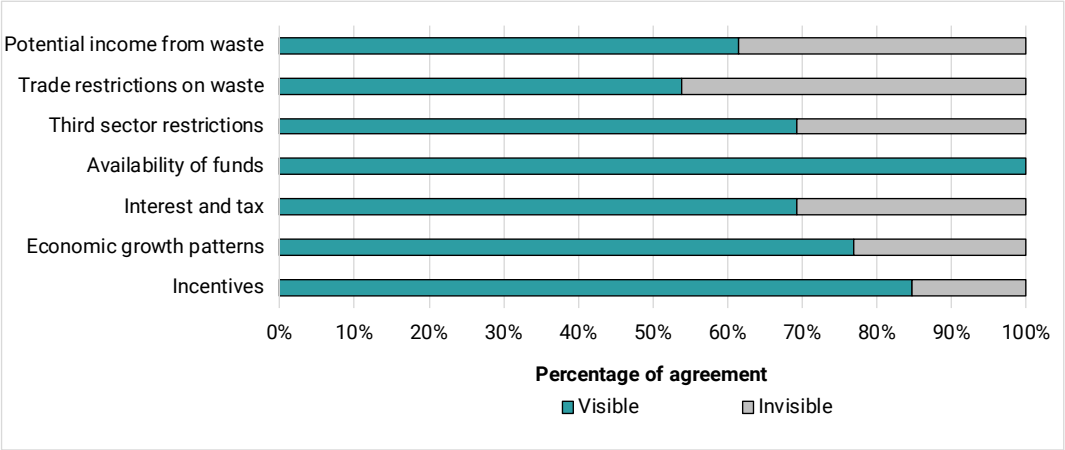

FIGURE 6: Proportions of Delphi survey participants classifying economic factors (Table 6) as visible or invisible.

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.

ACKNOWLEDGEMENTS

This study forms a part of the first author's PhD research, funded by the Majlis Amanah Rakyat (MARA), Malaysia.

REFERENCES

Baabereyir, A., 2009. Urban environmental problems in Ghana: A case study of social and environmental injustice in solid waste management in Accra and Sekondi-Takoradi. (Doctoral dissertation). University of Nottingham, UK.

Bai, R., Sutanto, M., 2002. The practice and challenges of solid waste management in Singapore. Waste Manag. 22, 557–567.

Bandara, N.J.G.J., Hettiaratchi, J.P. a, Wirasinghe, S.C., Pilapiiya, S.,

2007. Relation of waste generation and composition to socio-economic factors: A case study. Environ. Monit. Assess. 135, 31–9.
Barr, S., 2007. Factors influencing environmental attitudes and behaviors: A U.K. case study of household waste management. Environ. Behav. 39, 435–473.
Binder, C.R., Mosler, H.J., 2007. Waste-resource flows of short-lived goods in households of Santiago de Cuba. Resour. Conserv. Recycl. 51, 265–283.
C.Gibson, Wong, C., 2011. Greening rural festivals: Ecology, sustainability and human-nature relations, in: Gibson, C., Connell, J. (Eds.), Festival Places: Revitalising Rural Australia. Channel View Publications, Bristol,UK, p. 268.
Coffey, M., Coad, A., 2010. Collection of municipal solid waste in developing countries, UN Habitat. Nairobi, Kenya.
Contreras, F., Ishii, S., Aramaki, T., Hanaki, K., Connors, S., 2010. Drivers in current and future municipal solid waste management systems: Cases in Yokohama and Boston. Waste Manag. Res. 28, 76–93.
Damanhuri, E., 2012. The role of informal collectors of recyclable waste and used goods in Indonesia, Post-Consumer Waste Recycling and Optimal Production. Post-Consumer Waste Recycling and Optimal Production.
De Feo, G., De Gisi, S., 2010. Public opinion and awareness towards MSW and separate collection programmes: A sociological procedure for selecting areas and citizens with a low level of knowledge. Waste Manag. 30, 958–976.
Dinie, M., Samsudin, M., Don, M.M., 2013. Municipal solid waste management in Malaysia : Current practices ,challenges and prospect. J. Teknol. 1, 95–101.
Emery, A.D., Griffiths, A.J., Williams, K.P., 2003. An in-depth study of the effects of socio-economic conditions on household waste recycling practices. Waste Manag. Res. 21, 180–190.
Ferronato, N., D'Avino, C., Ragazzi, M., Torretta, V., De Feo, G., 2017. Social surveys about solid waste management within higher education institutes: A comparison. Sustainability 9, 391.
Godfrey, L., Scott, D., 2011. Improving waste management through a process of learning: the South African waste information system. Waste Manag. Res. 29, 501–511.
Gómez, G., Meneses, M., Ballinas, L., Castells, F., 2009. Seasonal characterization of municipal solid waste (MSW) in the city of Chihuahua, Mexico. Waste Manag. 29, 2018–2024.
Hazra, T., Goel, S., 2009. Solid waste management in Kolkata, India: Practices and challenges. Waste Manag. 29, 470–8.
Henry, R.K., Yongsheng, Z., Jun, D., 2006. Municipal solid waste management challenges in developing countries-Kenyan case study. Waste Manag. 26, 92–100.
Hsu, C., Sandford, B., 2007. The delphi technique: Making sense of consensus. Pract. Assessment, Res. Eval. 12, 1–8.
Hui, Y., Li'ao, W., Fenwei, S., Gang, H., 2006. Urban solid waste management in Chongqing: challenges and opportunities. Waste Manag. 26, 1052–62.
Johari, A., Alkali, H., Hashim, H., I. Ahmed, S., Mat, R., 2014. Municipal solid waste management and potential revenue from recycling in Malaysia. Mod. Appl. Sci. 8.
Johnson, B.H., Poulsen, T.G., Hansen, J.A., Lehmann, M., 2011. Cities as development drivers: From waste problems to energy recovery and climate change mitigation. Waste Manag. Res. 29, 1008–17.
Jones, N., Evangelinos, K., Halvadakis, C.P., Iosifides, T., Sophoulis, C.M., 2010. Social factors influencing perceptions and willingness to pay for a market-based policy aiming on solid waste management. Resour. Conserv. Recycl. 54, 533–540.
Kolios, A., Read, G., 2013. A political, economic, social, technology, legal and environmental (PESTLE) approach for risk identification of the tidal industry in the United Kingdom. Energies.
Le Courtois, A., 2012. Waste: The challenges facing developing countries. Priv. Sect. Dev. 15, 1–28.
Li, K., 2007. Study of influence factors in municipal solid waste management decision-making. (Master dissertation). Royal Institute of Technology, Stockholm.
Ma, J., Hipel, K.W., 2016. Exploring social dimensions of municipal solid waste management around the globe – A systematic literature review. Waste Manag. 56, 3–12.
Martin, M., Williams, I.D., Clark, M., 2006. Social, cultural and structural influences on household waste recycling: A case study. Resour. Conserv. Recycl. 48, 357–395.
McAllister, J., 2015. Factors influencing solid-waste management in the developing world. (Master dissertation). Utah State University, USA.
Moh, Y., Abd Manaf, L., 2016. Solid waste management transformation and future challenges of source separation and recycling practice in Malaysia. Resour. Conserv. Recycl. 116, 1–14.
Moh, Y.C., Abd Manaf, L., 2014. Overview of household solid waste recycling policy status and challenges in Malaysia. Resour. Conserv. Recycl. 82, 50–61.
Mohamad, Z.F., Idris, N., Baharuddin, A., 2011. Religion and waste. Waste Manag. 31, 1905–6.
Mohamad, Z.F., Idris, N., Baharuddin, A., Muhammad, A., Nik Sulaiman, N.M., 2012. The role of religious community in recycling: Empirical insights from Malaysia. Resour. Conserv. Recycl. 58, 143–151.
Mukhtar, E.., 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.
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.
Mull, J.E., 2005. Approaches toward sustainable urban solid waste management: Sahakaranagar layout. (Master dissertation). Lund University, Sweden.
Nunn, N., 2012. "It can be dangerous for the uterus": Hegemonic masculinity and cooperative recycling in São Paulo, Brazil. Gender, Place Cult. 0524, 1–17.
Pérez-Belis, V., Bovea, M.D., Ibáñez-Forés, V., 2015. An in-depth literature review of the waste electrical and electronic equipment context: trends and evolution. Waste Manag. Res. 33, 3–29.
Periathamby, A., Hamid, F.S., Khidzir, K., 2009a. Evolution of solid waste management in Malaysia: Impacts and implications of the solid waste bill, 2007. J. Mater. Cycles Waste Manag. 11, 96–103.
Periathamby, A., Khidzir, K.M., Hamid, F.S., 2009b. Drivers of sustainable waste management in Asia. Waste Manag. Res. 27, 625–33.
Perry, G.D.R., Williams, I.D., 2007. The participation of ethnic minorities in kerbside recycling: A case study. Resour. Conserv. Recycl. 49, 308–323.
Pickerin, P.L., Shaw, P.J., 2015. Age and aging as factors influencing waste management behaviour, in: 15th International Waste Management and Landfill Symposium. CISA Publisher, 5-9 October 2015, Sardinia, Italy.
Plata-Díaz, A.M., Zafra-Gómez, J.L., Pérez-López, G., López-Hernández, A.M., 2014. Alternative management structures for municipal waste collection services: The influence of economic and political factors. Waste Manag. 34, 1967–1976.
Ray, A., 2008. Developing Asia can trade and cooperation help ? J. Environ. an Dev. 17, 3–25.
Rudden, P.J., 2007. Report: Policy drivers and the planning and implementation of integrated waste management in Ireland using the regional approach. Waste Manag. Res. 25, 270–275.
Sembiring, E., Nitivattananon, V., 2010. Sustainable solid waste management toward an inclusive society: Integration of the informal sector. Resour. Conserv. Recycl. 54, 802–809.
Shaw, P.J., 2008. Nearest neighbour effects in kerbside household waste recycling. Resour. Conserv. Recycl. 52, 775–784.
Srdjevic, Z., Bajcetic, R., Srdjevic, B., 2012. Identifying the criteria set for multicriteria decision making based on SWOT/PESTLE analysis: A case study of reconstructing a water intake structure. Water Resour. Manag. 26, 3379–3393.
Storey, D., Santucci, L., Fraser, R., Aleluia, J., Chomchuen, L., 2015. Designing effective partnerships for waste-to-resource initiatives: Lessons learned from developing countries. Waste Manag. Res. 33, 1066–75.
Taherzadeh, M.J., Rajendran, K., 2014. Factors affecting development of waste management: Experiences from different cultures, in: Ekström, K.M. (Ed.), Waste Management and Sustainable Consumption: Reflections on Consumer Waste. Routledge, Croydon, p. 242.
The World Bank, 2015. World Bank country and lending groups [WWW Document]. URL https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries (accessed 4.1.17).
Thyberg, K.L., Tonjes, D.J., 2015. Drivers of food waste and their implications for sustainable policy development. Resour. Conserv. Recycl. 106, 110–123.
Triguero, A., Álvarez-Aledo, C., Cuerva, M.C., 2016. Factors influencing willingness to accept different waste management policies: Empirical evidence from the European Union. J. Clean. Prod. 138, 38–46.

Turner, D.A., 2016. Evaluating the life cycle climate impacts of solid waste management. (Doctoral dissertation). University of Southampton, UK.
Williams, I.D., Curran, T., Schneider, F., 2012. The role and contribution of the third sector in terms of waste management and resource recovery. Waste Manag. 32, 1739–41.
Williams, I.D., Shaw, P.J., 2017. Reuse: Fashion or future ? Waste Manag. 60, 1–2.
Wilson, C., Williams, I.D., Kemp, S., 2011. Compliance with producer responsibility legislation: experiences from UK small and medium-sized enterprises. Bus. Strateg. Environ. 20, 310–330.
Wilson, D.C., 2007. Development drivers for waste management. Waste Manag. Res. 25, 198–207.
Wilson, E.J., McDougall, F.., Willmore, J., 2001. Euro-trash: Searching Europe for a more sustainable approach to waste management. Resour. Conserv. Recycl. 31, 327–346. Zalengera, C., Blanchard, R.E., Eames, P.C., Juma, A.M., Chitawo, M.L., Gondwe, K.T., 2014. Overview of the Malawi energy situation and A PESTLE analysis for sustainable development of renewable energy. Renew. Sustain. Energy Rev. 38, 335–347.
Zaman, A.U., 2013. Identification of waste management development drivers and potential emerging waste treatment technologies. Int. J. Environ. Sci. Technol. 10, 455–464.
Zhang, N., 2011. Greening academia: Developing sustainable waste management at UK higher educational institutions. (Doctoral dissertation). University of Southampton,UK.
Zhang, N., Williams, I.D., Kemp, S., Smith, N.F., 2011. Greening academia: Developing sustainable waste management at Higher Education Institutions. Waste Manag. 31, 1606–16.
Zurbrügg, C., Schertenleib, R., 1998. Main problems and issues of municipal solid waste management in developing countries with emphasis on problems related to disposal by landfill, in: Third Swedish Landfill Research Symposia. Department of Water and Sanitation in Developing Countries (SANDEC) and Swiss Federal Institute for Environmental Science & Technology (EAWAG)., Lulea, Sweden, October 1998.