Considering Appropriate Decision Support Models for Construction and Demolition Waste Management Optimization: Possibilities and Limitations

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Abstract — *Significant number of modelling tools and methods that can be used for decision-support on C&D waste management at various levels have been developed. Examples of available management tools include Cost Benefit Analysis (CBA), Life Cycle Assessment (LCA), Risk Assessment (RA), Material Flow Analysis (MFA), Multi-Criteria Decision Analysis (MCDA), Decision Support Systems (DSS), System Dynamics (SD) and other types of optimizing models etc. Diverse range of different waste management methods that are available may be unclear or rather too complex to use. There is a growing concern and an urgent need to consider the appropriateness and attributes of using different waste management tools in different scenarios are required. Thus, the attributes considered in this paper focused solely on impacts categories and the entity under study. This paper focused on providing practical guidelines for selecting appropriate models for C&D waste management optimization and also finds a broader understanding of the opportunities and limitations with available modelling tools in order to achieve a realistic and a more sustainable decision-support approach to C&D waste management.*

Keywords - *construction and demolition (C&D) waste, decision support system, cost benefit analysis, life-cycle assessment, multi-criteria decision analysis, waste management*

I. Introduction

Globally, construction/demolition industry is considered one of the largest producers of solid wastes [1]. Over the years, C&D waste issues have received increasing attention from both practitioners and researchers around the world. Construction waste seems to have caused serious environmental problems in many large cities around the world over the past decades [2]. Significantly, C&D waste is generated from huge amounts of new build, renovation works, infrastructure and civil works which have been undertaken over the years as demolition of existing structures became more necessary [3]. Thinking about waste management from a limited perspective often result to environmental, economic and social concerns. This is because a significant amount of greenhouse gas emissions, time and monetary value are incurred on transporting, processing, recycling, reusing and disposal in landfill. Therefore, there is a need for a properly managed waste system to be established by considering appropriate waste management models.

A significant number of management theories, methods, approaches and modelling tools that can be adopted for decision support on C&D waste at various levels have been developed [4]. Some of these focused on the economic impact of C&D waste management systems in terms of recycling and reuse of C&W waste (e.g. Economic Theory, Equilibrium model, Cost-Benefit Analysis and Life Cycle Costing etc.) Other management tools concentrate on the environmental impact of C&D waste management systems (Life Cycle Assessment, Multi-Criteria Decision Analysis, Analytic Hierarchy Process etc.).

A wide range of different waste management methods that are available may be ambiguous and there is an urgent need to consider the appropriateness and attributes of using different tools in different situations. There is a growing interest in developing sustainable waste management models as these raise major concerns in the decision-making process [2]. Thus, decision support models often help policy makers to select and design sustainable and cost-effective waste management systems [5, 6]. A number of decision support models for C&D waste management can be found in literature [7, 8, 9, 10, 11, 12, 13, 14]. For example, the review of Calvo et al. [9] considers the Environmental Management System (EMS) based on regulation impact and economic incentives to develop 3Rs concept.

Bani et al. [4] reviews the development of decision support systems (DSS) and added that the various elements in developing the DSS must be integrated and optimized in order to produce a feasible model that is marketable and has practical application. Achillas et al. [8] on the other hand developed an inventory of decision processes based on multi-criteria decision analysis (MCDA) for different waste systems. Karmperis et al. [14] take a holistic view and discuss the decision support models commonly used in the solid waste management system. In Karmperis et al. [13] study, the authors closely examine the strengths, weakness and critical issues with four decision support models, which are the cost-benefit analysis (CBA), the game theory (GT), the life-cycle assessment (LCA) and the multi-criteria decision analysis (MCDA). The study concludes that the development of the bargaining game theory directly leads to all three pillars of sustainability (i.e. economic, environmental and social) and that two key areas such as optimal location of waste processing plant and optimal management strategy remains a central focus of the study.

Today, most available decision support models are getting increasing recognition in resolving complex solid waste problems. Yet, most these models are considered too complex and ambiguous in its capacity to demonstrate appropriateness and reliability during application. It is therefore imperative to find an understanding of the possibilities and limitations of available management models. This paper presents a review of available management tools and provides some valuable insights into selecting appropriate decision support model as well as discussing some key opportunities and limitations to the application of available waste management tools.

II. A Review of Waste Management tools

A significant number of waste management tools for assessing both economic and environmental impacts are available [15, 16, 17, 18]. Individual attributes for available tools are considered in this review as the study present an overview of management tools within the field of waste management. Thus, the attributes that will be used in this paper are the types of associated impacts and the entity under study. We intend to determine whether or not each available management tool can be classified as practical or systematic. Practical tools focus on hands-on procedures and links to its decision and social context. On the other hand, systematic tools focus on the technical aspects of the actual analysis [19]. Arguably, practical tools can be adopted within the framework of systematic tools [20].

Within the context of environment impact of waste management, both Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) are known and considered as practical tools. The EIA tool is used to predict the environmental consequences (positive or negative) of a plan, policy, program or project prior to the decision to proceed with the proposed action [21]. EIA is considered as a location-specific tool as compared to other management tools [22]. With this regard the project site locations and the greenhouse gas emissions are identified as EIA tool is commonly used to evaluate individual locations. SEA tool on the other hand is used to ensure that the environmental consequences of plans or programs (i.e. land use, traffic planning, site waste management planning etc.) are identified and gauged [23].

The SEA tool is used at the early stage of decision making for solid waste management. Both EIA and SEA are commonly known to be practical tools for solid waste management as compared to other systematic tools such as Life Cycle Assessment (LCA) and Risk Assessment (RA), which directly key parts of SEA process [24]. Thus, the use of SEA tool in waste management context is limited and it is often used for voluntary basis in few cases due to its practicality [23]. Examples of systematic tools are life cycle assessment (LCA), cost-benefit analysis (CBA), risk management (RA), multi-criteria decision analysis (MCDA) etc. Scholars at national and international level have made researches on C&D waste management economic and environmental impact [24, 25, 26], for example,

Banar et al. [27] use LCA tool to determine the optimum municipal solid waste by developing five different scenarios as alternatives to the current waste management system. Collection and transportation of C&D waste, a material recovery facility, recycling, composting, incineration and landfilling processes were considered in these scenarios as policy alternatives are investigated against associated environmental impact. LCA tool is often used to investigate the potential environmental impacts, throughout a product's life (i.e. from start to finish) [27]. The LCA methodology was first developed by ISO standard by considering four phases, namely, goal and scope definition, inventory analysis, (input/output), impact categories and interpretations [27]. Ulukan and Kop [13] conducted multi-criteria decision analysis (MCDA) of solid waste collection methods using LCA outputs. In this study, different solid waste collection methods are compared with fuzzy TOPSIS method, according to three pillars of sustainability (economic, social and environment criteria). This study limits measurement to economic and social and neglect environment criteria; however, the study further evaluates the environmental impact with the help of LCA.

TABLE I
LCA vs. MCDA model

LCA	MCDA
Use to understand trade-offs	Trade-offs and other complex issues
Systematic environmental management tool that analyses and assesses the environmental impact of a products/ process	Considers real world decision-making problems due to its complexities.
Use weighting factors to calculate LCIA	Use objective and subjective mapping to determine choice-based decision
Collects, organises, and evaluates quantified data useful for decision-making	Establish preference between options by reference to an explicit set of objectives that the decision making body has identified.
Decision-support system (sometimes evaluation are unclear enough to serve the purpose of comparative LCAs).	Clear and transparent methodology for decision-support system
Enables modelling, evaluation and comparison of different alternatives of products	Analyse the results of LCA of products. MCDA can be used to interpret LCIA

Evaluate decision on economic and environment impact	Use for analysing difficult scenario on environment impact such as Global Warming Potential (GWP), Human Toxicity Potential (HTP) etc.

The MCDA considers real world decision-making problems due to its complexities. The multi-criteria decision analysis has become a tool commonly applied to building waste management, allowing decision-makers to have deep understand of the problem, and suppliers alternative courses of action, from several viewpoints [28, 29]. Table I shows the comparison between LCA model and MDCA model. It is significantly beneficial to combine LCA with MCDA model in order to simplify basis understanding of trade-offs and multiple perspectives in the impact assessment [30].

TABLE II
ARRANGEMENT OF LITERATURE ON DECISION SUPPORT TOOLS FOR C&D WASTE MANAGEMENT

Authors	Type of decision support		Assessment Criteria			Modelling Orientation	
	Location - Specific	Treatment Systems/ processing	Economic/Financial	Social	Environment	Optimization	Universal decision support
Chen et al. (2002)		x	x		x	x	
Begum et al. (2006)	x	x	x	x		x	
Duran et al. (2006)	x	x	x				x
Hao et al. (2007)	x	x					x
Bani et al. (2009)		x	x	x	x	x	x
Ulukan and Kop (2009)	x	x	x		x	x	x
Bilec et al. (2010)		x			x	x	x
Milani et al. (2011)	x		x	x	x		x
Boufatech et al. (2011)	x	x			x	x	x
Achillas et al. (2013)		x	x	x	x	x	x
Coelho and De Brito (2013)	x	x			x		
Karmperis et al. (2013)		x	x	x	x	x	x
Calvo et al. (2014)	x	x	x	x		x	x
Abdelhamid (2014)	x	x	x		x	x	x
Chang and Pires (2015)		x	x	x	x		x

Milani et al. [30] conducted a multi-criteria decision making with life cycle assessment for material section of composites. This model is designed to deal with decision conflicts often seen among design criteria in composite material selection with the help of LCA methodology. The study found that simple MCDA model fully support trade-offs and design break-even points in large decision spaces as the decision maker's perspective over environmental, material performance and cost characteristics change during the design process. With the opportunities found with MCDA model, we found guidelines for selection of MCDA in literature [13, 31, 32]. Table III shows the guideline considered for the selection of MCDA tool.

TABLE III
GUIDELINE FOR SELECTING APPROPRIATE MCDA MODEL

Checklist for MCDA model	Guideline
✓	Determine the stakeholders of the decision process.
✓	Consider the cognitive nature of decision makers when choosing a particular preference clarification mode.
✓	Determine the key issues with decision identified by decision makers. If they will like to get an alternative ranking, then a ranking method is considered.
✓	Choose the multi-criterion aggregation (MCAP) procedure that can accurately accommodate the input information available for which the decision makers can easily give the required information
✓	The compensation degree of the multi-criterion aggregation procedure is an important aspect to consider and to explain to decision makers if he/she refuses any compensation, then MCAP will be rejected.
✓	The fundamental hypothesis of the method I to be met (verified), otherwise one should choose another method
✓	The decision support system which comes with the method is an important aspect to be considered when the time comes to choose a MCDA method

It is important to understand that these listed guidelines help many decision makers to evaluate the appropriate type of analysis suitable for the difference scenarios. Table II summarizes the key findings of the literature review. Universally, decision support for C&D waste management focus only on a few of the aspects listed in Table II. It is important to understand that decision support is based on complex estimation with the help of mathematical expression, assumptions, variables considered to be location or region-specific. The criteria used for selecting each potential treatment technologies are classified under four main groups: environmental and health performance, economic viability, technical efficiency and social acceptance [31]. Milani et al. [30] suggested that waste management treatment/processing using varieties of technologies should be able to assess the quality and quantity as well as the climatic conditions of individual location under study. Simonetto and Brenstein [33] develop a unique decision support model approach for solid waste management system flow. This paper focused on the conception, modeling, and the implementation of decision support system to the operational planning solid waste collection system. The system developed in the study attempt to generate alternatives to decision on allocation of separate collection vehicle and their travel distances as well as the determination of the daily amount of solid waste diverted to sorting facilities. The study suggests that full optimization process can be achieved if thorough investigation focused on reducing the amount of solid waste sent to landfill, assuring a waste input percentage at each sorting facility, estimating the work capacity of sorting facilities, assigning vehicles to collection trips, and finally defining their travel distances [33]. Other management tools include cost benefit analysis, risk management and material flow analysis, which a further discussed in this study.

Begum [34] carried out cost-benefit analysis (CBA) of on-site C&D waste reuse and recycling in Malaysia, by the statistical method, he pointed out that the total revenue of on-site C&D waste reuse and recycling operation is unruffled of the saved items such as: collection and transportation cost, purchasing cost, landfilling cost, sales income, separation costs, equipment costs, storage cost, and other tangible and intangible costs and benefits [34]. In contrast, Tam [35] carried out cost-benefit analysis on concrete waste disposal and recycling in Australia, by accounting and statistical method, and found that recycling concrete waste is more cost effective than disposal to landfill. CBA is commonly known as a systematic tool for assessing the total costs and benefits from a planned project. It is also known as a decision support tool that helps in defining scenarios for the feasibility of reuse and recycling C&D waste [34]. A number of economic assessments are carried out on a regular basis. Economic benefits gained from waste minimization and recycling are huge. For example, before decision-making is considered for many projects, an early start investment analysis is performed in order to determine the feasibility of embarking on individual project [36]. Calculating the costs of reuse and recycling and other diversion activities and comparing them with the disposal costs, a few studies also discussed the direct and indirect and indirect impacts of an increased level of waste diversion on the number of jobs created and sales of secondary (recyclable) materials [35, 36, 37].

Liu and Wang [37] conducted a location-specific cost analysis of C&D waste management in Pearl River of China. This study used detailed formulas for calculating costs of three typical kinds (landfill, recycling and reuse) of disposal routes of C&D waste.

Liu and Wang study shows that between 2010 and 2013 the region cost for landfill of C&D waste has increased as compared to the costs of recycling and reusing C&D waste form site collection waste management. The study suggests that the government should make proper compensations to local contractors to reduce waste disposal costs and promote C&D waste management.

Another economic-based study carried out by Jain [38] focused on the problem of construction waste and management awareness, techniques and practices in the Indian construction industry. This study evaluates the economic feasibility of construction waste management of projects in India. The paper used the cost-benefit analysis approach and found that costs are the key man determinants for decisions and choices for waste management technologies and practices. However, the study concludes that with proper site waste management, it is economically feasible to do significant cost savings from the whole process where total benefits of waste exceeds the total costs of reducing, reusing and recycling [38]. It is important to understand that optimization occurs typically with respect to financial implication such as costs and project risks. This led to the discovery of another important management tool found in literature - risk assessment, which is further discussed. Risk assessment (RA) tool is a holistic term covering different types of assessment. It is quite clear that risk assessment cut across many aspects, however, there is clear distinction between risk assessment of chemical substances and risk assessment of accidents. Risk of accident relate to unplanned incidents such as explosion and fire, which is contrasting to risk assessment of chemicals [39]. There is a growing interest in the environmental aspect of risk assessment [39].

Gao et al. [40] conducted environmental risk assessment of heavy metals in C&D waste from five sources (chemical, metallurgical and light industries, and residential and recycled aggregates). This study concludes that the risk assessment for specific chemical substances (Zn, Cu, Ni and Cr) found in C&D waste posed a very high risk while some substances such as Pb and Cd as a lower risk. Hu et al. [41] conducted a dynamic material flow analysis (MFA) for C&D waste in an urban housing system in Beijing. The effects on C&D waste flows of housing floor, per capital floor area, the concurrent consumption as well as wast stream of concrete were investigated. Authors considered and analysed three scenarios involving current trend, high GDP growth, and lifespan of housing system. The study concludes that the higher the GDP, the lower the 'per capital floor area' in future terms and that recycling is a better option. The study further implied that by prolonging the lifespan of dwellings, it is possible to postpone the arrival of the peak C&D waste. MFA is a very useful systematic tool commonly used in quantifying flows and stocks of materials or substances in a well-defined system [42]. Conversely, waste management systems are often closely linked to energy systems as significant amount of greenhouse gases are emitted through processing [27]. However, there are limitations in some cases on local level energy systems. A few studies have discussed energy systems modelling to integrated municipal solid waste management [43, 44].

Kostantinidis et al. [43] developed a generic energy system tools in the urban environment to examine the impact of urban form and layout on inhabitants behaviours, which determines the demands for various resources. This study used the energy system tool to study eco-town with a given layout and set of resources demands where these are compared with solid waste to landfill. Zhao et al [45] modelled and compared different demolition waste recycling and reuse centres in Chongqing based on system dynamics approach. This paper analysed the cost benefit of various consolidated waste and concluded that three key factors impact the cost benefit as further suggestions and recommendations to enrich waste management optimization were presented [45]. System dynamics is an approach to understanding the nonlinear behaviour of complex systems over time using stocks and flows; internal feedback loops ad time delays [45, 46]. System dynamics is considered to be mathematical modeling technique for framing, understanding and discussing complex issues and problems [45].Yuan et al. [46] developed a system dynamics modelling of demolition waste processing in Shenzhen. This paper analysed the sensitivity of each parameter in the waste system flow and concluded the significant trends with the cost-benefit curve of the disposal facilities. This study further recommends measures to enhance the key contributing factors. The different approaches can be described as systems analysis tools. Thus, the expectations of system dynamics tools often are quiet high, where this is sometimes unachievable. Arguably, choice of method can be considered wrong or right depending on the situation to be assessed. Also, data with system analysis tools often gives methodological uncertainties, which are significantly large and often leads to unclear conclusions and justifications. The choice of the appropriate decision support tool in different situations is largely considered by two key perspectives: 1) entity under study and 2) significant impact of concern [47, 49].

Table IV below shows the arrangement of different waste management tools discussed above with regards to these two key perspectives. The discussion presented in this paper focused on both environmental and economic impact categories, however, the types of entities discussed in literature are: projects, firms/organisation, programme, plan, policy, product/service, and chemical substance. Table IV can be used as guidelines in considering the appropriate decision support model for C&D waste management. For example, if there is a need to compare and contrast the environmental impacts of various policy options (i.e. recycling, incineration, landfill, reuse, and collection), a Life Cycle Assessment (LCA) and Multi-Criteria Decision Analysis (MCDA) would appropriate tools for such measure. Other tools such as EIA and SEA are reliable practical tools used for predicting environmental consequences (positive or negative) of a plan, policy, program or project prior to the decision to proceed with the proposed action. Thus, these two models often incorporate LCA and RA respectively in their evaluation process. For basic economic impact measurement for C&D waste management CBA tool would be an appropriate tool to be considered for such assessment. However, other economic tools are applied in relation to different situations and assessments. Despite the opportunities for various waste management tools, there are key limitations found in literature.

TABLE IIIV

MANAGEMENT TOOLS ARE SHOWN IN RELATION TO THEIR OPPORTUNITIES AND IMPACTS FACTOR. BOTH PRACTICAL & SYSTEMATIC TOOLS ARE DIFFRENTIATED BY BOLD & ITALICS TEXT. MODIFIED FROM FINNVEDEN AND MOBERG [45]

Type of Entity	Impacts		Mode/Approach	
	Environmental	**Economic**	**Optimization**	**Universal decision support approach**
Projects (construction and demolition works, manufacturing, civil works etc.)	**EIA**	*CBA* and other economic measure		*MCDA, DSS*
Organisation (firms, small business, Large-scale company, small-medium scale business etc.)	Environmental audits	Economic model/audits	*MCDA, AHP,* systems models of waste management	*MCDA, DSS,* System engineering
Chemical substance	*MFA, RA*	n/a	n/a	
Products/service	*LCA*	*LCC*		*LCA* with *MCDA*
Policy, programme and Plan	**SEA**	Impact Assessment	*RA*	

III. LIMITATIONS AND IMPLICATION TO PRACTICE

A. Possibilities to Predict the Future

Most decision support tools designed for waste management are often used to inform decision makers about policy options available for waste management optimization. Thus, these tools may inform decision makers about the prediction for possible or likelihood of direct impact of each decision made of various policy options. Decisions whether or not to recycle, reuse or disposal waste to landfill are weighted and ranked by decision makers in relation to impact measures. Waste management investments are known to be lasting operations to address both economic and environmental issues and concerns. For example, recycling and composting operations are considered to be viable as compared to landfilling, however, such investments depends on future development of advance technologies – the more technology involves the greater the energy use. This key limitation is considered in terms of energy use and the release of greenhouse gases, as it is almost impossible to predict associated costs as investment expands. The use of MCDA tool in few studies [12, 17, 28] has shown the possibility of uncertainty in measurement. The limitations found in MCDA techniques are that personal judgment and experience may be required to minimize uncertainty. Dealing with uncertainties within the MCDA framework required careful assessment and consideration in practice. As noted in Borhne [48], Ulukan and Kop [13], and Milani et al. [30] uncertainty is an important part when building a MCDA model. The common uncertainties in MCDA model are variations and lack of knowledge [30].

B. Composition of Various C&D Waste Materials

The knowledge of handling different types of C&D wastes composition and chemical substances, which maybe hazardous in nature pose significant limitations. Societal acceptance on how solid wastes are used, particularly chemical substances maybe limited and may create major challenge for assessment. This simply means that there might be possibility of lack of knowledge on content, characteristics and properties when construction and/or demolition materials end up as waste in combined state. There are tendencies that chemical substances are often diverted to landfill since the actual amount and content cannot be determined from its original source and this leads to the uncertainty that we cannot justify or make reliable assessments for the actual greenhouse gases released through the processes.

C. Scientific Perception of Different Processes

Although understanding is widely believed to be a (if not the) central aim of science, the philosophy of science has had surprisingly little to say about why certain things happen. With the knowledge of the content of waste stream, there are still limitations in practice around world. With the growing concern about global warming and basic environmental concerns, estimating actual greenhouse emission has become relatively impossible for future predictions. The use of management tool such as LCA model has its downside in terms of uncertainties in waste material flow system. In light of this, one can conclude the uncertainty in LCA model is scenario based – as different cases pose its challenges. This simply relate to different choices made e.g. waste material allocation, cut-off, etc. Thus, this can cause significant variation of results, which can be quantified through sensitivity analysis. However, model uncertainty creates key challenges for LCA model and this is as a result of insufficient knowledge of the mechanism of the studied waste system flow, becoming relatively impossible to quantify. Processing technologies often changes overtime as it directly or indirectly affect the output of the system within the assessment framework. This further prevents consolidated empirical data to be achieved when being investigated.

D. Criteria and Weighting of Impact Categories

Different management tools discussed above tend to measure various impacts by weightings against individual criteria set. For example, the MCDA tool sets goal and objectives, followed by criteria and further decomposes this into various alternatives/options, which are weighted against each other. Morrissey and Browne [7] argue that the allocation of weights are subjective and often affect end results. Finally, the authors pointed out that the MCDA technique limits to ease of approach as some aspect are very cumbersome and unwieldy. Also, the economic model and related environment assessment focused on cost benefit analysis and the economic value (weight) of major impacts on the environment [5, 21]. It is imperative that individual weighting technique developed can be disparagingly discussed and evaluated [5]. The limitations found in these methods in relation to impact measure are that the actual values cannot be determined as the outcome of most weightings are often criticised.

E. Possibilities of Having a Site Location-Specific Measure

There are a number of local and global impacts (i.e. noise and vibration disturbance, global warming, greenhouse gas, CO_2 emissions etc.) to C&D waste management. However, there are limitations to waste management techniques, approaches and models performed by various locations, regions and countries. For example, rate of production recycled and reused materials can varies from regions, locality/districts, construction sites etc. Waste systems are managed and investigated within a time frame by the help of LCA model where environmental impact measurement is incorporated. The technology used in such process may vary in other area and there is a need for many waste management facilities to be more location-specific and have broad system approach to fit into all types of waste management endeavours. This lead to the uncertainty in using diverse models for waste management in practice, and also it affects the definite conclusions in considering appropriate model for waste management optimization. However, Table IV provides guidelines for appropriate decision support models for various entities and scenarios of waste management.

IV. Conclusions

Considering appropriate decision support models for C&D waste management optimization can be very difficult in some cases. However, with careful selection criteria in place as discussed in the paper there will be tendency to apply the right model for the right C&D waste management scenario. This paper reviewed available management models and provided some key insights into selecting appropriate decision support model as well as it has discussed key opportunities and limitations to waste management decision support models. The study found that a number of studies have discussed models for decision making in solid waste management [8, 9, 12, 13, 18, 22]. However, in these studies, only a few have provided key guidelines in selecting appropriate models for decision making in solid waste management [22, 31, 32]. It is important to understand that waste management on it own is colossal and complex in nature to investigate.

Common models such as LCA, LCC, MFA, CBA, System Analysis/Dynamics, and MCDA have been found in literature with individual opportunities and limitations. LCA model among other models provides a more comprehensive analysis and assessment of environmental impact of a products or processes. LCA model helps in reducing the impacts of processing C&D waste system at designated facilities. MCDA tool on the other hand provides a clear and transparent methodology for making decisions and also offers a formal way for combining information from disparate sources. Both LCA and MCDA system tools are often used for trade-offs. However, the limitations discussed in this paper for these two models, along with valuable insights into careful consideration via guidelines provided will further enhance decision making during modelling tool selection process. Other practical tools such as EIA and SEA have been found useful in decision-making in predicting environmental consequences (positive or negative) of a plan, policy, program or project prior to the decision to proceed with the proposed action. The paper, however, suggests that the choice of individual models should be situational as demonstrated in table IV and that decision makers should play a key role in the selection process in order to appraise solid waste management at its full potential. Thus, basic assumptions in the use of some waste management models can be criticised and it may be difficult to use these as industry-wide systems for managing solid waste for all construction/demolition projects.

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