ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

DEPARTMENT OF INTERNATIONAL AND EUROPEAN ECONOMIC STUDIES

MSc in International Economics and Finance (Full Time)

Cost – Benefit Analysis for the Municipal Solid Waste Management Sector in the Hashemite Kingdom of Jordan

by
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Abstract

The intention of this thesis is to stimulate the interest of the reader on issues related to Municipal Solid Waste Management (MSWM) with special focus on developing nations and get involved with the methods used for the assessment of non-traded impacts a policy or an investment is expected to have. Specifically, a Cost Benefit Analysis and a Benefit Transfer Methodology have taken place, in order to study the case of Hashemite Kingdom of Jordan, which constitutes a developing country that needs intervention.

Key Words: Cost-Benefit Analysis, Benefit Transfer, Municipal Solid Waste Management, Sustainability, Economic Assessment, Hashemite Kingdom of Jordan.

1 Introduction

The environment and its functions are essential for the support of human activities and life. It provides humanity with goods and services that contribute to a qualitative standard of living and allows for their evolution, while on the other hand, the footprint human beings leave, is not the desirable one. Unfortunately, human activity most of the times, causes harm and damage to the natural resources and the environment and in many cases, the damage is irreversible. As a result, environment's preservation shall be a priority for every nation, while both the authorities (government) and the general society (citizens, institutions, NGO, etc) should promote an environmentally friendly way of living. Specific rules and instructions or laws with respect to the environment are needed, so that everyone behaves accordingly and their contribution to the preservation of the environment has a positive effect.

This thesis touches upon the issue of Municipal Solid Waste and its Management. Waste generation is a byproduct of various human activities[1], which has a great impact on the ecosystems, as well as on public health. It affects the air, the soil, the groundwater and the water in a negative way and its management is crucial to the sustaining of any form of life. What is more, the dangers related to health issues, are

[1] Industrial or Agricultural activities, households, Hospitals, Retail and Public sectors are the most important categories of waste generators.

of excessive importance and shall be seriously taken into account by the responsible Bodies.

The ability of any authority or organization in charge of the Municipal Solid Waste Management (MSWM) depends on various factors and is not always effective. Developing countries in contrast to developed ones, have to overcome various obstacles and difficulties in order to reach a sustainable level of MSWM. Such obstacles can be financial restraints, technical problems, legislative and institutional gaps or broader social constraints regarding traditions, religion and ethics. Sustainability can only be achieved if there is to be a thorough analysis of the driving or key factors related to the stages of the MSWM process, with respect to the special characteristics and potentials of the population and the physical attributes of the site of interest.

With regards to the Hashemite Kingdom of Jordan –the case study analyzed in Chapter 5, a developing nation, the aforementioned problems are indeed met, but there has been willingness on behalf of the Authorities expressed towards the improvement of the MSWM. The concerns about the improper management of the MSW, has led to the search for new methods that will prove to be more sustainable and environmentally friendly. Based on these grounds, eight (8) scenarios have been developed, each of which contain a number of treatment facilities (composting, recycling, sanitary landfilling, anaerobic/aerobic digestion etc.) that correspond to specific categories of the MSW of the Kingdom.

The purpose of this thesis, apart from presenting topics related to MSWM, is also to select the best scenario for Jordan. All the 8 scenarios should be evaluated in terms of their benefits and costs, compared and finally ranked and select the best scenario. An Economic Analysis was employed to produce the monetary values for the environmental and the social impact (in terms of welfare) that these 8 scenarios are expected to have, during the period 2017 -2034. Because a natural resource or service is not directly traded within markets, an analyst must extract the value of it through broadly used methodologies and assign to it a monetary value. Such methodologies are Travel Cost, Hedonic Pricing, Averting Behavior (known as revealed preference or market methodologies), as well as Contingent Valuation and Conjoint Analysis (known as stated preference methodologies) and the Benefit Transfer approach which

is further analyzed within this thesis, since it has been performed within the case study. On the other hand, the most common decision support tools are Life Cycle Assessment, Multi-criteria decision-making and Cost-Benefit Analysis, the pros and cons of which are presented in short. In order to reach to the selection especially for Jordan, apart from the Cost-Benefit Analysis which took place, also a Benefit Transfer methodology needed to be applied, for reasons presented thoroughly in Chapters 3 and 4.

2 Municipal Solid Waste Management (MSWM)

Municipal Solid Waste (MSW) has gained a lot of attention over the past decades, especially in the developing countries, revealing the urgent need for its efficient management. Its management is a responsibility of the local government and comprises a very complex task, which requires the interaction between numerous stakeholders in the public and private sectors, and also the appropriate organizational capacity (Schübeler, Christen & Wehrle, 1996).Waste generation is seen by many as a loss of the earth's resources, a byproduct of human activity that prohibits the nature's ability to manipulate (absorb and convert waste into non – hazardous compounds) the waste streams arriving at soil, water and air, deteriorating further the quality of its renewables (biodiversity, forests, water and soil, fish stocks) (McDougall, White, Franke & Hindle, 2008).

2.1 Municipal Solid Waste in Developing Nations: Definitions and Key Factors

A definition of the term "waste" can be: Waste is anything discarded by an individual, household or organization. As a result waste is a complex mixture of different substances, only some of which are intrinsically hazardous to health (Rushton, 2003). Economic development and an increase in living standards within developing countries, has led to an increasing demand for goods and services, resulting in the rising of the per capita municipal solid waste generation. Additionally, population

growth and rapid urbanization contribute significantly to the continuous rise in per capita waste generation (Minghua, Xiumin, Rovetta, Qichang, Vicentini, Bingkai & Yi, 2009). According to the regulations, management refers to the minimization at source, collection, transformation, reuse/recycling and disposal (Tinmaz & Demir, 2006).

The driving forces that have led to the need for waste management can be found in environmental and climate change issues, public health sector as well as in the institutional and public awareness framework or even in the importance of resource value of waste in human lives (Wilson, 2007).

2.2 Sustainable Development and Sustainability

Sustainable development has been incorporated into many levels of the societies in recent years, with the most dominant definition of the term "sustainability" given by the WCED (1987): to ensure that present generation meets its needs without compromising the ability of the future generations to meet their own needs (Ness, Urbel-Piirsalu, Anderberg & Olsson, 2007). Assessing sustainability is a crucial issue and there are two core questions among others, that need to be answered: first, how current operational systems for monitoring and reporting on environmental and social states can be integrated or expanded so as to provide decision-makers or policy-makers a more useful guidance for the transition toward sustainable development and second, how research, planning, monitoring, assessment and decision-support activities (or tools) can be treated interdependently and be integrated into systems for adaptive management and societal learning (Ness, Urbel-Piirsalu, Anderberg & Olsson, 2007).

2.2.1 Sustainability in Developing Countries: Constraints and Common Inadequacies

Developing countries need to overcome serious obstacles in order to follow a sustainable path with regards to their MSW. In contrary to developed countries, they continue to adopt simple methods of waste disposal such as open dumps (Berkun, Aras, Nemlioglu, 2005). It is widely known that poor waste collection and uncontrolled waste disposal, apart from environmental degradation, can and has put

human health in danger, causing serious diseases such as cholera or plague (Surat, India in 1994). In many developing countries collection coverage remains very low, allowing for concentration of large waste quantities on roadsides and generally in open dumps, deteriorating further the quality of the environment and posing threats to human health (Henry, Yongsheng, Jun, 2005; Wilson, 2007; Wilson, Velis & Cheeseman, 2006). When the collection of waste is not on a frequent basis, waste accumulated apart from revealing unpleasant odors and the possibility of flooding problems, they also attract rodent and insect vectors, which can further spread insect – borne – intestinal and parasitic diseases within a community (Al-Khatib, Arafat, Basheer, Shawahneh, Salahat, Eid & Ali, 2007; Zurbrugg, 2002). Also, the lack of legislative framework that sets the rules and standards for the handling of waste generated, as well as the limited funding and institutional capacity for such facilities shall be taken into account (Wilson, 2007). Local governments seem to find themselves settled to uncontrolled waste disposal (weak or underfinanced), despite of the fact that many acknowledge the dangers to the environment and public health deriving from uncontrolled waste dumping (Zurbrugg, 2002). Without sufficient information regarding regulations, planning and organization of waste management activities and because of financial restrictions, management systems that developing countries follow cannot be adequate (Tınmaz, Demir, 2006). In other words, cities of developing countries suffer from legislative, technical and operational constraints, that make existing systems inefficient (Minghua, Xiumin, Rovetta, Qichang, Vicentini, Bingkai & Yi, 2009).

2.3 Need for Change Towards a Proper MSWM

In economies where survival is threatened due to lack of the basics (water supply, food adequacy, sanitation facilities), the issue of waste management is not high in hierarchy, something that needs to change. The residents can become aware and change their perception towards the importance of a proper waste management scheme, by their involvement and / or the collaboration between the public and private sector (Henry, Yongsheng, Jun, 2005; Rathi, 2006; Wilson, 2007).

2.4 The Informal Sector

There are not few developing countries which host scavengers and waste pickers, who are mainly practicing separation and collection of recyclables. They are called the *"informal sector"*, since they are not registered as official workers , which means that they pay no taxes or social insurance fees, no trading license is required and generally, their contribution is not included in social welfare – criteria that any business activity must fulfill in order to be "formal" (Haan, Coad &Lardinois, 1998). Their whole activity of collection, separation and selling of the recyclable materials is of great importance to them and their families, the basis of their livelihoods (Wilson, Velis & Cheeseman, 2006). However, unavoidably they are exposed to various health risks because of the manual handling and the lack of appropriate equipment (Cointreau, 2006). They work in open dumps, where toxic and infectious materials, chemicals, pesticides, solvents, hospital waste (used bandages and needles for instance), broken glasses or other sharp objects lie on the ground. As a consequence, they run the risk of infection due to airborne bacteria or substances linger in the waste, respiratory and dermatological problems, injuries and cuts and there is always the (high) possibility of communicating diseases to the rest of the population. Thus, one can say that uncontrolled disposal of solid waste carries a high potential for environmental pollution (water, soil, air pollution), public health issues and other related problems such as landslide or explosion (Özeler, Yetiş & Demirer, 2006).

2.5 What a Successful Solid Waste Management Scheme Can be

All difficulties described above, can be met in almost every developing nation. The management scheme that can produce a substantial improvement in the situation of each country depends on specific characteristics: socio – economic, cultural, environmental and ecological, ethical etc. In order to suggest the most appealing waste management system, it is strongly recommended that among others, reliable information about waste quantities and composition and also the proportion that can be reused or recycled needs to be determined. Compliance with regulations, environmental protection and resource conservation, support of the local businesses and provision with raw materials, as well as job opportunities are valid goals that a management scheme shall encompass. These goals refer not only to the present

situation , but also to future trends (population growth, waste characterization) (Tınmaz, Demir, 2006). A successful SWM scheme shall satisfy three key features, to which analysts have reached by case study analyses (Zurbrügg, 2013) and are:

- *Effective organizational structure*, which includes clearly defined goals and objectives, strong forward looking leadership and skilled, motivated and continuously trained staff, operation under the principles of entrepreneurship, commitment to a high quality of service, customer care, accountability, transparency, and equity.
- *Viable business model and financially sound setup,* which refers to a well-developed business plan, capable of mobilizing capital investment, which adapts well-conceived sustainable mechanisms allowing for capital and operational costs recovery through reliable revenue sources over a long-term period.
- *Endorsement by government and compliance to legislation*, meaning that the project is recognized by the government as an integral part of the overall strategy and is in accordance with national laws, regulations, standards.

2.6 The Process of Waste Management and Solid Waste Categories

The management of waste is being described as the process of collection of waste generated, its processing, transport and final disposal. The whole process is of great importance to be accepted and implemented by any community, due to public health, aesthetic and environmental reasons. According to the UK Environment Agency, waste can be classified into two categories: controlled waste and non-controlled ones. By controlled waste, we refer to households waste (MSW), commercial and industrial organizations waste and waste from construction and demolition. On the other hand, uncontrolled waste can be those from agricultural activities, dredging operations, mines and quarries. Generally, all the aforementioned types of waste (depending on the generator - sector) may consist of food or garden waste, recyclables such as paper / cardboard, plastics, metals, glass, textiles, chemical or mineral waste, slurry and farmyard manure, significant quantities of straw, silage effluent, vegetable and cereal residues (Rushton, 2003).

2.7 Treatment Methods

For each type of waste a specific management method can be the most appropriate. For instance, recyclables can be treated separately in special units in order to be recovered. At this stage, it is worth describing the major *methods of municipal solid waste management* that are widely used in both developed and developing economies, but to a different extent, depending on various factors. These methods are recycling, composting, incineration and landfilling (Rushton, 2003). Each one of them has both its advantages and disadvantages that shall be taken into account by a policy maker or any authority in charge of municipal solid waste management (MSWM).

2.7.1 Composting

Regarding *composting*, it is broadly accepted as an appealing treatment method for the organic fraction of municipal solid waste stream. It is argued that as a cornerstone of sustainable development, it should be a more widespread practice especially in developing countries, where up to 50% of the total quantities of waste is organic. It should be considered as a part of an integrated management strategy with processes based on market opportunities, economic feasibility and social acceptance (Hoornweg, Thomas & Otten, 1999).

The benefits this treatment method provides are various and multidimensional. Specifically, the fact that organic waste is being removed from the total municipal solid waste stream, allows for less waste quantity to be disposed of. Besides, recycling and incineration operations can be enhanced by the divergence of organic matter. The low capital and operating costs makes it an inexpensive process, a very strong argument for composting facilities in developing economies. Departing from its direct effects, the valuable soil amendment it produces, can contribute significantly to the agricultural sector of a nation and the potential integration of the existing informal sector can give rise to the employment rates. Finally, provided that all processes and mechanisms are acknowledged and understood, composting reduces greenhouse gas (GHG^2) impact and as a result, health risks weaken.

[2] Aerobic and anaerobic decomposition of organic matter releases landfill gases (LGs) – a major source of Greenhouse gases (GHG), which deteriorate the global warming and ozone depletion

On the other hand, there are concerns related to composting. Biological processes require more attention and composting is closely dependent on externalities that affect the quality and the accounting prices of the final compost product. Such externalities have to do with soil erosion, water contamination, general climate change and avoided disposal costs. Also, nuisance potential because of odors or rodents, inadequate pathogen and weed seed suppression, absent or limited marketing experiences and planning for the final product, poor integration with agricultural communities and the priorities municipality authorities set for the MSW management (priority given to waste collection) raise concerns about its suitability. Finally, support of incentives for fertilizers or emphasis on capital intensive projects can prevent the implementation of composting facility.

2.7.2 Recycling

Recycling comprises an advantageous option for waste management. It has demonstrated significant environmental advantages over the alternatives of landfilling and incineration (Denison, 1996). It is a method used more in the developed nations than in the developing ones. Still, there has been interest towards recycling by municipal authorities of developing countries.

Its positive attribute to the environment lies on the reduction of atmospheric emissions of several gases (CO_2, CH_4, CO, NO_x, SO_2). Due to its application, energy as well as raw materials requirements stay in low levels and in addition, the output of solid waste is the lowest (recovered rather than virgin materials are used in manufacturing) (Denison, 1996, Denison & Ruston, 1990).

As far as recycling's drawbacks are concerned, it can be said that this method is the primary source of various substances such as aldehydes, ammonia, carbon monoxide, hydrocarbons, organics and particulates (Denison, 1996). Its operations produce wastes in the form of releases to air, water and soil, and as a result its environmental impact cannot be ignored (Denison & Ruston, 1990).

problems [Hoornweg, D., Thomas, L., & Otten, L. (1999). Composting and its applicability in developing countries. World Bank Working Paper Series, 8].

2.7.3 Landfilling

Landfilling is intensively present in low – middle income countries, despite the fact that its disadvantages overweigh its advantages. Solid waste disposal in landfills remains the most economic solution, a trait that will keep it the most attractive route for solid waste disposal (El-Fadel, Findikakis & Leckie, 1997).

It is an unsophisticated and inexpensive method compared to other alternatives and encompasses the potential for future use of the land where it is located. For instance, many landfill sites are converted to parks, golf courses, agricultural fields or even commercial places (El-Fadel, Findikakis & Leckie, 1997). Gas emissions a landfill site yields, can be recovered for beneficial purposes (there is not only *gas* but also *leachate* formation potential). However, it is difficult to acquire and measure the quantity of produced gases, because of uncertainty of gas collection methods, lack of reliable and uniform data collection protocols and also because of the complexity of biochemical interactions within a landfill (El-Fadel, Findikakis & Leckie, 1997).

With regards to aversion towards this option of waste management, various reasons can be presented. Concerns regarding the environment and public health have been raised, leading to the search for alternatives and a decline in landfilling (Denison & Ruston, 1990). Landfilling has been accused as the primary source of methane (Denison, 1996). What is more, during the process of aerobic decomposition, which starts at the time of waste disposition in a landfill site, with oxygen's presence, carbon dioxide is produced (methane and carbon dioxide concentrations are the highest among other components of gas composition released from landfills, while oxygen and nitrogen exist in small quantities). This depletion of oxygen has set the seeking for alternatives and in specific the substitution of aerobic decomposition with anaerobic (El-Fadel, Findikakis & Leckie, 1997). Besides, it poses detrimental risks to the environment and consequently to the health of the public. Contaminated leachate is being released from landfills, which ends up directly into groundwater or indirectly into surface water. Air emissions and explosive gases are also to be taken into account. There have been numerous incidents of explosions and fires stemming from gas migration away from landfills reported in the literature (MacFarlane, 1970; Environ, 1975; McOmber and Moore, 1981; Parker, 1981; Shafer, Renta-Babb, Bandy, Smith, & Malone, 1984; Raybould and Anderson, 1987). Decaying landfills'

leachate usually hosts hazardous chemicals, including metals such as lead, cadmium and mercury and organic chemicals such as benzene, vinyl chloride and tetrachloroethylene. Apart from all these hazardous elements, volatile and carcinogenic compounds shall be mentioned (tetrachloride, chloroform, benzene) (Denison & Ruston, 1990).

2.7.4 Incineration

Incineration is rather a waste processing technology which limits the amount of waste to be disposed of. Again, environmental concerns come in the forefront when this method of management is proposed for the manipulation of waste quantities.

Incineration technology creates air pollution and leaves a substantial portion of toxic ash and other dangerous constituents for both the environment and public health. Its byproducts can have adverse health effects on the residents of nearby cities such as birth defects or neurological development problems, while vagueness still remains regarding incineration's contribution to cancer (though several incineration pollutants have non-carcinogenic health effects) (Denison & Ruston, 1990). Direct inhalation of toxic emissions that incinerators release and the ingestion of contaminated food crops, shall be enlisted as health risks due to incineration plants.

2.8 The Importance of an Integrated Approach and Management Scheme

Whichever municipal solid waste treatment (method or technology) is to be chosen by an authority in charge of MSW management, there are two myths related to solid waste management to pay attention to: no waste management provides workable solutions unless awareness of waste's individual components does exist and secondly, no single method can manage the entire stream of waste. A rational argument could be that waste stream contains various materials, some of which are readily recyclable (recycling), others that can burn (incineration) and others that should best be buried (landfilling)) (Denison & Ruston, 1990). Hence, any approach to MSW management has to be comprehensive or integrated in order to produce reliable results. In other words, it is of great importance to evaluate the impacts of a MSWM system

considering all the processes involved and achieve the goal of sustainability, the balance between environment, economy and society (Diaz & Warith, 2006).

Interestingly, the term "integrated" was first associated to waste management during the 1970s and since then it has undergone various changes of interpretations or definitions (Wilson, Velis & Rodic, 2013). Indicatively, integration according to the waste hierarchy principles, suggests that a combination of waste prevention or reduction, reuse, recycling or composting, energy recovery and disposal takes place (Heimlich, Hughes & Christy, 2007; Memon, 2010; Consonni, Giugliano, Massarutto, Ragazzi & Saccani, 2011). Another approach of integrated sustainable waste management takes into account not only the waste hierarchy, but also the stakeholders involved and the "enabling environment". By "enabling environment" we mean political, social, economic, financial, institutional and technical aspects taken into consideration (Schübeler, Christen & Wehrle, 1996; van de Klundert & Anschütz, 2001). A great part of the literature recognizes four principles from where the integrated solid waste management (ISWM) concept starts. These are equity, effectiveness, efficiency and sustainability (van de Klundert & Anschütz, 2001). Equity entitles all the residents to an ISWM system which has to be effective in terms of safe removal and treatment of the waste quantities. A waste management system shall also be sustainable, meaning that it is technically, environmentally, economically, financially, institutionally and politically feasible and most importantly, it must have the ability to maintain itself and the resources upon which it depends over time. Finally, its overall performance has to be efficient, which simply implies that taking into account the other three principles, the waste management is done by optimizing the use of resources (without exhausting them), maximizing related benefits and minimizing any costs (van de Klundert & Anschütz, 2001).

3 Benefit Transfer

The natural environment provides societies with ecosystem services that support human activities. The term "ecosystem services" refers to the benefits human obtain from the ecosystems. These can be classified in provisioning services such as food, water and other materials obtained from the ecosystems, regulating services for floods, droughts or diseases, cultural services which refer to non-material or spiritual benefits and recreation and finally, supporting services, such as nutrient cycling and soil formation (Liu, Costanza, Farber & Troy, 2010). Valuing (in monetary terms) the importance of those ecosystem services is a challenging task, which in addition requires that a human society acknowledges the value of the natural capital.

3.1 Ecosystem Services Valuation (ESV)

Ecosystem Services Valuation (ESV) can be described as a method of assessing the contribution of ecosystem services in terms of sustainability, fair distribution among residents as well as between residents and other species and efficient allocation of resources and their services (Liu, Costanza, Farber & Troy, 2010). Their purpose is to reveal the total economic value of a natural resource for the residents of a site. Table 1 presents the "Total Economic Value" framework:

TOTAL ECONOMIC VALUE				
Use Values			**Non-Use Values**	
Direct Use	Indirect Use	OptionValue	Bequest Value	Existence Value
Outputs directly consumable	Functional benefits	Future direct and indirect values	Use and non-use value of environmental legacy	Value from knowledge and continuous existence
✓ food ✓ biomass ✓ recreation ✓ health ✓ increased living comfort	✓ flood control ✓ storm protection ✓ nutrient cycles ✓ carbon sequestration	✓ biodiversity ✓ conserved habitats	✓ habitats ✓ prevention of irreversible change	✓ habitats ✓ species ✓ genetic ✓ ecosystem

source: based on EFTEC/RIVM, 2000

Table 1: Total Economic Value Framework (Jantzen, 2006)

3.2 Valuation Methodologies

Various valuation methodologies (under utilitarian or non-utilitarian approach) have been developed that quantify the benefits (or costs) supplied by ecosystem services, while the selection of the method to be applied depends on data availability and on the characteristics of each case of consideration (Alcamo & Bennett, 2003).

Namely, in the category of *revealed* preference approaches the most common methods are Travel Cost, Hedonic Pricing, Averting Behavior / Defensive Expenditure and Cost of illness, known as Market Methods. They are called "Market Methods", because they make use of market-based data that show actual behavior, purchases that have taken place in *actual markets*, revealing how a non-market good has been valued.

In the category of *stated* preference approaches on the other hand, Contingent Valuation and Choice Modelling or Conjoint Analysis can be found. These studies design questionnaires referring to a *hypothetical market*, in order to elicit the value attained to a non-market good (via WtP or WtA) or rank different proposed policy options or investment projects (Liu, Costanza, Farber & Troy, 2010; Pearce, Atkinson & Mourato, 2006).

Besides, there is the *Benefit Transfer* approach which can serve cases where ESV information or data about a policy site are either scarce or do not exist (Liu, Costanza, Farber & Troy, 2010). A thorough analysis of this methodology based on the

literature follows. Table 2.2 includes the main strengths and weaknesses of the stated and revealed preference methodologies:

Stated Preference		**Revealed Preference**	
Strengths	***Weaknesses***	***Strengths***	***Weaknesses***
– Flexibility to control for many variables including risk context – Can elicit preferences for non-observable attributes – Can be representative of population if well designed	– Based on hypothetical behaviour – Lack of systematic responses to very small risk changes	– Based on actual behaviour – Some research finds consensus that wage is responsive to risk	– Context-insensitive, but risk valuation is context-sensitive – Some research finds that the wage-risk relationship is spurious – Difficult to account for non-risk determinants of wage variation – Panel data only gives cross-individual rates of substitution – High transaction costs means that workers not at wage-risk equilibrium – Wage-earners are not representative of the population – Estimates are distorted by the gap between real and perceived risks

Table 2: Strengths and Weaknesses of Stated and Revealed Preference Methods

3.3 Benefit Transfer

Benefit Transfer can be described as a method which uses results from pre-existing research to predict estimates about the welfare of a site (or more than one sites) that needs a policy intervention, but no primary valuation estimates are available for that site of policy significance (Johnston & Rosenberger, 2010). Other definitions of benefit transfer technique can be found in the literature too: the application of values or other information obtained by a study site in order to be used at a policy site with limited or no data (Rosenberger & Loomis, 2000) or the practice of adapting estimated values from past research in order to assess the value of a similar change in a different resource (Smith, Van Houtven & Pattanayak 2002) or a method that takes value estimates from original studies and adjust them to be used in a new context (Hanley, Wright & Alvarez-Farizo, 2006) or finally, the transfer of existing estimated non-market values to a new study different from the study for which values were originally estimated (Kirchhoff, Colby & LaFrance, 1997). The site from which

values are obtained is called the study site and the destination site is called the policy site (Plummer, 2009). The policy site needs to be studied and the study site has already been studied, making information in the form of values, available for other economic analysts. Its importance has been increasingly recognized by a substantial portion of the literature (Bergstrom and DeCivita, 1999; Smith et al., 2002; Griffiths and Wheeler, 2005; Hanley, Wright, & Alvarez-Farizo, 2006; Iovanna and Griffiths, 2006; McComb, Lantz, & Rittmaster, 2006; Rolfe & Bennet, 2006; Colombo and Hanley, 2008), since its time and cost-effectiveness is acknowledged (Liu, Costanza, Farber & Troy, 2010).

Although the results from a primary research are preferred, time and financial constraints, such as funding and the high cost, prohibit the conduct of an original valuation study (Johnston & Rosenberger, 2010; Rosenberger & Loomis, 2000; Hanley, Wright & Alvarez-Farizo, 2006; Bergland, Magnussen & Navrud, 2002; Plummer, 2009; NRC, 2005). As a result, in many cases not the "first best", which is a primary research, but the "second best" option, which is the Benefit Transfer technique, applies (Rosenberger & Loomis, 2000b; Liu, Costanza, Farber & Troy, 2010). Under such circumstances, Benefit Transfer seems to be the only option for estimating non-market values (Johnston & Rosenberger, 2010; Griffiths and Wheeler, 2005; Iovanna and Griffiths, 2006).

3.4 Skepticism Over Benefit Transfer's Reliability

Despite its acceptance by some authors, there is a number of papers and a part of the literature, where controversy issues regarding its reliability, methods and other shortcomings are born, while there is a widespread agreement that the development of studies on theory and methods shall be conducted (Wilson & Hoehn, 2006), in order to get more sophisticated techniques. Another area of divergence between academic researchers and policy practitioners is the role of available valuation databases. Environmental Valuation Reference Inventory (EVRI) for example, is an internet database including results from empirical studies about economic values of environmental costs and benefits and human health effects (Johnston & Rosenberger, 2010). EVRI database hosts a substantial number of study entries, each of which contains a summary of the relevant study (area, population, method, results),

providing researchers with useful material and what is more, the search cost is reduced (Pearce, Atkinson & Mourato, 2006). Nonetheless, studies that are designed to test the appropriateness of Benefit Transfer are needed, since they will serve as a guide to authorities in charge of a policy or investment application (Bergland, Magnussen & Navrud, 2002). What is more there has been divergence evidenced between methods and protocols suggested by the academia and the policies applied by analysts (Boyle and Bergstrom, 1992; Wilson and Hoehn, 2006; Colombo and Hanley, 2008), a reality that can be attributed in some degree to the confusing guidance by the government agencies.

3.5 How a Benefit Transfer Methodology Can be Conducted

There has been a broad classification of the ways a Benefit Transfer can be realized. The options offered are: (1) the transfer of fixed or unit values obtained from the study site(s), (2) adjusted to the policy site values and (3) function transfer. OECD proposes an even broader and more specified categorization of transfer methods: (1) naïve unit value transfer, (2) unit value transfer with income adjustments, (3) unit value transfer according to age groups, (4) benefit function transfer from only one study and (5) benefit function transfer by meta-analysis (OECD, 2012). In all the aforementioned categories, a special approach can be added, this of meta-analysis.

3.5.1 Meta-analysis Approach

Meta-analysis collects the results of WtP values of a large group of studies for instance and takes an average value – often weighed – which is then applied to the policy site context. Instead, whole functions rather than average values can be transferred, functions which again are obtained from collections of studies (Pearce, Atkinson & Mourato, 2006). Unit value transfer may involve the use of an unadjusted value or an adjusted one, based on observable attributes of the policy site, such as income data (Ready & Navrud, 2007).

3.6 Benefit Transfer and its Validity and Reliability

Again, there is a debate on whether function transfer performs better than unit (adjusted or not) transfer, although no relevant conclusions have been reported (Brouwer, 2000; Ready, Navrud, Day, Dubourg, Machado, Mourato & Rodriquez, 2004; Brouwer & Bateman, 2005a). By the function transfer approach generalization errors – assuming that the study and policy site belong to a broader group with a set of specific characteristics and so they can be treated equivalently – can be reduced (Loomis 1992; Kirchhoff, Colby & LaFrance, 1997; VandenBerg, Poe & Powell, 2001). Nevertheless, one may suggest that estimate values from pooled data (more than one study site) can produce smaller transfer errors than estimate values based on a single study. A rational interpretation might be that when suggesting a Benefit Transfer based on a single original study, it is likely that the results after application will be less valid compared to values based on a set of broader evidence from a collection of relevant studies (Pearce, Atkinson & Mourato, 2006). Arguments for or against the options provided (value or function transfer) are found throughout the literature. For instance, Loomis (1992) stated that the similarity between the policy and the study site might not be needed in case of function transfers, while Johnston (2007) and Colombo & Hanley (2008) said that in order to have a reliable function transfer the dependence on the choice of the study site will determine the accuracy of the results. Thus, various opinions and conclusions regarding the most appropriate way are available.

Yet, it is commonly identified that there has arisen the need for further "investigation" of theory and standards for the establishment of models and protocols that formalize Benefit Transfer practices (Boyle and Bergstrom, 1992; Brookshire and Neill, 1992; Desvousges, Johnson & Banzhaf, 1998).

3.7 Benefit Transfer Methodology

According to Environment Protection Agency (EPA, 1993, 2000), three steps have been developed as guidelines to economists or analysts:

Step 1: Careful description of the policy site and the policy or investment proposed. This description refers to physical and biological characteristics, expected uses of the

site by the population affected by the intervention, any non-use connection the population may have with the environmental good under consideration and of course the extent of the population affected by a policy or investment.

Step 2: Selection of the most suitable studies that already exist to serve as a basis for the Benefit Transfer application. The correspondence between the sites (study and policy ones) in terms of similar characteristics, type of use and non-use connections, extent of the change anticipated by a policy or investment has to be examined. If there is a satisfactory degree of similarity, then the correspondence has been achieved and the accuracy of the transfer can be ensured (Rosenberg & Philips, 2007). Also, it is of great importance for the data gathered to meet the usual quality criteria which are adequacy, soundness of economic method applied and correct empirical technique (Plummer, 2009).

Step 3: The analyst derives value estimates from the data collected (based on the existing studies chosen in step 2) and applies the results properly to the policy site (unit value transfer – adjusted or not- or function transfer).

Alternatively, for Ecosystem Services Valuation in specific, the steps proposed by Freeman (2002) are summarized in four steps as follows:

(1) In what way and by how much a policy or an investment is going to affect the structure and functions of the ecosystems of the site under consideration .
(2) What rearrangements regarding the flow of the ecosystem services are going to take place.
(3) Place a value for each of the changes anticipated, such as WtP (this is where Benefit Transfer can be used).
(4) Finally, aggregate the (WtP) values for the total population affected by the policy or investment.

In a generalized context, the steps of the methodology adapted in a Benefit Transfer can be described, based on the Milligan, Kopp, Dahdah & Montufar (2014) approach. Specifically, the first step is to decide on the value estimates (databases or original studies) to be used and then disaggregate them by income level. Then, a quality screening to those disaggregated estimates has to be applied, in order to assess the

appropriateness of the study site(s) value estimations. Finally, select an appropriate model specification and regression approach.

3.8 Benefit Transfer in a Socio-economic Context

Benefit Transfer often falls short to serve as a reliable technique that helps policy makers make a decision. In a socio-economic context, the population of the study site may differ significantly from the population of the policy site in terms of income, education or other demographic or socioeconomic characteristics. This means that each site may not value environmental impacts stemming from a policy or investment the same. Also, another critical factor is the opportunities each site provides to its habitants. In other words, it can happen that individuals' preferences for recreation are the same in both sites, but the opportunities might not (Bergland, Magnussen & Navrud, 2002). In a such framework, when unadjusted unit values are to be transferred, then the results are not the most accurate ones. Thus, the aforementioned issues can render Benefit Transfer's reliability and accuracy under question. The same problems arise when adjusted unit values or the entire valuation function is to be transferred. Again, there may be differences in the change in the environmental quality due to a policy or investment, differences in the socioeconomic and demographic background of each site or even difference in the composition of their markets (availability of substitute goods and services) (Bergland, Magnussen & Navrud, 2002).

There is a dependence between the study site estimates and the demand functions of site visitors or generally the user population affected. These demand functions reflect specific socioeconomic characteristics of the individuals, their preferences, price and substitutes availability in each site. Putting it differently, if there is lack of correspondence between the sites considered, then transfer errors are to arise (Plummer, 2009).

On these grounds, economists would expect differences between the study and policy sites, due to the fact that the aforementioned factors cannot be identical across the sites (Kirchhoff, Colby & LaFrance, 1997).

3.9 Benefit Transfer at an International Level

The above problems are present more intensely when Benefit Transfer is applied between sites in a developed nation and a developing one, increasing the uncertainty about the validity of the transfer. In an international context, there have to be various adjustments and challenges arise. These can refer to currency corrections, purchasing power parity or income (Ready & Navrud, 2006).

3.9.1 Challenges

As far as challenges when conducting a Benefit Transfer at an international level are concerned, various factors needing attention are encountered. A thorough enough description follows according to Kirchhoff, Colby & LaFrance (1997).

First, about currency conversions, it is worth mentioning that even if two countries use the same currency, corrections should be made by the help of the exchange rate between the currencies.

This can be explained if we think in a willingness to pay (WtP) framework as described by Kirchhoff, Colby & LaFrance (1997) :

Considering two individuals, with the same preference structure over consumption of market goods, living in countries A and B. Let Q be the level of available public goods and β the exchange rate between the currencies. WtP for a change in Q (from Q_o to Q_1) of each individual would be the same in *real* terms if:

$WtP_B = \beta * WtP_A$, $p_B = \beta * p_A$ and $I_B = \beta * I_A$ **(1)**

where I stands for the income level and p stands for the market prices the individuals face and also indirect utility functions (*homogeneous of degree 0*) are defined as : $V(I_A, p_A, Q_o) = V(A_A - WtP_A, p_A, Q_1)$. Equation (1) simply states that identical individuals who use different currencies will have equal real WtP, only if they face the same real market prices (p) and have the same real income (I). More specifically, the exchange rate adjusted for purchasing power parity[3] (PPP) is applied, which

[3] PPP – adjusted exchange rates can differ from financial exchange rates, offered in international financial markets, Kirchhoff, S., Colby, B. G., & LaFrance, J. T. (1997). Evaluating the performance of benefit transfer: an empirical inquiry. Journal of environmental economics and management, 33(1), 75-93

shows how much of each currency is required to buy the same amount of market goods. Willingness to pay method is favored, because it includes intangible dimensions and the preferences of the individuals (users or consumers), based on stated or revealed preference methods (Milligan, Kopp, Dahdah & Montufar, 2014). *Second*, different users measure differently the attributes of a policy or an investment. An environmental good is valued based on three sets of factors: the characteristics of the good itself, the context within which it exists and the traits of the population (users) that values the good. Thus, when choosing a study or a set of studies employed for an analysis at the policy site, similarity of the goods studied and of the general context is at least necessary. As for the characteristics of the population, the most striking issue is income differences. These can be adjusted by multiplying unit values by the ratio of income or GDP per capita in the policy and the study country. This approach assumes a proportionality between WtP and income level, which not always holds according to studies. A widely used formula for income adjustment is :

$$WtP_P = WtP_S * (Y_P/Y_S)^e \qquad \textbf{(2)}$$

This expression (2) adjusts the WtP value from a study site for the policy location by multiplying the former with the ratio of income levels of the policy and the study site, taking into account the income elasticity (e) of WtP (Pearce, Atkinson & Mourato, 2006).

A *third* issue has to do with the distinction between income and wealth. When conducting a Benefit Transfer within a country's boundaries (intra-country Benefit Transfer), the assumption that annual income is an approximate of wealth is used. But this assumption does not hold for inter-country Transfers, due to institutional or cultural differences (taxation system, health care, education, retirement system).

Culltural differences (cultural heritage, shared values and experiences, religion or even health status) – the *fourth* factor - are of great importance when choosing the countries from which values are to be obtained, since individuals develop various preferences and behaviors, assessing differently an environmental good, according to their culture.

As a *fifth* factor the extent of the market can be listed. By this, it is implied that geographic location must be taken seriously into account. The distance decay in value

is usually observed (different values for an environmental good depending on the distance from it – for example a lake, river, a forest, a park in a neighborhood etc). Finally, the critical question is whether values should be adjusted when transferring from site to site, but not much research has been dedicated to find answers.

3.9.2 Conclusions

In an inter-country framework, Benefit Transfer that makes use of the WtP, may need to make adjustments for patterns related to currency conversion, wealth and income measures, cultural differences, user attributes and extent of the market in the country of interest (Ready & Navrud, 2006).

For these reasons, it can be said that it may be better to avoid Benefit Transfer application between countries and limit it within a country (Czajkowski & Ščasný, 2010). Intuitively, it is more preferable that the study site is to a close distance to the policy site, because in that way it is more likely that both the user population affected and the "good" or resource being valued will be similar (Ready & Navrud, 2007). On the other hand though, international Benefit Transfer is being encouraged because it allows for a wider basis of original research and also comprises an important reference point for less developed and transitioning economies, which may lack national primary valuation studies of good quality (Ready & Navrud, 2006).

Not surprisingly, the greatest bulk of valuation studies have taken place in developed nations, such as Western Europe and the United States of America. Still, non-market values are increasingly demanded for policy analyses in developing or transitioning nations and in addition, multinational bodies need the ability to conduct policy analyses for coordinated actions regarding the environment. Thus, the feasibility of benefit transfers across national boundaries seems to be an interesting issue to be examined, since it can provide the potential of cost saving and the ability to use consistent estimates of values for analyses conducted in other countries too (Ready & Navrud, 2007).

3.10 Benefit Transfers and Transfer Errors

Benefit Transfer technique is accompanied by transfer errors (TE). Transfer Error analysis is used to capture the quality of the study and the level of uncertainty

regarding the accuracy or reliability of the results (Milligan, Kopp, Dahdah & Montufar, 2014). Typically, transfer errors can be calculated based on this formula – instead of WtP, any other variable studied can be used:

$$TE = |WtP_T - WtP_P| / WtP_p \quad \textbf{(3)}$$

These errors can arise from differences in wealth or income levels of a country or simply because of the use of different methodologies. It is evidenced that in many Benefit Transfer applications the policy and study sites are not fully homogeneous with respect to time, currency and resident's income. Therefore, price levels may be corrected for using consumer price index and currencies may be converted based on market (nominal) or purchasing power parity corrected exchange rate (Czajkowski & Ščasný, 2010). It is common in a number of studies to summarize the performance of a Benefit Transfer by using the mean or median absolute Transfer Error, but there are limitations to be taken into account. The mean or median TE reflects a descriptive dispersion of non-absolute values and is highly sensitive to outliers (values that are significantly "detached" from the dominant values), while no bias and asymmetry information are taken into account (Milligan, Kopp, Dahdah & Montufar, 2014).

4 Cost – Benefit Analysis

Substantial research has been carried out in the field of Solid Waste Management (SWM) with special focus on tools and methods developed, aiming to serve as an aid to decision makers with regards to waste management systems. The most widely used decision support methods are Life-cycle Assessment (LCA), Multi-criteria decision-making (MCDM) and Cost-Benefit Analysis (CBA), each of which is accompanied by strengths and weaknesses described below (Karmperis, Aravossis, Tatsiopoulos & Sotirchos, 2013).

4.1 Life-cycle Assessment: Strengths and Weaknesses

Life-cycle Assessment (LCA) is a method used to determine the environmental impacts of a good or service throughout its life phases, which are design/resource, consumption, production, usage/utilization and finally disposal (Zurbrügg, 2013; Karmperis, Aravossis, Tatsiopoulos & Sotirchos, 2013).

Some of the strengths of this methodology can be the simplicity of its framework, the ability to capture long-term impacts, the potential for environmental and economic improvements, the quantification of emissions released in air, water and soil, the evaluation and estimations of the effects on humans and ecosystems arising through the consumption of a good or a service and finally, the flexibility it allows to compare alternative options and distinguish the most suitable one.

As for its weaknesses as a decision-support method, it is time-demanding to be designed comprehensively, it may ignore additional alternatives that could be examined, the assumptions it is based on might be subjective or even arbitrary, its reliability comes under question where limited data are available and another

weakness is that it cannot quantify impacts on species diversity and ecosystems. The fact that there are assumptions made by each analyst, has rendered LCA under criticism (Finnveden, 2000; Finnveden, Björklund, Moberg & Ekvall, 2007), since differentiated assumptions lead to different results. Especially for developing countries, in the UNEP (2005) publication crucial limitations are mentioned, such as lack of appropriate data, limited funding for LCA and lack of LCA expertise and know-how. Also, the difficulty in implementation of LCA that local governments and small or medium enterprises face, could be listed as another barrier (UNEP, 2005b). Furthermore, the inclusion of broader environmental, social and economic information (found in data sources) is recommended in order to reach the dimension of sustainability.

4.2 Multi-criteria Decision Making: Strengths and Weaknesses

About *Multi-criteria (MCDM)* approach, it can be described as a process that evaluates different policies or investments. The basic framework of MCDM is developed on some common steps (Mourits & Oude Lansink, 2006), that decision makers must follow, presented below:

1. The clear definition of the objective(s) of the MCDM. The objective(s) needs to be specific, measurable and realistic.
2. The determination of all options that satisfy the objective(s) of the first step.
3. The definition of the evaluation criteria, which assess the performance of each option and also, the assignment of a weight value in each criterion (prioritization)[4].
4. The last step is to compute the score of each option and compare them in order to select the optimal one, according to the criteria and the weight values applied.

[4] Analytical Hierarchy Process (AHP) arranges a problem into hierarchical structure and selects the optimal option, according to the resulted score of each option (Ramanathan, R. (2001). A note on the use of the analytic hierarchy process for environmental impact assessment. Journal of Environmental Management, 63(1), 27-35).

This methodology allows for multiple evaluation criteria to be incorporated into the planning process (Kou, Miettinen & Shi, 2011), which in addition can be both quantitative and qualitative (Linkov, Satterstrom, Kiker, Batchelor, Bridges & Ferguson, 2006) and can contain economic, environmental or technical information (Linkov, Loney, Cormier, Satterstrom & Bridges, 2009). It has been characterized as a structured procedure which fosters transparency, coherence, consistency and comprehensiveness (Lohri, Rodić & Zurbrügg, 2013). The flexibility of assigning weights in each alternative, is revealing indications about participants' preferences. It has been proved that despite the differentiation in option hierarchy, the top alternatives are the same, regardless of which MCDM model is applied (Huang, Keisler & Linkov, 2011). As far as its main weaknesses as a methodology are concerned, it does not take into account the impact that possible risks posed by the alternatives under consideration can have (Morrissey & Browne, 2004) and it gives no directives for waste minimization or prevention. In addition, though the incorporation of multiple criteria is regarded as beneficial, at the same time it can produce highly subjective results (the option selected), which are therefore considered not the most reliable ones.

4.3 Cost - Benefit Analysis: Strengths and Weaknesses

The method of *Cost - Benefit Analysis (CBA)* in specific, has gone under substantial research over the past decades. It first appeared in the early 1800 in the USA, as a comparison methodology between benefits and costs in water – related projects. Its theoretical framework was initially based on the "Welfare Economics Theory" (Pigou, 1920) along with the appearance of the marginal side of view in the 19th century, resulting in the necessity for the distinction between the private and the social cost as well as for the benefit – cost comparison (Pearce, Atkinson & Mourato, 2006).

Cost – Benefit Analysis is one of the most applicable methods in Waste Management issues, serving as a "decision support" tool for policymakers.

The term "decision support" can be explained as a set of techniques helping people choose among complex decisions or alternatives the best or the optimal option (Bardos, Mariotti, Maro & Sullivan, 2001; Sullivan, 2002; Bohanec, 2003). In the

area of Municipal Solid Waste Management (MSWM), these decisions are policies or projects/investments to be implemented in a country or a region. Each decision support framework relies on a specific model, based on special assumptions and carrying its limitations.

4.3.1 Feasibility Assesment

As already mentioned, apart from CBA, models commonly used in the Waste Management field are Life Cycle Assessment (LCA) and Multi – criteria Decision-making (MCDM). Assessment methods can help policymakers/decision-makers analyze the impacts the implementation of a policy or project can have and assess its total performance, while they also allow for the evaluation and comparison among improvement options, which encompass some criteria of choice (Zurbrügg, 2013). A critical issue in the adaption of these techniques serving as decision-making tools, is the evaluation of the feasibility of a policy or investment proposed. For this purpose, a *feasibility assessment* can be conducted and determine aspects such as the *enabling environment*, the appropriateness of available or suggested technologies, social features regarding the stakeholders and social networks, economic feasibility determined by a financial analysis and anticipated environmental emissions or impacts (Zurbrügg, 2013). Figure 1 is a depiction of what we call "enabling environment":

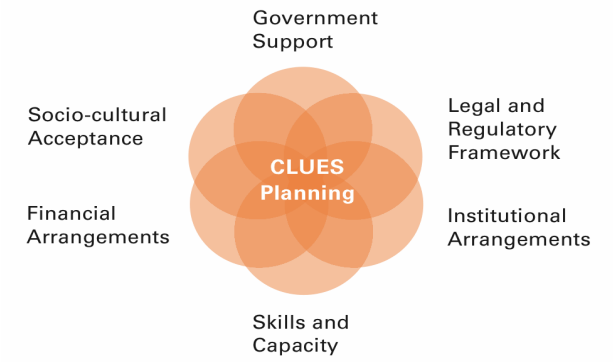

Figure 1: Interrelated Features of the "Enabling Environment", (Lüthi, Morel, Tilley & Ulrich, 2011)

4.4 What is Cost-Benefit Analysis

Cost- Benefit Analysis can be described as a systematic process which calculates in monetary terms and compares the benefits and costs arising from a policy or a project.

Its goal is to *compare* proposals (policies or projects) and then justify the decision to invest in a management scheme (Zurbrügg, 2013). Monetary valuation constitutes a supportive tool for the CBA and has proved to be of great importance especially for situations where monetary values for goods or services not traded in the marketplace are not available (Ness, Urbel-Piirsalu, Anderberg & Olsson, 2007), making possible the comparison aforementioned, since all values are expressed in the same unit (money).

Benefits can be defined as an increase in human well-being, while costs can be defined as a reduction in human well-being (Chang, Pires & Martinho, 2011). In order to follow the concept and the purpose of Cost-Benefit Analysis or any other assessment methodology, it is helpful to have in mind that the well-being of the individuals comprising a society, depends on the use of resources available. Welfare Economics focuses on the achievement of the maximum well-being of the members of a society, given the most optimal allocation or use of the resources that is possible. Also, another clarification worth making is that of the definition of the term "economic welfare", which shall be treated as the level of utility or satisfaction that one enjoys while "consuming" a resource and not just as a set of material objects or profits (Just, Hueth & Schmitz, 2005).

4.4.1 The Concepts of Willingness to Pay and Willingness to Accept

Before proceeding to the review of the CBA concept, it is necessary to take o close look to the concepts of Willingness to Pay (WtP) and Willingness to Accept (WtA), which have been mentioned throughout this dissertation and are inextricably linked to the concepts of income or welfare. The notion behind WtP and WtA, lies on the grounds of the gain in utility (or welfare or well-being) due to a change which is going to take place when implementing a policy or a project, which in our case refers to municipal solid waste management (MSWM). Since utility cannot be measured directly, WtP or WtA have been broadly used as indirect measures of utility. WtP reflects the amount of income or welfare an individual is willing to forego (pay) in order to obtain a positive gain, specifically here, an improvement in environmental quality due to a MSWM scheme. On the other hand, WtA is described as the additional income (or compensation) an individual would require in order to forego the environmental quality improvement under consideration (by a proposed MSWM).

Despite the fact that in the past decades economists used to treat these magnitudes as very similar, empirical estimations have shown that they do vary and usually, WtP<WtA (Pearce, Atkinson & Mourato, 2006), something that depends on income elasticity, as well as the existence of substitutes or the uncertainty that the valued good carries (Hanemann, 1991; Horowitz & McConnell, 2002.).

4.5 Cost – Benefit Analysis Methodology

As a decision – guiding procedure, CBA methodology is being developed according to specific steps. The ten-step process for conducting a CBA according to Cellini & Kee, (2010) is:

1. Set the theoretical framework for the analysis: after setting the baseline scenario, an analyst must state the importance of the CBA and the reasons led to the selection of that methodology.
2. Recognize the beneficiaries and the losers of a project or policy implementation: in other words, the analyst must determine the stakeholders affected by a policy or project and the way the stakeholders are affected (positively or negatively).
3. Identification and classification of the costs and benefits: the analyst must try to identify as many benefits as possible, the ones that will have the most significant implications, since not every impact cane be predicted or known for certain.
4. Projections of costs and benefits over the life of the project or policy: at this stage the analyst must consider the time frame as well as the way benefits and costs are expected to change throughout that period (usually 5-50 years).
5. Monetization of costs: here, currency units are assigned to each cost (financial and social)
6. Monetization of benefits: the benefits shall be quantified (which is a difficult task) and then monetized

7. Discounting[5] of costs and benefits in order to obtain their present values: the process of discounting reflects the common truth that people tend to value benefits or costs incurred today more than those expected to incur in the future. Analysts usually choose a social discount rate (s) at a level of 3%. After the discounting of all costs and benefits, NPV can be calculated by subtracting the NPV of the costs from the NPV of the benefits.
8. Computation of a Net Present Value (NPV): there are two alternatives that help the analyst decide on the best option (policy or project). The first is the Benefit-Cost Ratio. If this ratio gives a number higher than unit (1), then the proposed policy or project is considered an efficient allocation of resources. The second alternative calculation is that of the return of an investment, known also as Economic Rate of Return (ERR) or Internal Rate of Return (IRR). ERR is the discount rate that would yield total present value benefits equal to total present value costs. According to that rate the decision-maker can assess whether a policy or project is worth by comparing it to a certain rate of return (a critical value or criterion).
9. Sensitivity Analysis: this stage is necessary because a CBA is based on specific assumptions set by the analyst. So, it is critical that a CBA contains a Sensitivity Analysis to examine by how much these assumptions vary when a change takes place.
10. Recommendations where appropriate: according to the NPV or Benefit-Cost criterion of step 8 and also taking into account the results of the Sensitivity Analysis at step 9, a project can be simply proposed or rejected.

Similar approaches regarding the procedure for the conduct of a CBA have been suggested throughout the literature ("Hanley & Spash, 1993; Karmperis, Aravossis, Tatsiopoulos, Sotirchos, 2013) and are described below:

[5] Before discounting, the analyst shall net out inflation, by choosing a base year so that all values are expressed in constant prices. Thus, there is distinction between inflation and discounting (Pearce, D., Atkinson, G., & Mourato, S. (2006). Cost-benefit analysis and the environment. Recent Developments, Organisation for Economic Co-operation and Development).

a) The objectives of a policy or investment have to be defined, as well as its socio – economic context - the same goes for any alternatives embodied in a project. Also, its feasibility in terms of personnel adequacy and skills, technical equipment and infrastructure has to be investigated.

b) The population affected by the application of the policy or project needs to be identified. Who will be the beneficiaries and who the losers of a project or policy at a regional or national level must be explicit.

c) Identification of the anticipated impacts of it, regarding natural resources, macroeconomic aggregates or even physical quantities of a region or a country.

d) Monetary Valuation[6] of all impacts stemming from a policy or a project, allowing for a comparison in a common unit, which in the Cost – Benefit Analysis is money. At this stage all the externalities and non – market impacts identified, are monetized and the market prices are customized into accounting ones.

e) Conduct of the Economic Analysis follows. Setting the time horizon (T) along with the process of discounting (discount factor: $(1 + \mathrm{i})^{-\mathrm{t}}$ and " i " stands for the discount rate set by the analyst), once all benefits and costs have been expressed in monetary terms. By discounting, present values are calculated. The discount factor simply shows the time preference (how people value net future benefits over present ones.

f) After aggregating all the costs and benefits (in monetary values), a decision criterion for the acceptance or rejection of a proposal shall be applied. Various economic performance indicators are suggested such as:

a. NPV = $\sum_{t=0}^{T}((B_t - C_t) * \frac{1}{(1+i)^t})$, the Net Present Value criterion
   This equation simply states that the Net Present Value of a project (NPV) equals the difference between the sum of all discounted benefits and costs. Projects with a positive NPV are characterized as the efficient ones in terms of their use of resources (discounted benefits shall exceed discounted costs).

[6] Monetary Valuation is applied in order to attach prices (money values) in goods that are not traded in markets, thus there are no price information available.

b. B/C = PV of inflows/PV of outflows, the conventional Benefit – Cost Ratio

   This indicator suggests that a project is selected if B/C>1, where B,C are the total benefits and costs respectively and PV stands for the present values calculated based on the formula: PV(Bt) = Bt*(1+i)-t (the same expression is used for the calculation of the costs (C)).

g) Risk Assessment -Sensitivity Analysis has to take place. This stage is a crucial one, since the whole Cost -Benefit Analysis is conducted based on specific data, assumptions and projections / estimates for their future values. In simple words, the analyst has to take into account the related uncertainty. Predictions for the data or parameters calculated are not characterized by perfect foresight. The Sensitivity Analysis gathers the values of critical parameters used in the analysis and tests the sensitivity of the result towards a change in their values. In other words, this procedure is followed in order to ascertain the probability with which the project or policy selected will meet its target performance.

The procedure described above (the stages of a CBA) is an *integrated* Cost – Benefit Analysis, since it takes into account not only the financial perspective of a project or policy, but also the environmental, social and (macro)economic perspectives, by monetizing the ecosystem services and the environmental impacts related to a project or a policy (Huang, Chou & Weng, 2005; Pearce, Atkinson & Mourato, 2006; TEEB, 2010; Weng & Fujiwara, 2011). Ecological Economics have a triple goal in order to make use of the term "integrated": sustainable scale, social fairness and finally, economic efficiency (Costanza, d'Arge, de Groot, Farber, Grasso, Hannon, Limburg, Naeem, O'Neill, Paruelo, Raskin, Sutton & van den Belt, 1998).

4.5.1 The Integrated Municipal Solid Waste Management Principle

The increasing stream of waste generation in both developed and developing countries, has led policymakers to the adoption of practices designed under the principle of Integrated Municipal Solid Waste Management (IMSWM) and the use of the proper decision support models (ERRA, 1999; Gabola, 1999; Kowalewski, Reid, Tittebaum, 1999; Clift, Doig & Finnveden, 2000; Berger, Savard & Wizere, 1999; EPIC and CSR, 2000). Nonetheless, an integrated or sustainable MSWM scheme shall

be economically affordable, socially acceptable and environmentally effective (Nilsson-Djerf & McDougall, 2000).

In addition, it has been proved that it is of great importance that all stakeholders are actively involved in any venture affecting the environment (undoubtedly it holds for the MSWM), so that adaptive management is realized (Gilmour, Walkerden & Scandol, 1999; Gunderson, 1999; Shindler & Cheek, 1999). The active participation of all stakeholders and especially the public, means that they are kept informed not only about the methods that are due to be applied in order to achieve a goal (here an effective management of the MSW), but also about possible problems related to the processes (Linkov, Loney, Cormier, Satterstrom & Bridges, 2009).

4.6 Cost-Benefit Analysis Overview

As far as the strengths of the Cost-Benefit Analysis as a decision making tool are concerned, it provides the ability to make a comparison between a set of alternative management schemes and choose the most appealing one, the one that is the least costly and the most beneficial (Morrissey, J. Browne, 2004). Its ability to examine a policy's or a project's performance taking into account the direct and indirect impacts (negative and positive) for the society through their summation, sets it as the main evaluation technique (Almansa and Martinez-Paz, 2011). Additionally to the former, by the conduct of the financial analysis on behalf of the investor, its holistic approach is acknowledged. Finally, by the Risk Assessment – Sensitivity Analysis it does not ignore the *uncertainty*[7] that lingers (Hanley & Spash, 1993).

The main weakness of the CBA framework is that it relies on estimated values and the ecosystems are too complex to be quantified and valued with high precision. During the implementation of a project many parameters calculated may undergo unanticipated variations, making the project selected not the most optimal anymore. This consequently, generates uncertainty, a trait that seems to be more often met in a CBA than in other decision-making techniques. Still, the certainty that other techniques provide in contrast to CBA, is being characterized as "illusory". This

[7] In contrast to risk, which can be defined as probabilistic outcomes, in the case of uncertainty no probabilities are known to the analyst or decision makers.

characterization is based on the argument that, while CBA can be developed according to stated preference techniques related to hypothetical states or scenarios (i.e. by using questionnaires) which adds to the level of uncertainty, at the same time it takes into account factors that matter to making decisions, ignored by other techniques. As a result, there seems to be a trade-off between CBA and other assessment techniques, letting no space for setting CBA a worse assessment tool than the other ones (Pearce, Atkinson & Mourato, 2006).

5 CASE STUDY: HASHEMITE KINGDOM OF JORDAN

5.1 Description of The Country

Hashemite Kingdom of Jordan (or simply Jordan) is an independent sovereign state, that lies in the Western Asia and is bordered by Syria, Iraq, Saudi Arabia, Israel and Palestine from the north, east, south and west respectively (clockwise). Its capital is the city of Amman. What is more, its close proximity to Egypt and Lebanon undoubtedly, sets Jordan as a nation of strategic importance due to its location. As a result, Jordan is a country that accepts a large number of refugees from the surrounding countries seeking for settlement, mainly because of incidents of wars and violence (i.e. the Iraq War in 2003, the influx of Lebanese because of the War with Israel in 2006 and the influx of Syrian refugees in 2013). Its current population is estimated to be around 7,930,491, with an expected growth rate of 3.86%[8].

ADMINISTRATIVE DIVIVSION

Jordan's administrative division is of special interest, since it is divided *geographically* (a distribution based on geographical connectivity and distance among population centers and not according to population or size of land) into 3 regions, North, Central and South, consisting of 12 "governorates" in total, which are further subdivided into 54 districts. A comprehensive table[9] can be found in the Wikipedia site, while the relevant map of Jordan depicting the governorates is presented below:

[8] July 2014 est., https://www.cia.gov/library/publications/the-world-factbook/geos/jo.html
[9] End-of-year 2012 data obtained from the Department of Statistics and retrieved 27 December 2013 (http://en.wikipedia.org/wiki/Governorates_of_Jordan)

Figure 2: The map of Hashemite Kingdom of Jordan by Governorate

ECONOMY

It is a country that has experienced wars and imperialistic ventures by its kings and leaders, and as a sequence its *economy* has gone through various phases, setting her today as an emerging market of high human development, that has an upper middle income economy according to the World Bank. Jordan's GDP level was estimated at $40.02 billion or $6,100 per capita (PPP) in 2013, with a growth rate of 3.3% (calculated based on data in 2013 US dollars[10]). Since 1999, Jordan's economy has witnessed a great improvement of its economy resulting from a set of important activities, such as increasing foreign investment, improving public-private partnerships, free-trade agreement with the United States (2001) and another one with Turkey, which further contributed to the foundation of Aqaba's (port of Jordan) free-trade zone and the flourishing information and communication technology (ICT) sector. However, despite the fact that Jordan's economy is well diversified, it encompasses a set of characteristics that interact and are interdependent, posing challenges to policy-makers. Indicatively, there has been observed natural resource scarcity, inadequacy supply of water and oil, which underlie a strong reliance of the Jordanian government on foreign assistance. High budget deficit and an outstanding

[10] Section "Economy" at: https://www.cia.gov/library/publications/the-world-factbook/geos/jo.html

public debt, attributed to a respective extent to the pronounce corruption in the country, as well as increased rates of unemployment, a significantly high level of poverty across the country and a slow domestic growth are also worth-mentioning factors, which cannot be ignored.

With regards to its exports and imports activity, Jordan provides its partners (United States, Iraq, Saudi Arabia, India, Indonesia) with phosphates, potash, pharmaceuticals, fertilizers as well as vegetables and clothing, while its imports (from Saudi Arabia, China, United States, Italy, Turkey) mainly consist of crude oil, iron, machinery and transport equipment and cereals.

Another important source of revenue and employment in Jordan is *tourism*, which since 2011 has dropped in terms of tourist arrivals, due to the Great Recession and the turmoil caused by the Arab Spring (18 December, 2010), two facts that also "hit" Jordan's GDP growth, export-oriented sectors and construction sector.

NATURAL RESOURCES

With regards to Jordan's natural resources, Jordan comprises one of the largest producers and exporters of phosphate mineral, while the reserves of natural gas are utilized in electricity production (covering nearly 10% of Jordan's electricity needs). However, there has been no progress in exploiting commercially its rich stockpiles of oil shale found in the central and northern regions west of Jordan. Currently, apart from the exploitation of abundant oil shale reserves and renewable technologies, Jordan is exploring nuclear power generation, aiming at coming up against energy shortfalls.

CLIMATE and GEOGRAPHY

As far as its climate and geography are concerned, it has got an arid plateau in the east part, irrigated by oasis and seasonal water streams, while in the west part it is arable with Mediterranean evergreen forestry. Jordan has semi-dry and hot summers with an average temperature of 30^{o} C and cool winters of an average 13^{o} C, with significant humidity from November to April. Precipitation and snowfalls are also met during these 9 months of winter, especially in the western areas of the country. Its climate can be said to be Mediterranean-style, but as we move into the mainland, we meet seasonal temperature contrasts and less rainfall.

OTHER CHARACTERISTICS

Jordan is included in the European Union's European Neighbourhood Policy (ENP) which aims at bringing the EU and its neighbors closer, while it comprises a constitutional monarchy, where the king holds executive and legislative powers. As a country, it has got a strong law enforcement, that has set her among the safest countries in the world, in terms of police services' reliability and prevention of organized crime. Another interesting trait of this country is its high ranking internationally (3rd) as one of the United Nations (UN) countries participating in peacekeeping missions, with a significant contribution of its troops to areas suffering from natural disasters and the provision of aid through several field hospitals in conflict zones.

5.2 Cost-Benefit Analysis for the Municipal Solid Waste Management (MSWM) in the Hashemite Kingdom of Jordan

A Cost-Benefit Analysis (CBA) has been conducted for the Jordan's waste management proposals (8 proposed options) in order to select the most feasible option. The objective of the analysis is to identify as many impacts as possible - positive and negative - the proposals are expected to have on the national economy, which then shall be monetized in order to be compared. Any comparison requires that the objects compared are expressed in the same unit, which here the unit used is money values (JOD).

Regarding the existing situation (which corresponds to the "do-nothing" scenario) of Municipal Solid Waste Management (MSWM) in the Hashemite Kingdom of Jordan, as well as special characteristics of the nation under the scope, shall be presented, in order to describe and identify the contribution of the proposals. The effort put by an analyst or policymaker, aims at providing a holistic approach of the issue, touching on environmental, economic and financial, institutional, legal, social and infrastructural issues related to the MSWM system applied in Jordan in our case. Since all the aforementioned sectors interact, an integrated approach (with regards to MSWM) can be achieved, if all these aspects are taken into account.

The Government of Jordan has set the environmentally sustainable economic development as a priority, taking into account the negative impact and threats that the mismanagement of the MSW can have for the environment and for public health (Abu Qdais, 2007). The realization that current practices do not follow the principles of sustainability, has led policy makers to take action and improve the MSWM techniques and management schemes. Specifically, the Ministry of Municipal Affairs with the assistance of the Cities and Villages Development Bank, has taken on the initiative regarding the development of a National Strategy to improve the Municipal Solid Waste Management Sector, based on the prospects of the general growth of the Kingdom in terms of equity and adequacy of natural resources, efficient and diverse provision of goods and services, revenue generation and municipal financial management and also, inter-municipal coordination and enhancement of regional planning. What is more, the intention to adopt MSWM policies is included in the National Agenda 2006-2015, and among others, it includes the minimization of waste generation, the promotion of environmentally sound disposal and the encouragement of Reuse and Recycling.

Jordan is a country that suffers from an increasing rate of population growth (mainly because of forced migration from neighbor countries such as Syria and Iraq) which is accompanied by the increase of consumption and the change of consumer habits. As a result, the rate of waste generation has also accelerated, and has been estimated at about 1,960,000 tons per year with an average rate at 0.95 kg/cap/day and is expected to exceed the 2.5 million tons annually by 2015 (M. Aljaradin &Persson, 2012). Thus, the need for a drastic and immediate intervention has arisen.

The main task of the analyst or policy-maker is to identify the best solution to the MSWM problem that Jordan faces and suggest the most cost-effective, economically efficient, financially affordable and sound - environmentally and socially – MSWM strategy, which may require significant institutional, legal, operational, financial and socio-economic amendments. These aspects' presentation follows, in order to form a comprehensive picture of the framework in which a MSWM scheme is to be proposed based on the results of the Cost Benefit Analysis.

As a first step, the identification of the quantities and the composition of waste produced is a prerequisite and critical, in order to insert proper management

mechanisms according to the synthesis of the waste. Jordanian cities generate a significant quantity of organic waste, with food and paper comprising the major fractions that exceed the 50% of total waste produced, while other recyclable materials follow, such as plastics, metals, glass and miscellaneous (other materials). Table 3 presents the waste composition of MSW in the 3 main cities of Jordan.

Solid waste component	Average percent by weight		
	Amman	Irbid	Zarqa
Food waste	54.4	77.5	73
Paper and cardboard	14	14.9	9
Plastics	13.2	2.5	10
Metals	2.4	1.3	2
Glass	2.8	2.6	2
Miscellaneous	13.2	1.2	4
Moisture content (%)	65	62	57
Density (kg/m3)	259	241	223

Table 3: Composition of MSW in Jordan (Amman, Irbid, Zarqa), Abu Qdais (2007)

5.3 Legal and Regulatory Framework (regarding the MSWM)

In charge of the MSWM are the Ministry of Municipal Affairs[11] (MoMA) and the Ministry if Environment (MoENV), working independently and following their own regulations each. The former is responsible for the collection and transportation of MSW, and the latter is charged with the establishment of disposal sites and landfills. Apart from the laws, regulations and instructions it encompasses, it also gives a definition for the (Municipal) Solid Waste, describing them as solid or semi-solid materials resulting from any (human) activity, which follow the stages of sorting, collection, transportation, storage, treatment, recycling and final disposal, while additionally, they are not included in the category of hazardous or harmful waste.

The legal and regulatory framework that the MoMA has set for handling waste in Jordan, consists of the following:

1. Law No. 14/2007 and its amendment 13/2011 (for the Municipalities).
2. Regulation No. 75/2009 (for the Joint Services Councils).

[11] The Ministry of Municipal Affairs has delegated the Municipalities and the Joint Services Council with the responsibility of the Management of Solid Waste.

3. Supplies, Purchases and Civil Works Regulation No. 70/2009.
4. Regulation No. 1/1978 and its amendment /2009 for the Prevention of Health Nuisances within Municipal areas.

The MoENV on the other hand has set its legislative framework which establishing the following :

1. The Environmental Protection Law No. 52/2006, which does not provide explicit legal context for SWM issues in specific.
2. Regulation No. 27/2005 for the Management of Solid Waste.
3. Regulation No. 24/2005 for the Management, Transportation and Handling of Harmful/Hazardous Substances.
4. Instruction for Hazardous Waste Management and Handling (2003).
5. Instructions for the Management of Solid Waste (2006).

All in all, the Law encourages and supports the 3 R's approach – the widely known triptych of reduce-reuse-recycle – and additionally it promotes the "Polluter-pays" principle.

As a conclusion regarding the legislative framework in Jordan, there shall be amendments and more specific instructions and laws regarding the environment and the MSWM itself, so that any attempt to manage either type of waste is well-defined and statutory and not general.

INSTITUTIONAL SET-UP

Jordan is divided in 3 regions: Northern, Central and Southern. Each region consists of 4 governorates:

a. Northern Region consists of Irbid, Mafraq, Ajloun and Jerash
b. Central Region consists of Amman, Madaba, Balqa and Zarqa
c. Southern Region consists of Aqaba, Ma'an, Karak and Tafileh

These governorates are further divided, so that finally, in a *local level*, municipalities are formed. The *municipalities* are responsible for the services regarding the MSW produced within each municipality's borders. Thus, it is obvious that there have to be clear duties for each authority (municipality or ministry) involved in the MSWM process, which promote an efficient cooperation among them, in order to achieve the

sustainability of any managerial system proposed. At a national level, the MoMA is the entity that is charged with the responsibility of the monitoring and support of the Joint Services Councils (JSCs) and the Municipalities and assesses their performance and ability to provide services of high quality and contribute in that way to the local and national development within Jordan.

Unfortunately, a significant number of municipalities lack technical and financial (revenues and funding) capacity, as well as qualified human resources, necessary to support the operation of a complete and autonomous process of waste management, starting from the collection of waste, its transfer and treatment and ending with the final disposal. This shortcoming, is alleviated by the delegation of some stages of the MSWM process to the JSCs, where formed (there are municipalities that do not belong to a Joint Service Council).

Another inefficiency regarding the MSWM system in Jordan, is that the payment (or cost) of the MSWM services does not function properly. The billing system is weak and the revenues collected do not allow for the recovery of costs of the services related to the MSWM. This issue shall be taken seriously into account, so that any new (proposed) facility implemented will not lead to the proliferation of operational expenses, but on the contrary, will be able to achieve the target of cost recovery (any revenues stemming from related to MSWM activities shall exceed the costs of the related to MSWM services). This is one reason why a well documented Cost-Benefit Analysis and a feasibility study are crucial. In that way, the implementation of any new treatment facilities will be characterized as efficient and cost-effective.

Finally, the participation of the private sector[12] and its cooperation with the public authorities, seem to be necessary, as proposed by the literature. The Private and Public Partnership (PPP) is not explicitly defined and is not practiced often in Jordan, though it can produce very positive results. The Private and Public Participation (PPP) is a way to improve the MSWM system in Jordan, since the Private sector can support financially various activities such as the purchase of needed equipment and machinery, the education of the public or the staff of the MSWM units, the raise of awareness and interest towards the environment through events or educational

[12] Apart from companies, Non-Governmental Organiazations (NGO) can also play important role in the MSWM system, since they are dedicated to serve a specific purpose, which can be the environment.

programs, the promotion of recycling through campaigns and a lot of other pioneering ideas. The public sector will gain in terms of operational efficiency, since any financial support on behalf of the private entities will be specifically and properly distributed among the activities/stages of MSWM (collection, transportation, treatment, disposal and also, street-cleaning), while at the same time, the members of the system (staff and workers , residents) will become familiar with the MSWM and the importance of each proper treatment of the solid waste, something that consequently will contribute to the well-being of the whole nation.

From an institutional point of view, one could reach the following conclusion: the cooperation between the authorities involved in the MSWM is mandatory and the allocation of specific responsibilities is needed. Also, the technical and financial autonomy of the Municipalities would allow their more efficient operation, while the revision of PPP framework would be of great importance, a driving factor to sustainability.

TECHNICAL AND OPERATIONAL ISSUES

The authorities in charge of MSWM have to face severe technical and operational shortages. Specifically, the existing infrastructure is inadequate, mechanical equipment such as vehicles and machinery is unable to serve the municipality it belongs to, while the staff is not properly equipped, meaning that it has not been provided with masks, gloves or other related tools that support their activities. Thus, their safety is under threat, a fact that needs to be examined, while the safety rules in any unit of MSW treatment shall be reviewed and be encompassed for the safety of their personnel. What is more, the lack of funding makes the maintenance of existing equipment difficult. As a result, again the workers' health is under risk and their performance is seriously prohibited. The manual street-cleaning is another obsolete method - if one considers that this process is mostly done by special vehicles in other countries - that also poses threats to the health of the staff in charge, since they are exposed directly to pathogens or other microorganisms that solid waste contain.

Another characteristic of Jordan's existing MSWM, that may be considered as a problem, but has strong potential for the future, is that of the informal sector. The informal sector consists of waste-pickers and scavengers who collect materials and sell them. Their activity is mainly concentrated on recyclables and due to this, they

make their living. Their help lies in the mitigation of the harm to the environment and to public health because of the air, soil, water and groundwater pollution caused by the improper treatment of the solid waste (especially their disposal, which according to a UNDP survey in 1997 was ranked as the second most serious problem for cities), on behalf of both the businesses and the inhabitants. Still, despite their contribution and their specialization that the authorities could utilize, they remain as an external factor to the MSWM, and additionally, they are not awarded for their beneficial offer, since their services (or their essential offer) cost nothing to the public.

5.4 Economic Assessment

The Economic Evaluation or Assessment for any other project or investment or policy and specifically here, of the 8 alternative options-proposals for Jordan's MSWM, has been broadly applied as a method that assesses the *economic impacts* of a project (here, of the 8 options), expressed in terms of national economic welfare. Its objective is to identify and predict as many benefits and costs a project may induce and assign to each of them a monetary value. The costs and benefits refer to ecological or environmental and social impacts – described in the next section - which are not accompanied by property rights and they are not traded in markets. As a result, a corresponding price for each impact does not exist and therefore, it must be estimated by the help of the Economic Assessment. The assignment of monetary values to the costs and benefits of a project, makes the comparison between them possible and finally, a decision for or against a project/investment can be reached (Cost-Benefit Analysis).

An Economic Evaluation does not take into account any financial data. The Financial Analysis assesses the costs and the revenues of a project in a strictly financial context and is usually conducted by the private or public entity that is to take on the project. It may be that a project induces changes which benefit the entity in charge, but are inefficient at a national level and vice versa. However, the "right" decision is to promote those investments which are beneficial for the national economy (those that promote the protection of public health, the environment and the conservation of its resources, the employment and the incomes of the population) and exclude those that create profits *only* for the private or public entity in charge. In other words, a financial

analysis is limited within the financial costs and revenues of a project or investment-at a company or organization level, while an economic analysis determines the economic impact that a project or investment is expected to have on the national welfare-at a national level.

EXPECTED IMPACTS OF THE 8 SCENARIOS

Before proceeding to the presentation of related to the MSWM scenarios impacts, the description of the treatment options for the bulk of solid waste generated contained in each scenario is necessary.

There have been 8 different scenarios, each of which consists of a set of treatment options. These 8 scenarios consist of some basic and *common treatment options* and are differentiated in some other treatment alternatives. In specific, the common methods are:

1. The expansion of collection services and street-cleaning, so that all areas are covered and served.
2. The establishment of transfer stations in areas that lack one.
3. The establishment of units for the separate collection of bio-waste.
4. The establishment of units for the separate collection of recyclable materials (paper and cardboard, plastics, metals etc).
5. The establishment of "clean" Material Recovery Facilities (MRFs).
6. The rehabilitation of dumpsites that currently "operate".
7. The establishment of landfills especially for non-hazardous MSW.

All the 7 aforementioned methods and suggestions seem to be of great necessity, given the circumstances within the Hashemite Kingdom of Jordan, which set them as common factors that are expected to improve the current MSWM system and lead to a sustainable management of the MSW of Jordan.

As far as the points of differentiation are concerned, the suggestions for the management of the municipal solid waste (MSW) are either of the following (in combination with the basic ones above):

1. The treatment of pre-segregated bio-waste by composting or anaerobic digestion.

2. The establishment of Mechanical Biological Treatments (MBTs) for mixed MSW, which may be:
3. "Dirty" MRF or
4. Composting or
5. Anaerobic Digestion or
6. Bio-drying
7. The establishment of incineration units

A table summarizing the (8) scenarios proposed follows:

Alternative treatment methods/Scenarios		Scenario #1	Scenario #2	Scenario #3	Scenario #4	Scenario #5	Scenario #6	Scenario #7	Scenario #8
Expansion of street-cleaning and collection services		✓	✓	✓	✓	✓	✓	✓	✓
Separate collection systems for recyclables		✓	✓	✓	✓	✓	✓	✓	✓
Separate collection systems for bio-waste		✓	✓	✓	✓	✓	✓	✓	✓
Establishment of transfer stations (where needed)		✓	✓	✓	✓	✓	✓	✓	✓
Establishment of "clean" MRFs		✓	✓	✓	✓	✓	✓	✓	✓
Composting units for pre-segregated bio-waste		✓	✓	✓	✓				
Anaerobic Digestion units for pre-segregated bio-waste						✓	✓	✓	✓
MBTs for mixed MSW	"Dirty" MRF	✓	✓			✓	✓		
	Composting	✓				✓			
	Anaerobic digestion		✓				✓		
	Bio-drying			✓				✓	
Incineration units					✓				✓
Dumpsite rehabilitation		✓	✓	✓	✓	✓	✓	✓	✓
Establishment of landfills for non-hazardous MSW		✓	✓	✓	✓	✓	✓	✓	✓

Table 4: Sets of Alternative Treatment Methods for each Scenario

The reform of the MSWM system in Jordan through the sets of various treatment options within the 8 scenarios proposed, is expected to affect the national economy in many ways. Indirect or induced effects are to appear and their impact on the national economy shall be taken into account. In an economic context, the scenario or project which will "win" the contest constitutes an externality.

An externality can be defined as the consequence(s) of an activity which will be experienced by third parties not directly involved in that activity. In this case, the

activity refers to the improvement of the MSWM system through the selected scenario and the recipients of that activity will be mainly the residents of the Municipalities. Despite the fact that they do not participate in the process in a direct way, their lives and activities are going to undergo changes and there will arise the need to adopt to new behaviors (for example, recycling).

These indirect effects may refer to the structure of the employment and also, to the levels of the incomes of the population residing the Hashemite Kingdom of Jordan. The establishment of new MSW units will require more staff, while the suggested incorporation of the informal sector will also lead to a rise in incomes and consequently to consumption and probably to a positive effect in social welfare.

By the expansion of street-cleaning and collection services and due to the landfill rehabilitation, the health of the Jordanian population (both working and residential population) will be improved. Sources of contamination will vanish gradually and less stressors will "live" on the sites. Also, animals, rodents and insects (mostly birds, rats, mice, mosquitoes) will no longer have access to waste lying on roads and generally open areas, so they will not be able anymore to spread contagious illnesses. What is more, the obtaining of proper equipment and the establishment of the safety in the treatment units is also a factor that promotes the healthy state of the working groups, ensuring a satisfactory level of sanitation. All in all, the expenditures for pharmaceuticals and generally, healthcare are expected to be limited and this is translated as a benefit again for the social welfare.

Another issue that focuses a lot of attention regarding the management of MSW in Jordan is the relative weak network of *transfer stations*. The scarcity of such stations and mechanical equipment (vehicles) result in an ineffective way of collection and disposal of the solid waste. If more stations are to be established in key locations as proposed in the project, then the itinerary of routes for the collection can become more efficient. Less time and fuel will be spent and by the adoption of a specific itinerary, all the areas will be covered and served. In this context, the authorities that will have the responsibility for MSWM may reduce their operational costs, having thus the choice to develop other activities for the population. For instance, public awareness and educational programs may be financed for promoting specific safe MSWM initiatives (e.g. recycling, etc.) in accordance to the public awareness and

educational programmes, attributing to the familiarization of the public with the idea of safe MSWM. What is more, there can be road construction in order to facilitate the collection and transfer processes allowing for trade expansion and opportunities.

The great number of illegal landfills and dumpsites across Jordan could be nothing but an important issue for the MWSM strategy. The rehabilitation plan for these open areas is anticipated to restore the surrounding environment and its ecosystems, allowing for an ideal habitat for any living organism and of course the even conduct of ecosystem functions and processes. At the same time, landfills for non-hazardous waste are proposed to be designed. In that way, the waste will no longer be scattered upon various open areas within the Governorates, but they will be restricted and controlled in the landfills designed for this special purpose. Another point related to landfills (and dumpsites) rehabilitation touches on what we call the "option value" of those sites. Those areas of land have the potential to be utilized for other purposes. The land will gain in value and if some facilities are to be developed, then also additional incomes and a rise in employment may be achieved in some cases. For instance, a green park that functions by the light and heat of the sun or a recycling simulation plant, could be investments that constitute a tangible proof of the potential of the natural resources and in addition, promote the urgent need for its protection.

The incineration units are an effective way or solution to the huge bulk of waste generated in the Regions of Jordan, reducing the amount of solid waste ending up to landfills or just disposed of. However, the processes followed in these units must be conducted under specific and inviolable rules, so that the impact to the environment (during the burning of the waste) is under control.

As it has been stated, Jordan has to face the problem of the natural and energy resource scarcity, forcing the government to import needed quantities of crude oil and oil products at a significantly high cost, compared to international levels. In this context, MSW could be a valuable source of energy generation for industries, institutions and households, which could also make intense use of natural gas as a fuel and also, turn to renewable energy sources, contributing to the reduction of foreign dependence on energy imports and the alleviation of the Budget and as a result, the improvement of the Trade Balance Account.

As an alternative energy source, Municipal Solid Waste can be exploited in various ways (directly or indirectly). Waste-to-Energy (WtE) is a direct way of generating electricity from waste. Since landfilling is the most common disposal method [13] in Jordan, the Landfill Gas (LFG) emissions produced, can serve as a fuel for electricity generation. Additionally, another opportunity provided by landfills is the leachate[14] formed in those sites. Though currently not utilized, it can be collected and properly treated, in order to serve as an energy resource.

Another issue related to energy is that of recycling. By the adoption of recycling processes, energy demand (by industries) will fall significantly and the production of any good will therefore require less of it, contributing again to the environment protection (less emissions released by the production units – industries, factories etc – during their operation) and to a lower level of energy imports (and lower cost). The familiarity with recycling notion will contribute significantly to the reduction of energy demands and consequently to the pollution of the environment (soil, air, water and groundwater) and the conservation of natural resources, since raw materials will be ready to be utilized again in order to produce new products and the process will be limited to fewer steps.

The last point worth attention, is that of the establishment of separate units for the collection of recyclables and bio-waste, which is anticipated to allow for a more proper management of such materials. As far as the bio-waste is concerned, by its special treatment through composting or anaerobic digestion, it can function as a valuable source for the agricultural sector as a fertilizer or soil additive, supporting the agricultural activities. Apart from that, bio-waste can be recovered into gas or electricity and serve either as a fuel or as energy generator (heating or electricity). It is

[13] 20 landfill sites and only one sanitary landfill are in operation (Aljaradin, M., & Persson, K. M. (2012). Environmental Impact of Municipal Solid Waste Landfills in Semi-Arid Climates-Case Study–Jordan. The Open Waste Management Journal, 5(1), 28-39).

[14] Leachate may contain large amounts of organic matter, where humic-type constituents consist an important group, as well as ammonia-nitrogen, heavy metals, chlorinated organic and inorganic salts (Renou, S., Givaudan, J. G., Poulain, S., Dirassouyan, F., & Moulin, P. (2008). Landfill leachate treatment: Review and opportunity. Journal of hazardous materials, 150(3), 468-493).

obvious that this potential again supplements the minimization of the harm to the environment and the further deterioration of the climate change problem.

5.5 Process Followed, Assumptions and Conditions

In order to reach to the selection of the most suitable scenario, a Benefit Transfer technique took place, where various values from different studies were gathered and elaborated. Also, the Cost-Benefit Analysis made use of adjusted values from the Benefit Transfer and other critical information, and the final selection among the 8 scenarios could be made.

The time horizon for the proposals for the MSWM strategy covers the years from 2017 to 2034. This means that the impacts of the alternatives within each of the 8 scenarios investigated here, are going to have some duration, which here is set as the interval 2017-2034 (2017 is considered to be the year when any unit or facility will have begun to operate). For this interval, projections have been made, in order to assess the performance of each scenario. A crucial assumption made is that the scenarios are expected to affect the national welfare in a positive way. In other words, we consider that any scenario (#1 to #8) reduces the negative impact to the national economy that the existing situation or "do-nothing" scenario has, but to a different extent. Thus, the task is to extract the total economic benefit after the comparison between the baseline scenario (the "do-nothing" scenario) and each of the 8 scenarios.

In order to express that, there has been an environmental ranking for the treatment alternatives included in each scenario, regarding their environmental impact[15], presented in Table 3. The highest negative impact (or cost) is represented by the number "1" and the lowest by the number "10".

[15] The impact on the environment here, is a negative one and not an improvement or a benefit.

MSWM Technique	Ranking
Dumpsite	1
Sanitary Landfill	3
Incineration Unit	4
MBTs ("dirty" MRF and composting unit)	5
MBTs ("dirty" MRF and anaerobic digestion unit)	6
MBTs (Biodrying units)	7
"Clean" MRFs (for pre-segregated recyclables)	8
Anaerobic digestion units (for pre-segregated biowaste)	9
Composting units (for pre-segregated biowaste)	10

Table 5: Environmental Ranking of the MSW Treatment Alternatives

The reason for ranking the treatment alternatives was that the relative magnitudes needed to be generated. Specifically, every treatment alternative's environmental impact (cost) was compared to that of the dumpsite's. In that way, we could calculate the *relative cost* of each alternative treatment with respect to the disposal of a specific MSW quantity on a dumpsite. When the MSW quantities are not managed or are disposed, there arises an *environmental impact*. The impact can be seen from the perspective of either the benefit due to the management (through the treatment alternatives) of the waste or the cost if there is no or inadequate management (the existing situation – the "do-nothing" scenario). By making use of the relative costs combined with the expected quantities of MSW and the capacity of each scenario, the calculation of the total cost and benefit was feasible.

The next step was to combine the expected MSW generation and the estimated or expected capacity (the amount of MSW each option can accept and treat) of each alternative and subsequently, of each scenario and for each waste category (bio-waste or recyclables) - again for the period 2017-2034, in order to obtain the *percentage coverage* throughout that period interval (a high percentage is desired). What is more, the MSW quantities calculated (their projections for the interval 2017 – 2034) were then used to find the costs for each option (per annum and throughout the interval). At that step, the estimated cost for each alternative of the 8 different scenarios was obtained by calibrating the impact of the "do-nothing" scenario to the relative cost of each alternative treatment (based on the assumption that any alternative will have a positive impact). The negative impact of the "do-nothing" scenario was estimated at 0.27% of national GDP *annually*, after the process of calibration. Finally, the costs

and the estimated MSW quantities were combined in order to obtain the expected cost[16] of each scenario/option for the years 2017-2034.

Year	Option #1	Option #2	Option #3	Option #4	Option #5	Option #6	Option #7	Option #8	No Action
2017	67.81	69.37	71.27	71.27	74.39	74.39	71.45	71.45	74.81
2018	59.97	60.15	51.19	50.25	55.23	52.75	51.37	50.41	77.80
2019	45.15	44.01	36.12	44.14	42.82	38.56	36.30	44.29	80.91
2020	42.54	40.07	30.75	37.10	39.24	36.04	31.43	37.67	84.15
2021	42.55	40.29	30.83	37.99	39.47	36.14	31.51	38.56	87.51
2022	42.62	40.78	30.95	38.93	39.73	36.28	31.64	39.51	91.01
2023	42.49	41.05	31.21	40.08	40.15	35.22	31.89	40.66	94.65
2024	42.36	41.37	31.49	41.26	40.59	35.07	32.17	41.84	98.44
2025	40.29	37.44	29.55	38.37	38.74	35.36	31.14	39.72	102.38
2026	39.91	36.97	29.52	38.87	38.85	35.43	31.31	40.41	106.47
2027	39.49	36.48	29.47	39.34	38.93	35.49	31.49	41.08	110.73
2028	39.01	35.93	29.41	39.79	38.98	35.52	31.66	41.72	115.16
2029	38.41	35.25	29.34	40.19	39.00	35.53	31.82	42.35	119.77
2030	38.29	34.99	29.25	40.57	38.99	35.51	31.99	42.95	124.56
2031	38.38	34.90	29.14	40.90	39.18	35.67	32.15	43.53	129.54
2032	38.47	34.81	29.01	41.20	39.45	35.88	32.30	44.09	134.72
2033	38.56	34.73	29.46	42.41	40.29	36.57	32.85	45.39	140.11
2034	38.65	34.72	30.23	44.13	41.46	37.54	33.61	47.13	145.71
Total	774.96	733.31	608.18	766.78	765.50	702.93	638.08	792.77	1,918.41

Table 6: Cost of each Scenario Estimated, in JOD (in 2013 prices)

The expected benefit (arising from the environmental impact reduction) was simply calculated by subtracting the cost of each scenario from the cost of the "do-nothing" scenario. To put it differently, the difference between the costs for each of the

[16] In 2013 prices.

scenarios and the "do-nothing" scenario simply reflects the improvement that can be achieved if a scenario (the optimal one) is going to be adopted by the authorities in charge. In that way the positive *environmental impact* could be captured (quantified and estimated).

Year	Option #1	Option #2	Option #3	Option #4	Option #5	Option #6	Option #7	Option #8
2017	6,994,473	5,438,410	3,536,109	3,536,109	410,732	410,732	3,354,109	3,354,109
2018	17,831,997	17,646,133	26,609,530	27,545,904	22,570,210	25,049,829	26,427,529	27,392,173
2019	35,756,600	36,895,538	44,786,950	36,773,466	38,084,996	42,346,516	44,604,950	36,618,888
2020	41,604,821	44,077,907	53,400,193	47,042,277	44,901,201	48,110,435	52,717,693	46,472,728
2021	44,957,338	47,221,629	56,683,166	49,524,777	48,042,795	51,372,467	56,000,666	48,952,618
2022	48,394,936	50,231,890	60,057,746	52,080,669	51,277,985	54,730,230	59,375,245	51,505,890
2023	52,165,078	53,600,175	63,446,294	54,574,415	54,500,321	59,433,994	62,763,794	53,996,753
2024	56,074,733	57,073,303	66,950,960	57,174,389	57,848,600	63,367,982	66,268,460	56,593,914
2025	62,082,682	64,939,283	72,827,618	64,008,368	63,633,782	67,014,400	71,234,616	62,651,725
2026	66,559,861	69,497,176	76,954,414	67,600,626	67,623,773	71,038,077	75,156,387	66,061,700
2027	71,238,708	74,249,722	81,258,151	71,386,082	71,803,745	75,244,722	79,243,412	69,653,350
2028	76,151,306	79,232,571	85,746,362	75,373,311	76,181,931	79,642,225	83,502,816	73,434,832
2029	81,358,008	84,514,291	90,426,867	79,571,191	80,766,867	84,238,772	87,941,998	77,414,598
2030	86,263,419	89,563,644	95,307,778	83,988,920	85,567,398	89,042,850	92,568,647	81,601,409
2031	91,154,897	94,636,834	100,397,517	88,636,021	90,354,216	93,872,482	97,390,748	86,004,348
2032	96,246,781	99,906,894	105,704,821	93,522,361	95,269,863	98,843,228	102,416,594	90,632,828
2033	101,547,995	105,382,573	110,647,599	97,702,101	99,816,150	103,538,421	107,260,692	94,714,379
2034	107,067,771	110,988,619	115,486,172	101,582,460	104,253,393	108,176,329	112,099,266	98,583,635
Total	1,143,451,404	1,185,096,590	1,310,228,246	1,151,623,446	1,152,907,958	1,215,473,692	1,280,327,624	1,125,639,875

Table 7: Gain with Respect to the "Do-nothing" Scenario for each Option, in JOD (in 2013 prices)

5.6 Value or Benefit Transfer Technique

Apart from the realization of the above process, the Benefit Transfer Technique had to take place. The reason for this, is that previously no relevant studies had been conducted especially for the MWSM system and any proposed amendment practices in Hashemite Kingdom of Jordan, so no values were available in order to proceed to the extraction of any results with regards to the MSWM system reform. Additionally, the conduct of a primary valuation study was not feasible, due to time and financial constraints. So, the Benefit Transfer technique was the best solution to that problem, since it is regarded as the cheapest and quickest method.

A number of studies from other developing countries (study sites) as well, have been selected to provide values for the willingness to pay[17] (WtP) for activities related to MSWM, that would be of use for the MSWM in Jordan (policy site). The WtP and WtA concepts are in fact the same and differ in the perspective they are seen. Willingness to pay is used when an individual is eager to pay to obtain a benefit or to get rid of a cost (positive or negative externality respectively). On the other hand, willingness to accept is the compensation an individual requires to quit from a benefit or to tolerate a cost.

When it comes to solid waste for instance, an individual would be willing to pay in order to prevent the establishment of a sanitary landfill near to his home or he would be willing to accept a compensation for the establishment of a sanitary landfill nearby.

The values obtained had to be adjusted for Jordan's profile and then be applied in the CBA (adjusted value transfer technique was applied). Specifically, WtP values for improved waste collection services from a study in Pakistan were adjusted for GDP per capita differentials and the results showed that the willingness to pay for improved waste collection services was estimated between 2.4 – 3.1 million JOD per annum[18]. If a 49% increase in nominal GDP from 2008 to 2013 was taken into account, then the results obtained were 3.58 -4.62 million JOD per annum, assuming that the ratio WtP/GDP remains constant[19].

WtP in an environmental economics context, reflects the *Total Economic Value* (TEV) that a natural resource has for a group of people. In the context of the MSWM system improvement in Jordan, the WtP can reflect how much the affected population assesses the improvement due to the proposed scenarios. So, it is of great importance to take such information into account when conducting a socioeconomic evaluation. A figure that shows how the Total Economic Value can be analysed follows:

[17] Willingness to pay is an indicator of the values of any object or service to an individual or a group of individuals and is expressed in monetary terms.
[18] In 2008 prices.
[19] World Bank study in 2009 based on: Altaf, M. A., & Deshazo, J. R. (1996). Household demand for improved solid waste management: A case study of Gujranwala, Pakistan. World Development, 24(5), 857-868.

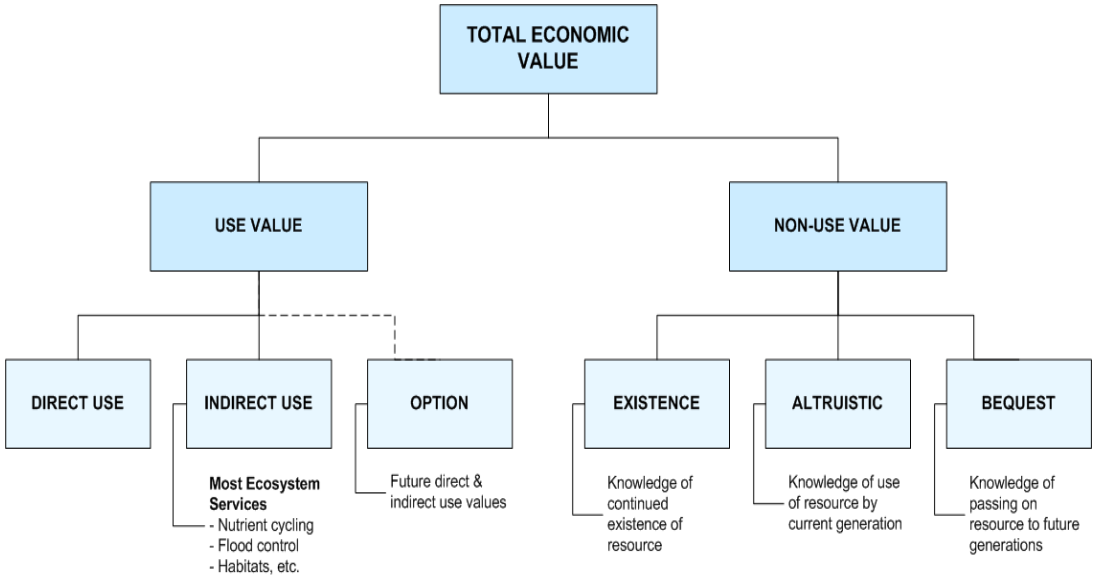

Figure 3: Total Economic Value of a Natural Resource

Also, a study by the World Bank in 2006, found that the indirect effect of the improper management, and more specifically of the improper disposal of the MSW in Jordan, could result in a 0.23% drop of the country's GDP[20], because of the environmental degradation this action causes.

As far as other studies used for the values they provided, most of them catch up on issues related to the values of houses depending on their proximity to a landfill and on how much households in the United States (US) are willing to pay ($/month) for recycling services. In other words, the information they provide are about the effect on house prices as a function of the distance from a landfill or a dumpsite and the effect of pre-segregating recyclable materials. In the case of the house prices, on average a 12.8% reduction corresponds to a high proximity to a landfill or a dumpsite, while the effect vanished when the distance is more than 3.4 miles. On the other hand, the WtP for the segregation of recyclables (and related services), this was calculated on average at $5.61 per month (in 2006 prices)[21].

Returning to Jordan, the estimated WtP for each scenario within the period 2017 – 2034 could be calculated based on the values collected from the studies. First, a

[20] Mahdi I., Yoshiro H., Helmut Y., Takeshi M., (2013). Proposal for a Sustainable and Integrated Municipal Solid Waste Management System in Amman, Jordan Based on the Life Cycle Assessment Method.

[21] Jakus, Tiller and Park (1996), Lake, Bateman and Partiff (1996), Tiller, Jakus and Park (1997), Kinnaman (2000), Aadlan and Caplan (2005).

reference value was selected according to the values obtained before (3.58 and 4.62 million JOD) and a formula, generating the result :

V_a = 3.58 +0.75 * (4.62 – 3.58) = **4.36 million JOD**

That reference value (V_a) is assumed to be the third quartile between 3.58 and 4.62 million JOD and corresponds to the year 2013[22]. For the rest of the time period (until 2034) the corresponding WtP was then calculated, taking into account the real GDP level for each year. Finally, the total WtP for each scenario was obtained, by aggregating the WtP values of each year and for each scenario/option.

Year	Option #1	Option #2	Option #3	Option #4	Option #5	Option #6	Option #7	Option #8
2017	514,167	399,780	259,941	259,941	30,193	30,193	246,562	246,562
2018	1,310,838	1,297,175	1,956,078	2,024,911	1,659,146	1,841,424	1,942,699	2,013,610
2019	2,628,483	2,712,207	3,292,308	2,703,233	2,799,644	3,112,910	3,278,929	2,691,870
2020	3,058,388	3,240,186	3,925,471	3,458,098	3,300,706	3,536,618	3,875,300	3,416,230
2021	3,304,833	3,471,282	4,166,804	3,640,587	3,531,646	3,776,412	4,116,633	3,598,528
2022	3,557,532	3,692,567	4,414,870	3,828,472	3,769,466	4,023,242	4,364,699	3,786,220
2023	3,834,677	3,940,171	4,663,964	4,011,788	4,006,342	4,369,018	4,613,793	3,969,324
2024	4,122,077	4,195,483	4,921,593	4,202,913	4,252,475	4,658,207	4,871,423	4,160,243
2025	4,563,724	4,773,714	5,353,589	4,705,282	4,677,746	4,926,257	5,236,487	4,605,555
2026	4,892,844	5,108,767	5,656,952	4,969,351	4,971,052	5,222,039	5,524,778	4,856,223
2027	5,236,787	5,458,128	5,973,321	5,247,621	5,278,324	5,531,271	5,825,217	5,120,247
2028	5,597,915	5,824,420	6,303,251	5,540,724	5,600,166	5,854,534	6,138,327	5,398,226
2029	5,980,662	6,212,681	6,647,317	5,849,312	5,937,207	6,192,428	6,464,653	5,690,780
2030	6,341,260	6,583,861	7,006,115	6,174,061	6,290,096	6,545,578	6,804,760	5,998,554
2031	6,700,835	6,956,794	7,380,264	6,515,671	6,641,977	6,900,606	7,159,235	6,322,216
2032	7,075,142	7,344,198	7,770,406	6,874,868	7,003,328	7,266,007	7,528,687	6,662,457
2033	7,464,836	7,746,717	8,133,752	7,182,123	7,337,527	7,611,153	7,884,779	6,962,494
2034	7,870,597	8,158,820	8,489,437	7,467,370	7,663,711	7,952,088	8,240,464	7,246,925
Total	84,055,596	87,116,951	96,315,432	84,656,326	84,750,751	89,349,985	94,117,425	82,746,263

Table 8: Estimated Total WtP for each Scenario, in JOD (in 2013 prices)

The last move was to add the results (for the whole interval and for each option) from the Economic Evaluation and WtP procedures and obtain the estimation of the *Total*

[22] We also assume that the most environmentally friendly option is under full development in 2013.

Economic Benefit with regards to each scenario (from the best to the least appropriate option).

Rank	Options	Total Relative Benefit
1	**OPTION #3**: MBTs (biodrying units) and non-hazardous waste landfills for mixed MSW / composting units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,406,543,678
2	**OPTION #7**: MBTs (biodrying units) and non-hazardous waste landfills for mixed MSW / anaerobic digestion units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,374,445,048
3	**OPTION #6**: MBTs ("dirty" MRFs and anaerobic digestion units) and non-hazardous waste landfills for mixed MSW / anaerobic digestion units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,304,823,677
4	**OPTION #2**: MBTs ("dirty" MRFs and anaerobic digestion units) and non-hazardous waste landfills for mixed MSW / composting units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,272,213,541
5	**OPTION #5**: MBTs ("dirty" MRFs and composting units) and non-hazardous waste landfills for mixed MSW / anaerobic digestion units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,237,658,710
6	**OPTION #4**: Incineration units, non-hazardous waste landfills and post-management of hazardous residues for mixed MSW / composting units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,236,279,772
7	**OPTION #1**: MBTs ("dirty" MRFs and composting units) and non-hazardous waste landfills for mixed MSW / composting units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,227,507,000
8	**OPTION #8**: Incineration units, non-hazardous waste landfills and post-management of hazardous residues for mixed MSW / anaerobic digestion units for pre-segregated biowaste / "clean" MRFs for pre-segregated recyclables	1,208,386,138

Table 9: Total Economic Benefit of each Scenario for the Period 2017-2034, in JOD (in 2013 prices)

5.7 Results of the Cost - Benefit Analysis

Following the above procedures of Economic Evaluation and Value or Benefit Transfer, the total economic benefit (the value of indirect and induced effects and the total economic value for each scenario with respect to the "do-nothing" scenario) in monetary terms (JOD) was calculated and the result was obtained.

According to the assumptions made and to the values applied (from specific studies), the best option was found to be the *#3 scenario*. The #3 scenario was found to be the most efficient one among the others through the Cost-Benefit Analysis.

However, when a project is being examined, many aspects have to be taken into account seriously. If a financial analysis was also used in the CBA, then the result could be different. Thus, it is of great importance to stress the framework of each study and have in mind that the results are a product of specific assumptions and procedures, which most of the times are subjective.

6 Conclusion

Through the analysis of the topic of Municipal Solid Waste Management with regards to the Hashemite Kingdom of Jordan, one could realize what a hard task is to capture all the aspects that matter to a MSWM system. Apart from the direct effects the improper or inadequate management of the MSW quantities, there are also many indirect effects that any Organization or Authority in charge, shall account for, if the goal is an IMSWM. The proposed scenarios tried to cover as many categories of waste generated within the Kingdom as possible, taking into account the current situation in the country, while at the same time the main axle was that of sustainability. In that way the attempt to reach to an integrated solution for the MSW problem the country faces, was at least satisfactory.

The problems that an Organization or an Authority has to deal with are numerous and interrelated within a developing nation. Apart from issues directly related to the MSWM (lack of trained staff and equipment, limited funding, legislative inadequacies with regards to waste, etc), a major influx of refugees had to be taken into account especially for Jordan (an externality that is accompanied by high uncertainty). Generally, externalities and unanticipated events are crucial in analyses as the one conducted, since they can reverse any results produced.

As far as the technical part is concerned, Cost-Benefit Analysis has proved to be one of the most useful tools, which can accept an infinite number of factors that are going to be compared (in terms of monetary costs and benefits). As a methodology, it allows for the examination of various and numerous factors that can affect the effectiveness of a project or policy, such as one concerning a MSWM strategy. Also, Benefit Transfer's performance was nothing but salutary in the case of Jordan, an unexplored country (in MSWM sector). In case of Jordan, no relevant studies had previously been carried out and as a result any approach was made very carefully and the assumptions

followed were strictly defined. Both methodologies are highly respected by the literature and are widely used, too. Thus, their results should be reliable enough, always paying attention to the specific assumptions and adjustments made within the analysis.

7 References

"Estimated Population of the Kingdom by Urban* and Rural, at End-year 2012". Department of Statistics - Jordan. 2012. Retrieved 27 December 2013.

"Estimated Population of the Kingdom, Area (Km2) and Population Density by Governorate, at End-year 2012". Department of Statistics - Jordan. 2012. Retrieved 27 December 2013.

Aadlan, David and Arthur J. Caplan.2005."CurbSide Recycling: Waste Resources or Waste of Resources?" Economic Research InstituteWorking Paper 2003-13, Utah State University.

Abu Qdais, H. A. (2007). Techno-economic assessment of municipal solid waste management in Jordan. *Waste management*, *27*(11), 1666-1672.

Alcamo, J., & Bennett, E. M. (Eds.). (2003). Ecosystems and human well-being: a framework for assessment. Island Press. (ONLINE)

Aljaradin, M., & Persson, K. M. (2012). Environmental Impact of Municipal Solid Waste Landfills in Semi-Arid Climates-Case Study–Jordan. *The Open Waste Management Journal*, *5*(1), 28-39.

Al-Khatib, I. A., Arafat, H. A., Basheer, T., Shawahneh, H., Salahat, A., Eid, J., & Ali, W. (2007). Trends and problems of solid waste management in developing countries: A case study in seven Palestinian districts. Waste Management, 27(12), 1910-1919.

Almansa, C., & Martínez-Paz, J. M. (2011). What weight should be assigned to future environmental impacts? A probabilistic cost benefit analysis using recent advances on discounting. *Science of the Total Environment*, *409*(7), 1305-1314.

Altaf, M. A., & Deshazo, J. R. (1996). Household demand for improved solid waste management: A case study of Gujranwala, Pakistan. *World Development*, *24*(5), 857-868.

Bardos, R. P., Mariotti, C., Marot, F., & Sullivan, T. (2001). Framework for decision support used in contaminated land management in Europe and North America. *NATO/CCMS Pilot Study*, 9.

Berger, C., Savard, G., & Wizere, A. (1999). EUGENE: an optimisation model for integrated regional solid waste management planning. *International Journal of Environment and Pollution*, *12*(2), 280-307.

Bergland, O., Magnussen, K., & Navrud, S. (2002). Benefit transfer: testing for accuracy and reliability. Comparative environmental economic assessment. Edward Elgar, Cheltenham, UK, 117-132. (ONLINE)

Bergstrom, J. C., & Civita, P. (1999). Status of benefits transfer in the United States and Canada: a review. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, *47*(1), 79-87.

Berkun, M., Aras, E., & Nemlioglu, S. (2005). Disposal of solid waste in Istanbul and along the Black Sea coast of Turkey. Waste Management, 25(8), 847-855.

Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. Cost-Benefit Analysis, Concepts and Practice, 2001. *New Jersey: PearsonEducation*.

Bohanec, M. (2003). *Decision support* (pp. 23-35). Springer US.

Boyle, K. J., & Bergstrom, J. C. (1992). Benefit transfer studies: myths, pragmatism, and idealism. *Water Resources Research*, *28*(3), 657-663.

Brookshire, D. S., & Neill, H. R. (1992). Benefit transfers: conceptual and empirical issues. *Water resources research*, *28*(3), 651-655.

Cellini, S. R., & Kee, J. E. (2010). Cost-effectiveness and cost-benefit analysis. *Handbook of practical program evaluation*, 493.

Chang, N. B., Pires, A., & Martinho, G. (2011). Empowering systems analysis for solid waste management: challenges, trends, and perspectives. *Critical Reviews in Environmental Science and Technology*, *41*(16), 1449-1530.

Clift, R., Doig, A., & Finnveden, G. (2000). The application of life cycle assessment to integrated solid waste management: Part 1—Methodology. *Process Safety and Environmental Protection*, *78*(4), 279-287.

Cointreau, S. (2006). Occupational and environmental health issues of solid waste management: special emphasis on middle and lower-income countries. The World Bank, Urban Solid Waste Management, 2005.

Colombo, S., & Hanley, N. (2008). How can we reduce the errors from benefits transfer? An investigation using the choice experiment method. *Land Economics*, *84*(1), 128-147.

Colombo, S., & Hanley, N. (2008). What determines prediction errors in benefits transfer models. *Land Economics*, *84*(1), 128-147.

Consonni, S., Giugliano, M., Massarutto, A., Ragazzi, M., & Saccani, C. (2011). Material and energy recovery in integrated waste management systems: project overview and main results. Waste management, 31(9), 2057-2065.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... & van den Belt, M. (1998). The value of ecosystem services: putting the issues in perspective. *Ecological economics*, *25*(1), 67-72.

Czajkowski, M., & Ščasný, M. (2010). Study on benefit transfer in an international setting. How to improve welfare estimates in the case of the countries' income heterogeneity?. Ecological Economics, 69(12), 2409-2416.

De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological economics, 41(3), 393-408.

Denison, R. A. (1996). Environmental life-cycle comparisons of recycling, landfilling, and incineration: A review of recent studies. Annual Review of Energy and the Environment, 21(1), 191-237.

Denison, R., & Ruston, J. (1990). Recycling and incineration: evaluating the choices. Island Press.

Desvousges, W. H., Johnson, F. R., & Banzhaf, H. S. (1998). Environmental policy analysis with limited information: principles and applications of the transfer method. Edward Elgar Publishing.

Diaz, R., & Warith, M. (2006). Life-cycle assessment of municipal solid wastes: Development of the WASTED model. Waste Management, 26(8), 886-901.

EFTEC/RIVM 2000, "Valuing the Benefits of Environmental Policy: The Netherlands", London, 30 June 2000.

El-Fadel, M., Findikakis, A. N., & Leckie, J. O. (1997). Environmental impacts of solid waste landfilling. Journal of environmental management, 50(1), 1-25.

Environ Engineers, Inc. and City of Winston Salem. (1975). An evaluation of landfill gas migration and a prototype gas migration barrier. US EPA Report, NTIS, PB-239 357.

EPIC and CSR, 2000. Integrated Solid Waste Management Tools: Measuring the Environmental Performance of Waste Management Systems. Environment and Plastics Industry Council and Corporations supporting recycling.

ERRA, 1999. The Case for Integrated Waste Management, a briefing paper. European Recovery and Recycling Association.

Finnveden, G. (2000). On the limitations of life cycle assessment and environmental systems analysis tools in general. *The International Journal of Life Cycle Assessment*, *5*(4), 229-238. Finnveden, G., Björklund, A., Moberg, Å., & Ekvall, T. (2007). Environmental and economic assessment methods for waste management decision-support: possibilities and limitations. *Waste management & research*, *25*(3), 263-269.

Freeman III, A. M. (2002). How much is Nature really worth? An economic perspective. VALUING NATURE, 19.

Gabola, S., (1999). Towards a sustainable basis for the EU Packaging and Packaging Waste Directive. In: ERRA Symposium November, Brussels.

Gilmour, A., Walkerden, G., & Scandol, J. (1999). Adaptive management of the water cycle on the urban fringe: three Australian case studies. *Conservation Ecology*, *3*(1), 11.

Gowdy, J. M. (2004). The revolution in welfare economics and its implications for environmental valuation and policy. *Land economics*, *80*(2), 239-257.

Griffiths, C. and Wheeler, W. (2005) Benefit–cost analysis of regulations affecting surface water quality in the United States. In R. Brouwer and D. Pearce (eds), Cost–Benefit Analysis and Water Resources Management (pp. 223–250). Cheltenham: Edward Elgar.

Gunderson, L. (1999). Resilience, flexibility and adaptive management—antidotes for spurious certitude. *Conservation ecology*, *3*(1), 7.

Haan, H. C., Coad, A., & Lardinois, I. (1998). Municipal solid waste management: involving micro-and small enterprises, guidelines for municipal managers. ILO.

HAES, H. A. U., & ROOIJEN, M. V. (2005). Life Cycle Approaches: the road from analysis to practice. *UNEP/SETAC Life Cycle Initiative*.

Hanemann, W. M. (1991). Willingness to pay and willingness to accept: how much can they differ?. *The American Economic Review*, 635-647.

Hanley, N., & Spash, C. L. (1993). *Cost-benefit analysis and the environment* (No. P01 176). Cheltenham: Edward Elgar.

Hanley, N., Wright, R. E., & Alvarez-Farizo, B. (2006). Estimating the economic value of improvements in river ecology using choice experiments: an application to the water framework directive. Journal of environmental management, 78(2), 183-193.

Heimlich, J. E., Hughes, K. L., & Christy, A. D. (2007). Integrated solid waste management.

Henry, R. K., Yongsheng, Z., & Jun, D. (2006). Municipal solid waste management challenges in developing countries–Kenyan case study. Waste management, 26(1), 92-100.

Hoornweg, D., Thomas, L., & Otten, L. (1999). Composting and its applicability in developing countries. World Bank Working Paper Series, 8.

Horowitz, J. K., & McConnell, K. E. (2003). Willingness to accept, willingness to pay and the income effect. *Journal of Economic Behavior & Organization*, *51*(4), 537-545.

http://en.wikipedia.org/wiki/Jordan

https://www.cia.gov/library/publications/the-world-factbook/geos/jo.html

Huang, C.C., Chou, C.E., Weng, Y.C., 2005. Environmental Cost–Benefit Analysis of Water Resource Development Project and Management (2/3). Taiwan Water Resource Agency Report, Taiwan, ROC (in Chinese).

Huang, I. B., Keisler, J., & Linkov, I. (2011). Multi-criteria decision analysis in environmental sciences: ten years of applications and trends. *Science of the total environment*, *409*(19), 3578-3594.

Iovanna and Griffiths, 2006 Iovanna, R., & Griffiths, C. (2006). Clean water, ecological benefits, and benefits transfer: a work in progress at the US EPA. *Ecological Economics*, *60*(2), 473-482.

Jakus, P. M., Tiller, K. H., & Park, W. M. (1996). Generation of recyclables by rural households. *Journal of Agricultural and Resource Economics*, 96-108.

Jantzen, J. (2006). The Economic Value of Natural and Environmental Resources.

Johnston, R. J., & Rosenberger, R. S. (2010). Methods, trends and controversies in contemporary benefit transfer. Journal of Economic Surveys, 24(3), 479-510.

Just, R. E., Hueth, D. L., & Schmitz, A. (2005). The welfare economics of public policy: A practical approach to project and policy evaluation. Edward Elgar Publishing.

Karmperis, A. C., Aravossis, K., Tatsiopoulos, I. P., & Sotirchos, A. (2013). Decision support models for solid waste management: Review and game-theoretic approaches. *Waste management*, *33*(5), 1290-1301.

Kinnaman, T. C. (2000). Explaining the Growth in Municipal Recycling Programs The Role of Market and Nonmarket Factors. *Public Works Management & Policy*, *5*(1), 37-51.

Kinnaman, T. C. (2000). The efficiency of curbside recycling: a benefit-cost analysis. *Journal of Public Works Management and Policy*, *5*(1), 37-51.

Kirchhoff, S., Colby, B. G., & LaFrance, J. T. (1997). Evaluating the performance of benefit transfer: an empirical inquiry. Journal of environmental economics and management, 33(1), 75-93.

Kou, G., Miettinen, K., & Shi, Y. (2011). Multiple criteria decision making: challenges and advancements. *Journal of Multi‐Criteria Decision Analysis*, *18*(1-2), 1-4.

Kowalewski, R., Reid Lea, W., Tittebaum, M., 1999. A standardised data reporting methodology for long-term integrated municipal solid waste management—a case study. Journal of solid waste technology and management 26 (1), 26–35.

KristÒFersson, D., & Navrud, S. (2007). Can use and non-use values be transferred across countries?. In Environmental value transfer: issues and methods (pp. 207-225). Springer Netherlands.

Lake, I. R., Bateman, I. J., & Parfitt, J. P. (1996). Assessing a kerbside recycling scheme: a quantitative and willingness to pay case study. *Journal of Environmental Management*, *46*(3), 239-254.

Lavrač, N., Bohanec, M., Pur, A., Cestnik, B., Debeljak, M., & Kobler, A. (2007). Data mining and visualization for decision support and modeling of public health-care resources. *Journal of Biomedical Informatics*, *40*(4), 438-447.

Linkov, I., Loney, D., Cormier, S., Satterstrom, F. K., & Bridges, T. (2009). Weight-of-evidence evaluation in environmental assessment: Review of qualitative and quantitative approaches. *Science of the Total Environment*, *407*(19), 5199-5205.

Linkov, I., Satterstrom, F. K., Kiker, G., Batchelor, C., Bridges, T., & Ferguson, E. (2006). From comparative risk assessment to multi-criteria decision analysis and adaptive management: recent developments and applications. *Environment International*, *32*(8), 1072-1093.

Liu, S., Costanza, R., Farber, S., & Troy, A. (2010). Valuing ecosystem services. Annals of the New York Academy of Sciences, 1185(1), 54-78.

Lohri, C. R., Rodić, L., & Zurbrügg, C. (2013). Feasibility assessment tool for urban anaerobic digestion in developing countries. *Journal of environmental management*, *126*, 122-131.

Loomis, J. B. (1992). The evolution of a more rigorous approach to benefit transfer: benefit function transfer. *Water Resources Research*, *28*(3), 701-705.

Lüthi, C., Morel, A., Tilley, E., & Ulrich, L. (2011). Community-Led Urban Environmental Sanitation Planning (CLUES). *Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland*.

M. Aljaradin and K. Persson (2012), "Comparison of Different Waste Management Technologies and Climate Change Effect—Jordan," *American Journal of Climate Change*, Vol. 1 No. 2, 2012, pp. 57-63.

MacFarlane, I. C. (1970). Gas explosion hazards in sanitary landfills. Public Works Magazine, 101(5), 76-78.

MacFarlane, I. C., & National Research Council Canada. Division of Building Research. (1970). Gas explosion hazards in sanitary landfills and garbage dumps. National Research Council of Canada, Division of Building Research.

McComb, G., Lantz, V., Nash, K., & Rittmaster, R. (2006). International valuation databases: overview, methods and operational issues. *Ecological Economics*, *60*(2), 461-472.

McDougall, F. R., White, P. R., Franke, M., & Hindle, P. (2008). Integrated solid waste management: a life cycle inventory. John Wiley & Sons.

McOmber, R. M. and Moore, C. A. (1981). Field evaluation of landfill methane movement and methane control systems. In Land Disposal: Municipal Solid Waste, Proceedings of the 7th Annual Research Symposium, (D. W. Shulz, ed.), Philadelphia, Pennsylvania, pp. 104–115.

Memon, M. A. (2010). Integrated solid waste management based on the 3R approach. Journal of Material Cycles and Waste Management, 12(1), 30-40.

Milligan, C., Kopp, A., Dahdah, S., & Montufar, J. (2014). Value of a statistical life in road safety: A benefit-transfer function with risk-analysis guidance based on developing country data. Accident Analysis & Prevention, 71, 236-247.

Minghua, Z., Xiumin, F., Rovetta, A., Qichang, H., Vicentini, F., Bingkai, L., ... & Yi, L. (2009). Municipal solid waste management in Pudong New Area, China. Waste management, 29(3), 1227-1233.

Morrissey, A. J., & Browne, J. (2004). Waste management models and their application to sustainable waste management. *Waste management*, *24*(3), 297-308.

Mourits, M., & Oude Lansink, A. G. J. M. (2007). Multi-criteria decision making to evaluate quarantine disease control strategies. *New approaches to the economics of plant health. Heidelberg, Germany: Springer*, 131-144.

Munda, G. (1996). Cost-benefit analysis in integrated environmental assessment: some methodological issues. *Ecological economics*, *19*(2), 157-168.

Navrud, S., & Ready, R. C. (Eds.). (2007). *Environmental value transfer: issues and methods*. Dordrecht: Springer.

Ness, B., Urbel-Piirsalu, E., Anderberg, S., & Olsson, L. (2007). Categorising tools for sustainability assessment. *Ecological economics*, *60*(3), 498-508.

Nilsson-Djerf, J. (2000). Social factors in sustainable waste management. *Warmer Bulletin*, (73), 18-20.

NRC (National Research Council). 2005. Valuing ecosystem services: toward better environmental decision- aking. Washington, DC: National Academy Press.

OECD. Mortality Risk Valuation in Environment, Health and Transport Policies. Paris:OECD Publishing, 2012

Özeler, D., Yetiş, Ü., & Demirer, G. N. (2006). Life cycle assesment of municipal solid waste management methods: Ankara case study. Environment International, 32(3), 405-411.

Parker, A. (1981, May). Landfill gas problems—case histories. In Proceedings of Landfill Gas Symposium, UK AERE Harwell (pp. 161-175).

Pearce, D., Atkinson, G., & Mourato, S. (2006). Cost-benefit analysis and the environment. *Recent Developments, Organisation for Economic Co-operation and Development*.

Plummer, M. L. (2009). Assessing benefit transfer for the valuation of ecosystem services. Frontiers in Ecology and the Environment, 7(1), 38-45.

Ramanathan, R. (2001). A note on the use of the analytic hierarchy process for environmental impact assessment. *Journal of Environmental Management*, *63*(1), 27-35.

Rathi, S. (2006). Alternative approaches for better municipal solid waste management in Mumbai, India. Waste Management, 26(10), 1192-1200.

Raybould, J. G., & Anderson, D. J. (1987). Migration of landfill gas and its control by grouting—a case history. Quarterly Journal of Engineering Geology and Hydrogeology, 20(1), 75-83.

Ready, R., & Navrud, S. (2006). International benefit transfer: Methods and validity tests. *Ecological economics*, *60*(2), 429-434.

Ready, R., Navrud, S., Day, B., Dubourg, R., Machado, F., Mourato, S., ... & Rodriquez, M. X. V. (2004). Benefit transfer in Europe: how reliable are transfers between countries?. Environmental and resource economics, 29(1), 67-82.

Renou, S., Givaudan, J. G., Poulain, S., Dirassouyan, F., & Moulin, P. (2008). Landfill leachate treatment: Review and opportunity. *Journal of hazardous materials*, *150*(3), 468-493.

Rolfe, J., & Bennett, J. (Eds.). (2006). *Choice modelling and the transfer of environmental values*. Northampton, MA: Edward Elgar.

Rosenberger, R. S., & Loomis, J. B. (2000). Using meta-analysis for benefit transfer: In-sample convergent validity tests of an outdoor recreation database. Water Resources Research, 36(4), 1097-1107.

Rushton, L. (2003). Health hazards and waste management. British medical bulletin, 68(1), 183-197.

Schübeler, P., Christen, J., & Wehrle, K. (1996). Conceptual framework for municipal solid waste management in low-income countries (Vol. 9). SKAT (Swiss Center for Development Cooperation).

Shafer, R. A., Renta-Babb, A., Bandy, J. T., Smith, E. D., & Malone, P. (1984). Landfill Gas Control at Military Installations (No. CERL-TR-N-173). CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL.

Shindler, B., & Cheek, K. A. (1999). Integrating citizens in adaptive management: a propositional analysis. *Conservation Ecology*, *3*(1), 9.

Smith, V. K., & Pattanayak, S. K. (2002). Is meta-analysis a Noah's ark for non-market valuation?. *Environmental and Resource Economics*, *22*(1-2), 271-296.

Smith, V. K., Van Houtven, G., & Pattanayak, S. K. (2002). Benefit transfer via preference calibration:"Prudential algebra" for policy. *Land Economics*, *78*(1), 132-152.

Tiller, K. H., Jakus, P. M., & Park, W. M. (1997). Household willingness to pay for dropoff recycling. *Journal of Agricultural and Resource Economics*, 310-320.

Tınmaz, E., & Demir, I. (2006). Research on solid waste management system: to improve existing situation in Corlu Town of Turkey. Waste management, 26(3), 307-314.

UNEP, 2005b. Life Cycle Approaches: The road from analysis to practice. United Nations Environment Programme, Division of Technology, Industry and Economics (DTIE).

UNEP, CalRecovery (2005). Solid Waste Management. United Nations Environment Programme, Division of Technology, Industry and Economics (DTIE)- International Environmental Technology Center (IETC).

UNEP-IETC, HIID, 1996. International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management, United Nations Environment Programme (UNEP), International Environmental Technology Centre (IETC).

Van Beukering, P., Schoon, E., & Mani, A. (1996). *The informal sector and waste paper recovery in Bombay* (No. 5). Environmental Economics Programme, IIED.

van de Klundert, A., & Anschütz, J. (2001). Integrated sustainable waste management: The concept. WASTE.

VandenBerg, T.P., Poe, G.L., Powell, J.R., 2001. Assessing the accuracy of benefits transfers: evidence from a multi-site contingent valuation study of groundwater quality. In: Berg- strom, J.C., Boyle, K.J., Poe, G.L. (Eds.), The Economic Value of Water Quality. Edward Elgar, Massachusetts

Weng, Y. C., & Fujiwara, T. (2011). Examining the effectiveness of municipal solid waste management systems: an integrated cost–benefit analysis perspective with a financial cost modeling in Taiwan. *Waste management*, *31*(6), 1393-1406.

Wilson, D. C. (2007). Development drivers for waste management. Waste Management & Research, 25(3), 198-207.

Wilson, D. C., Velis, C. A., & Rodic, L. (2013, May). Integrated sustainable waste management in developing countries. In Proceedings of the Institution of Civil Engineers: Waste and Resource Management (Vol. 166, No. 2, pp. 52-68). Thomas Telford.

Wilson, D. C., Velis, C., & Cheeseman, C. (2006). Role of informal sector recycling in waste management in developing countries. Habitat international, 30(4), 797-808.

Wilson, M. A., & Hoehn, J. P. (2006). Valuing environmental goods and services using benefit transfer: the state-of-the art and science. Ecological economics, 60(2), 335-342.

Wittmer, H., Schröter-Schlaack, C., Nesshöver, C., Bishop, J., ten Brink, P., Gundimeda, H. & Simmons, B. (2010). The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB (p. 36). TEEB.

Zurbrugg, C. (2002). Urban solid waste management in low-income countries of Asia how to cope with the garbage crisis. Presented for: Scientific Committee on Problems of the Environment (SCOPE) Urban Solid Waste Management Review Session, Durban, South Africa, 1-13.

Zurbrügg, C. (2013). Assessment Methods for Waste Management Decision-Support in Developing Countries.