Waste Management

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I. INTRODUCTION

A green economy is characterized by public and private investments that result in improved economic returns, a healthier environment, and social development. The process of greening any sector has been defined as "the process of configuring businesses and infrastructure to deliver better returns on natural, human, and economic capital investments, while at the same time reducing greenhouse gas emissions, extracting and using less natural resources, creating less waste, and reducing social disparities" (Gueye, 2010). Policies in green economies are often formulated to stimulate investment in green initiatives. Thus, making the transition to a green economy requires a political environment that holds the long-term wellbeing of individuals as the highest priority and manages resources as assets for future generations. This political environment can only develop in a democracy. It is therefore our strong belief that democracy is a prerequisite for a green economy.

Economic activities in general drive the production, distribution, and consumption of goods and services, which lead to waste generation. Public health and wellbeing can be severely affected by the quality and standards of waste management. Waste exists in solid, liquid, and gaseous forms. Solid waste in turn varies by content and has many sources, as indicated in Figure 1. Solid waste may be classified by source as municipal, industrial, agricultural, or medical. It can also be classified by content as non-hazardous, hazardous, bulky, or biogenic.

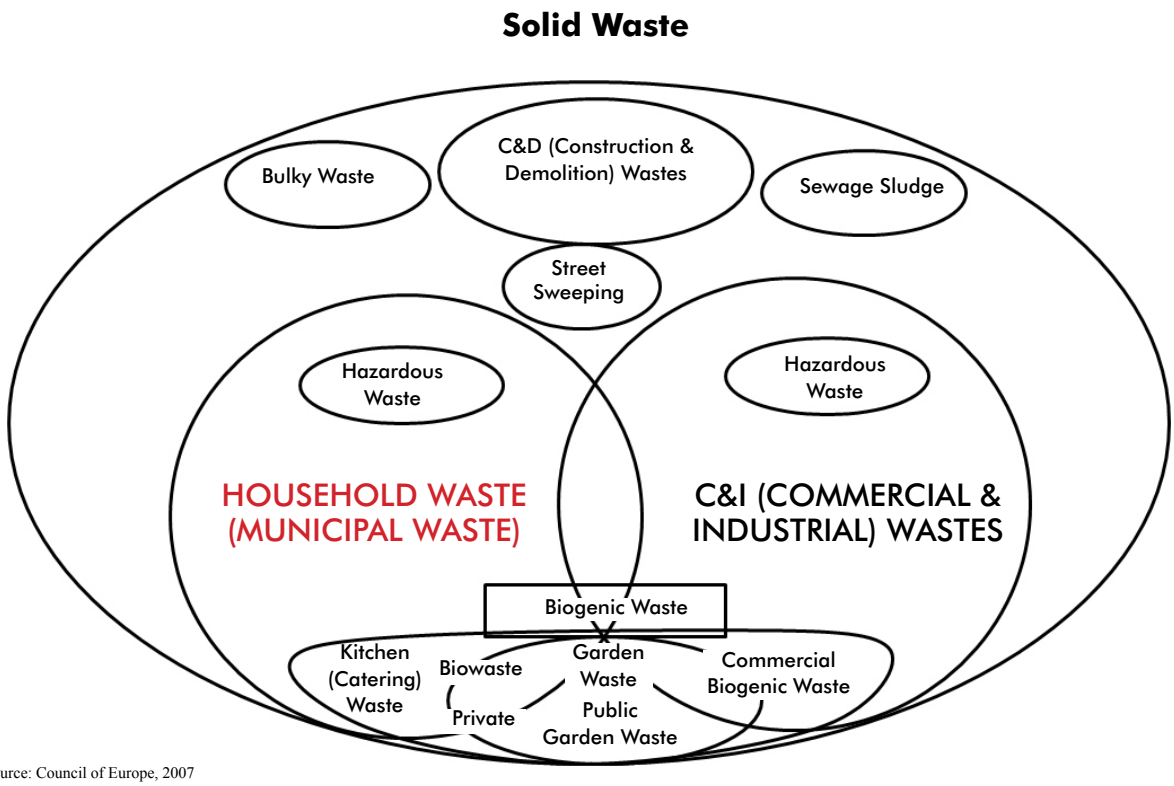
Discarded waste is often perceived as a liability. However, in a green economy it is considered a resource because of the ability to alter this waste and make it reusable. Solid waste management is the term used to describe all activities related to the collection, sorting, processing, and disposing of solid waste. The goal of a green solid waste management is to manage waste in a manner that meets public health and environmental concerns, while conserving resources through reuse and recycling of the waste materials.

Municipal waste is often generated in greater quantities relative to other forms of solid waste. Therefore, the value of municipal waste as a resource as well as its impact on the functioning

of cities makes it one of the most important components of solid waste. Municipal solid waste (MSW) management directly stimulates the economy because it is labor-intensive and requires investments in machinery and equipment for handling, transport, and processing. In addition, MSW management stimulates multiple economic activities such as recycling, composting, and energy production. This chapter provides an overview of municipal solid waste management in Arab countries and proposes strategies to promote more sustainable patterns of waste management. The chapter seeks to:

a. Present and evaluate current trends in the waste management sector in Arab countries.
b. Provide an overview of the best green practices in MSW management.
c. Discuss the enabling conditions needed to shift to more environmentally sustainable forms of waste management in Arab countries.
d. Propose policy measures to catalyze the shift to a green waste management sector.

FIGURE 1 CLASSIFICATION OF MUNICIPAL SOLID WASTE



Source: Council of Europe, 2007

II. DEFINING THE SECTOR AND ITS SUBSECTORS

There is no published definition available in Arab countries for the solid waste sector. For the time being, we may adopt an international or a well agreed upon definition of the sector. The United Kingdom (UK) government, for example, defines waste management, recovery, and recycling as "products, systems and services for the minimization, collection, treatment, segregation, recovery, recycling and disposal of waste that may include paper, organics, metals, glass, plastics, demolition and construction wastes, electrical and white goods" (UK, 2006).

III. CURRENT PRACTICES

The generation of solid waste in Arab countries has recently been growing due to population and economic growth, accelerated rate of urbanization, rapid industrialization, rising standards of living, changing consumption patterns, and the lack of public awareness. The growing volume of waste has been accompanied by changes in waste composition and characteristics due to changes in lifestyle. It is predicted that the amount of municipal solid waste generated in Arab countries in 2020 will exceed 200 million tons per year (LAS, 2009), with higher waste generation correlated to a higher gross domestic product (GDP). On average, organic matter accounts for approximately 50 to 60% of municipal solid waste, while paper, plastic, glass, metals, and textiles account for about 30 to 40% (LAS, 2009). Thus close to 80% of total municipal solid waste generated in Arab countries is decomposable and recyclable. However, the recycling rate is lower than 5% (AFED , 2008).

The concept of integrated municipal solid waste management and utilizing waste as a resource has been spreading in the Arab region. However, the solid waste sector in many Arab countries can be characterized as a disorganized sector with sporadic service coverage. In most cities of the Arab world, municipal solid waste management is undertaken by municipalities. Subcontractors are commonly brought in to handle specific activities

EXAMPLES OF SOLID WASTE SUBSECTORS (PRODUCTS, SYSTEMS AND SERVICES)

- Advice on waste minimization, landfill, mechanical and biological treatment, and regulatory consulting.
- Technologies such as specialized containment, shredders, compactors, and waste management vehicles.
- Collection and transport of solid wastes.
- Construction of landfills/incinerators (without energy recovery).
- Manufacture of equipment/vehicles for storage/collection/transport of solid waste.
- Research and development of new waste treatment technologies and technologies that minimize waste production.
- Treatment of waste prior to landfill/incineration.
- Vitrification.
- Construction of energy and material recovery facilities/equipment.
- Manufacture and supply of specialist equipment for collection, sorting, and processing of materials.
- Materials collection and reprocessing.
- Operation of material and energy recovery facilities, including composting, anaerobic digestion, and waste-to-energy.
- Segregation, treatment, and supply of recyclables and untreated waste materials.
- Research and development and production of cleaner technologies & processes.

Source: UK, 2006

such as collection and transportation. Private sector participation has been increasing over the past decade but the volume of waste handled is still limited. An informal waste management sector exists in a few Arab countries, living off earnings made from the recycling of waste. Many Arab countries lack a national strategy for solid waste management while regulations to govern the sector do not exist. In Arab countries, the political commitment to waste management is limited.

Current MSW management practices in the Arab world vary drastically from one region to the other. The wide spectrum of practices in all stages of waste management varies from very poor in some countries to state-of-the-art in others.

For example, waste collection efficiency in Egypt is 65% on average, with uncollected waste accounting for up to 50% of all waste generated in some regions (EEAA, 2008).

Even in urban areas, waste collection is more regular in more affluent neighborhoods. This section presents an overview of current practices in Arab countries followed by a discussion of cross-cutting issues.

A. Variation in current practices

Solid waste management practices in the Arab world include waste collection, transport, transfer, sorting, treatment, and final disposal. These practices vary widely from country to country, and even within a country or region. The variation in current waste management practices in the Arab world is depicted in Table 1. For example, man pulled carts and donkey carts are still used in transporting waste. However, open bed, covered, and compactor vehicles are predominantly used in urban areas. Transfer stations are not used in many regions of the Arab world. In some regions, transfer station practices involve labor-intensive handling activities at curbside locations. Vehicle to vehicle transfer, open lot, and formal state-of-the art transfer stations are also utilized in other regions.

Waste generation rates in Arab countries vary widely, between 0.5 and 2.7 kg/capita-day (AFED, 2008). The amount of total waste generated by country depends on population size and GDP. For example, Bahrain and Egypt generate 1 million and 16 million tons of waste annually, respectively (AFED, 2008). In Egypt, Iraq, Jordan, Sudan, Syria, Tunisia, and Yemen, the rate of MSW generation is 0.5-0.9 kg/capita-day. In these countries, MSW is managed by the local public authorities with some private sector participation.

Waste management in Arab countries is characterized by a high percentage of uncollected waste, with most of the waste directed to open or controlled dumpsites. Sorting and composting facilities are being operated with limited capacity. Waste management operations in many Arab countries are strained by limited budgets due to inadequate cost recovery and low service fees. Although countries of the Gulf Cooperation Council (GCC) have higher waste generation rates of 1.2-2.7 kg/capita-day (AFED, 2008), they are able to provide better waste management services with coverage extending to remote or low density population areas, as indicated in Figure 2. The GCC countries have also begun operating sanitary landfills, albeit with a lesser

degrees of success. Waste recycling and treatment operations are still not widely adopted.

Recycling, reuse, and recovery are still at their infancy in Arab countries, although they are gaining increased consideration. Waste sorting and recycling are driven by an active informal sector. Such recycling activities are mostly manual and labor intensive. Composting is also gaining increased interest due to the high organic content of MSW. Composting has been adopted increasingly in some countries as a strategic choice for processing the organic content of waste. Some countries have deployed waste-to-energy technologies using incineration and anaerobic digestion on a prototype scale. However, such practices have not been scaled up yet.

Still, recycling rates remain low with most waste ending up in dumpsites. Waste disposal along curbsides and in uncontrolled dumps is still practiced in many parts of the Arab region. Open-air burning is often used where these dumpsites exist. In addition, MSW is commonly mixed with industrial and medical wastes during waste disposal. The most commonly used method of disposal is in "controlled" dumpsites. Disposal in sanitary landfills is increasingly being adopted, particularly where there is a strong sense of environmental awareness. Yet only a small percentage of waste is disposed in such landfills. Contamination of old landfill sites and intrusions of waste into residential areas have prompted remediation and rehabilitation efforts in several countries.

Judging by the size of the recycling industry in other nations, the inability of Arab countries to recycle municipal solid waste is a lost economic opportunity. In addition, the mismanagement of municipal solid waste causes significant

TABLE 1 **SPECTRUM OF CURRENT WASTE MANAGEMENT PRACTICES IN ARAB COUNTRIES**

	Spectrum of Practices				
Collection	Curbside	Street Bins	Door to door	Chutes	Underground collection
Transport	Man pulled cart	Donkey cart	Open bed/Covered vehicles	Compactor vehicle	Container carrier
Transfer	None	Curbside	Vehicle to vehicle	Open lot	Transfer station
Sorting & treatment	None	Recycling	Recycling and composting	Waste-to-energy/ Incineration	Anaerobic digestion
Disposal	Open burning	Curbside dumping	Uncontrolled dumpsite	Controlled dumpsite	Sanitary landfilling

FIGURE 2 PICTURES DEPICTING VARIATION IN LEVEL OF SERVICE WITHIN ARAB COUNTRIES

degradation to the environment, with direct negative consequences for human health and standards of living. Improper handling of solid waste can result in the spread of parasites, insects, and diseases. Uncollected waste is an eyesore and bad odors are a continuous source of nuisance to nearby communities. Improper dumping of solid waste allows decomposed waste products to pollute the air, ground and surface water, and the soil. These pollutants may then find their way to the air we breathe or may enter the food chain through the water we drink or the produce we consume, causing direct health hazards and significant health care costs.

B. Cross Cutting Issues

Current waste management practices and policies in Arab countries are not economically sustainable. These practices are often driven by the availability or unavailability of financing, rather than by long-term economic and environmental benefits. Given the sector's underdeveloped condition and unsustainable practice, there is an urgent need to adopt a different strategic approach to create the conditions for more sustainable patterns of waste management practices.

Based on various discussions about MSW management in the region with relevant stakeholders combined with our own observations of the sector in a number of Arab countries, including Bahrain, Egypt, Kuwait, Oman, and Qatar, we have identified a number of key trends and issues that require immediate attention as follows:

1. There is a lack of national policies and strategies for waste management.
2. Arab countries do not have integrated MSW management plans locally or regionally.
3. The region has weak waste disposal standards.
4. Waste management in the region is not adequately financed and levels of cost recovery are low.
5. The volume of solid waste generated is alarmingly increasing.
6. Proper waste collection and transport systems are lacking and coverage is inadequate.
7. Environmental monitoring at MSW facilities is lacking.
8. The sector is plagued by insufficient MSW regulations and enforcement.
9. Reliable data for monitoring and planning purposes is lacking.
10. The sector suffers from a shortage of well-trained staff in MSW management.
11. There is considerable lack of public awareness about MSW management.

The solutions that are commonly proposed to address the problems in municipal solid waste management in Arab countries often have the following features:

1. Centralized and undiversified – solutions that do not distinguish among the different needs and heterogeneity of neighborhoods within each city, and between cities.
2. Bureaucratic – top-down solutions, usually reached without or with little community participation.
3. Capital-intensive approaches – involving advanced technology and equipment,

frequently imported from industrialized countries.

4. Formal – conventional solutions only consider the formal sector, neglecting the existence and possible contribution from the informal sector, despite its experience in waste collection and recycling.

In summary, municipal solid waste management is one of the most underdeveloped sectors in most Arab countries. It needs far more government attention and conceptual development than it has been assigned, if it is to become a sustainable economy driver rather than a source of burden and shame to society.

IV. BEST PRACTICES WITHIN GREENER ECONOMIES

Best practices in industrialized countries have arisen through the development of new concepts and technologies focused on pollution abatement and resource productivity. Considerations of the interaction between the economy, society and the environment have generated a number of significant developments in green concepts and technologies over the past few decades (Bass et al., 2009) that are briefly discussed below.

A. Development of Concepts

The development of a continuous stream of new concepts over the past few decades has marked a new approach seeking to set alternative frameworks for environmental protection and resource conservation. Below is a summary of the main concepts that have been introduced.

The impact of human activities on the planet was investigated by Paul Ehrlich and John Holdren through the "Questioning Consumption" concept in which they arithmetically modeled the impacts of each dollar spent on the planet (Bass et al., 2009). Understanding the implications of human activities has led to the concept of "sustainable development" which was defined by the Brundtland Commission in 1989 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The concept advocates preserving a resource base for future generations, integrating environmental management, setting social and economic objectives, and making informed trade-offs when needed. These principles remain valid and are very relevant to MSW management activities.

Daly and Cobb called for an index of sustainable economic welfare that measures wellbeing in financial terms that subtracts negatives such as pollution, disease, and the depletion of natural resources (Bass et al., 2009). The above concepts have gradually built pressure for new initiatives towards the green economy.

Of particular relevance to waste management are zero waste initiatives that are now being adopted by cities and some corporations. With the emergence of new technologies in recycling and recovery, in parallel with waste reduction and reuse initiatives, the concept of "zero waste" that targets the prevention of waste by-product formation and advocates putting an end to landfill activities, has gathered steam. It has been suggested that "zero waste reflects a shared global vision where resources are used sparingly, efficiently, and optimally with systems in place to ensure that waste is effectively managed without significant negative impacts on the health of citizens and the quality of the environment. It represents an aspiration to both minimize the use of resources in the manufacture, distribution, and use of products consumed by society and maximize the capture, reuse, recycling, and recovery of the intrinsic resource value within the waste generated by society" (CSD, 2011). Germany and Japan have launched initiatives with set targets and schedules to end landfills. However, there is yet to be an initiative achieving zero waste in absolute sense.

B. Development of Technologies

The conceptual development in resource management over the past few decades has been accompanied by a fundamental shift in the approach to solid waste management from "getting rid" of waste to a resource management approach seeking to capture value from waste material through reuse, recycling, and recovery (Chandak, 2010). A combination of waste management practices and technologies are therefore being employed to divert waste away from landfill disposal and make use of otherwise wasted resources. Green economies tend to stimulate increased investment in waste management to accommodate increased waste generation rates associated with economic development. Investments are directed towards developing means for waste diversion and resource conservation to reduce the amount of garbage going to landfills.

Waste diversion is fundamentally based on minimizing waste going to final disposal. Strange (2002) argued that "while some consider the diversion of waste materials into recycling to be waste minimization, the original intent of the term was to reduce to a minimum the amount of waste being generated" in the first place.

The broader definition of minimization encompasses the three elements in order of desirability beginning with avoiding or reducing waste generation and increasing waste quality at the source, followed by material recovery through reuse and recycling (Strange, 2002). Successful implementation of material recovery may achieve approximately 70% waste diversion. However, material recovery is not the only measure for waste diversion. Additional treatment and processing is applied to manage the remainder of the waste stream in order to recover energy. It is however unavoidable that some waste residuals remain at the end of the pipeline.

The waste management hierarchy from a desirability perspective is illustrated in Figure 3 (European Parliament, 2008). The hierarchy has little scientific or technical basis but can be used as a reminder of the waste management options available to decision makers. For example, the hierarchy does not factor in costs, nor is it of use when comparing a combination of options.
The greener the economy, the higher up the diversion targets are on the waste hierarchy. The so-called 5-Rs of solid waste management (Reduce, Reuse, Recycle, Recover, and Residue management) are further discussed in the following sections.

1. Reduce

Reducing waste is the most important element of waste minimization and is considered the most desirable. It is often achieved through judicious process and input design. Waste reduction avoids the unnecessary use of materials, energy, and water. In addition, avoided waste has no environmental impact and requires no management. The aim of waste reduction is to eliminate waste before it is produced and to reduce both the quantity and toxicity of waste. This should be achieved through resource optimization, in which an integrated system-wide approach is taken.

There are a number of practices that can be adopted by stakeholders to achieve waste minimization. Households can contribute to waste minimization by moderating and monitoring their consumption habits, focusing on their needs rather than wants. Good household strategies include purchasing longer life products and repairing items whenever possible.

Manufacturers have the dual responsibility of reducing waste associated with their operations, as well as making products with longer lifetimes. Extending the product life contributes directly to resource optimization. In addition, designing products that are amenable to re-manufacturability, reparability, and recyclability are effective strategies. Government authorities need to promote waste minimization through mandatory regulations, incentives, and public awareness campaigns. Therefore, political engagement and public participation are necessary.

2. Reuse & Recycling

Reuse obviates the need to make purchases, thus reducing the consumption of energy and virgin materials that would have been used to make new products. Reuse and recycling prevent waste from reaching a landfill. Recycling often involves the reprocessing of waste materials to produce other products. Examples include the recycling of plastic bottles to make buckets or the conversion of organic waste into compost. Wastewater is sometimes treated for reuse in landscape irrigation.

AL-AZHAR PARK: FROM WASTE-DUMP TO CAIRO'S GREEN LUNG

Nidaa Hilal

For 500 years, the 30-hectare (74 acre) derelict Darassa site in Cairo had been used as a waste dump. It is adjacent to Darb al-Ahmar, one of the Egyptian capital's poorest districts and one of the world's most congested sites, ironically featuring one of the world's richest concentrations of Islamic architecture.

Working in over 30 countries on development, the Aga Khan Trust for Culture (AKTC) undertook to restore the whole area to become a "green lung" for inhabitants of the city and a powerful catalyst for urban renewal, now known as Al-Azhar Park.

The story dates back to 1984 when AKTC decided to finance the construction of a $30 million park, which now attracts over one million visitors a year. The project included excavating a 12th Century Ayyubid wall to a depth of 15 meters after being buried up to its battlements. Having undergone extensive restoration, a 1.5 km section of the wall, with several towers and battlements almost intact, appeared in its entire splendor. Other landmark monuments and buildings in the Historic City were restored: the 14th Century Umm Sultan Shaban Mosque, the Khayrbek complex (encompassing a 13th century palace, a mosque, and an Ottoman house), and the Darb Shoughlan School.

The multidisciplinary project presented complex technical issues, including incorporating three large fresh water reservoirs for Cairo, each 80 meters in diameter and 14 meters deep. Hundreds of families have benefited from the improvement of the water supply network and the reparation of the electrical systems that began in 2007. Parts of the sewage network have been upgraded and expanded into alleys previously not served by these facilities. New drainage works are preventing the pooling of water, thereby reducing the potential for water-borne disease.

The horticultural challenges, such as the highly saline soil, were formidable. To overcome this challenge, over two million plants and trees have been planted after creating specialized nurseries to identify and grow the best plants and trees for the soil, terrain, and climate.

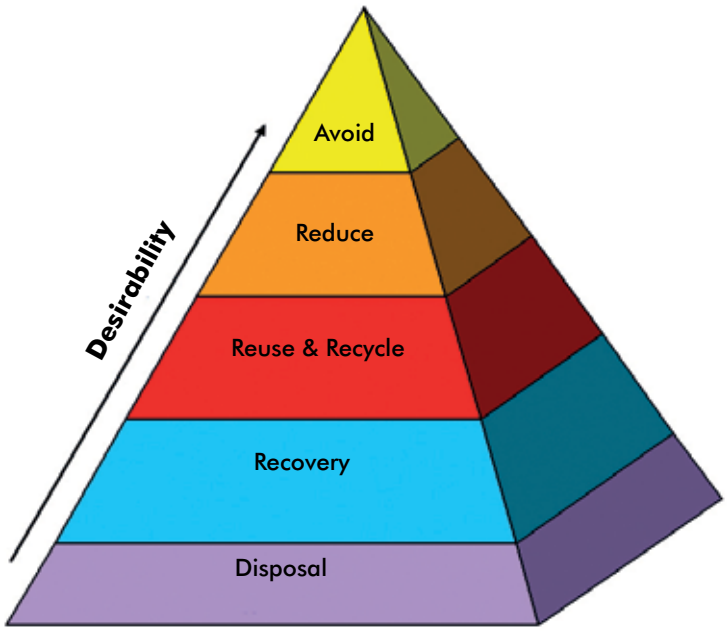
Environmental programs stressed general awareness, focusing specifically on green solid waste disposal practices. A program to remove the trash and rubble strewn across most roofs and replace them with vegetable gardens was undertaken. Additionally, a pilot project for affordable solar water heating systems was started, addressing the lack of heating in 25 percent of the area's homes.

The Agha Khan vision also encompassed extensive social development programs. Job training and employment opportunities are being offered in different sectors such as shoemaking, furniture manufacturing, and tourist goods production. Apprenticeships are available for automobile electronics, mobile phones, computers, masonry, carpentry, and office skills. Micro-credit loans have enabled residents to open small businesses.

In short, AKTC has worked with the locals on identifying priorities before taking practical steps to address their needs. Such an approach has stimulated rehabilitation without displacing residents, ensuring that they have a stake in the future of their community and helping to create viable businesses.

Nidaa Hilal is writer at Al-Bia Wal-Tanmia (Environment & Development) magazine

FIGURE 3 WASTE MANAGEMENT HIERARCHY



Source: adopted from European Parliament, 2008

Waste recycling can be hindered when market conditions are unfavorable. Sources of waste need to be in proximity to secondary materials dealers and processors. Barriers to waste recycling include changing demand caused by gaps between perceived and actual performance of the recycled products, cross contamination, and limited public participation. The most effective strategy for improving recycling is by promoting source segregation. Developing separate collection systems and improving coverage of collection at curbsides, while increasing the density of recycling centers are all factors that make recycling more effective.

3. Recovery

Energy or materials can be recovered from wastes that are not reused or recycled. A number of technologies are used to recover energy from waste. Waste combustion is one of the methods used where waste is incinerated after the removal of bulky items. In the past, waste was incinerated as a treatment process but today incineration is used to recover energy. Fluidized bed combustion is a second method of waste incineration where a fire bed of sand or ash is used. When air is blown through the bed the material behaves as a fluid, enhancing mixing and process efficiency. Fluidized bed incinerators reduce air emissions, which results in lower-cost air pollution control equipment. This technology requires uniform size waste, which is accomplished by pre-processing before injection into the fluidized bed reactor.

Another method of energy recovery from waste is refuse derived fuel (RDF), which is produced by processing waste to produce palletized fuel that can be sold, transported, and combusted as a source of energy.

Waste-to-energy through direct combustion of municipal solid waste (MSW) or through the production of refuse derived fuel (RDF) may be considered a waste diversion system. Some analysts, though, view waste-to-energy as a waste of resources because the energy recovered is only a small fraction of the energy that goes into producing the waste (Morris, 2009). However, waste may be separated at the source into combustible and non-combustible portions before sending the combustible portions to incinerators. The combustible portions would naturally have the highest possible calorific value,

PROCESSING OF OLIVE MILLS WASTEWATER

Fuad Hashwa

Olive oil making, one of the oldest agricultural industries, has traditionally been a hallmark throughout the Mediterranean basin. It is an economically significant product for many countries and a major source of income for olive growers in Arab countries. However, high organic content process water from olive oil manufacturing is a significant environmental problem.

Olive oil is produced by extraction from olives under pressure. The oil content of olives varies between 15-22% by weight. The process waste generated, making up the remaining 78-85% of olives, is made up of olive cake and organically rich wastewater called Zibar. Many countries restrict olive mills wastewater (OMW) dumping into city sewers, streams, or rivers. Technologically and economically feasible technologies for the safe disposal of OMW have not been available till now.

The small, mostly family owned olive oil processors in Lebanon are of fundamental economic importance due to the high nutritional value of their products. However, a huge waste of agricultural potential and natural resources accompany their trade. During the annual olive-harvesting season (October-January), Zibar is generated in large quantities from olive mills, adversely impacting the environment in different parts of Lebanon.

There are few technologies available to alleviate the adverse effects of wastewater effluents in general, and none have been applied to the problems associated with Zibar in Lebanon. Since there is no disposal system, OMW is dumped on land without treatment, thus becoming a major pollutant to surface water, groundwater, and soils. Zibar is known to be toxic to plants, inhibiting their growth. The untreated olive cake doesn't decompose at a high rate, accumulating over time as a persistent environmental pollutant. However, its nutritional value after composting permits its use as a significant feed source for animals. Proper recycling of these wastes would alleviate the annual water shortage and would reduce economic dependency resulting from the import of human food and animal feed.

To address these problems, the Lebanese American University (LAU) Biotechnology Labs in Byblos initiated a research project to develop a process for the safe treatment of OMW. The main objective of the project was to develop a low cost OMW bio-treatment technology that can reduce the high organic load of OMW and minimize its toxic impacts on the environment. The technology had to be also affordable to olive mills owners. Bio-processing of OMW is viewed as desirable because of the capability to convert toxic compounds to potentially commercial products such as proteins, fertilizers, phenols, and biogas (methane).

The low cost OMW bio-treatment process developed at LAU achieved significant organic matter reduction rates, and has proven to be suitable for deployment in small rural olive mills in Lebanon and in the Middle East. The bioprocess can also be exploited to produce additional valuable products such as phenols and biogas, thus bringing additional benefits to improve the socioeconomic status of the farmers and protect the environment.

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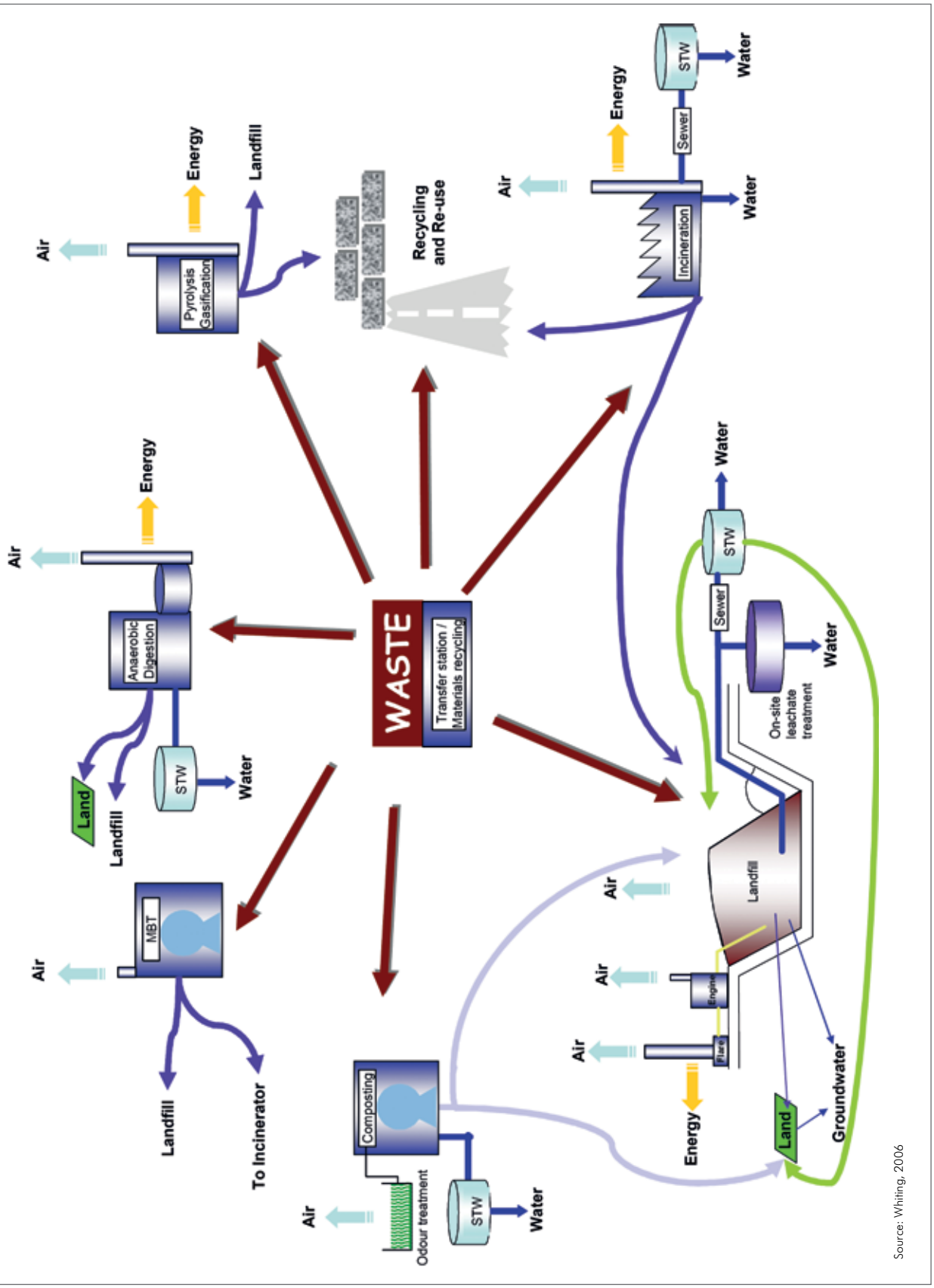
which could preclude the use of auxiliary fuel. Many of the cities that achieve high diversion rates rely on waste incineration to generate heat and electricity (Vancouver, 2009). In addition, incineration is the option of choice in communities where it is difficult to secure land for landfills.

The beneficial conversion of landfill gas into energy evolved in order to address the potential of explosive gas leaking from landfills. Anaerobic decomposition of organic waste in landfills generates methane gas, which can then be collected and burned for energy recovery. Methane is a greenhouse gas with higher global warming potency than carbon dioxide. Therefore, the combustion of methane gas for energy recovery has the further benefit of reducing the net potential for global warming. Anaerobic digestion of organic waste provides a higher recovery rate than landfill gas recovery. In anaerobic digesters, only organic waste is introduced to the reactor where it is mixed with sewage sludge. Gas emissions from anaerobic digesters are used for energy recovery while the remaining residue can be used as a fertilizer.

FIGURE 4 OVERVIEW OF A WASTE MANAGEMENT SYSTEM



Source: Whiting, 2006

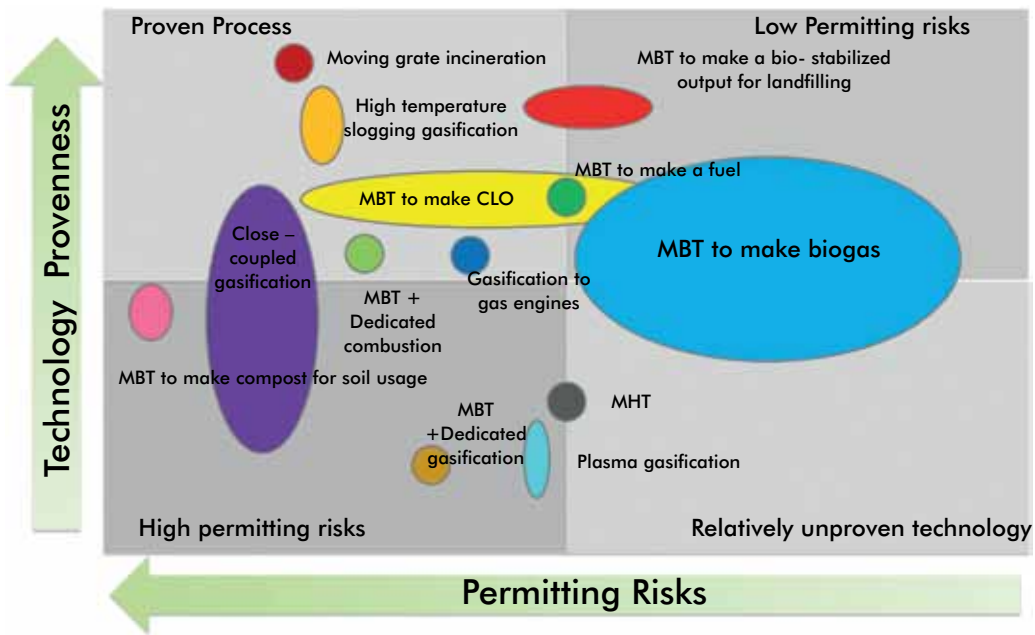
Waste-to-energy gasification is the process of reacting waste with steam at a high temperature without combustion to produce synthesis gas or syngas, a mixture of hydrogen and carbon monoxide, which is often used as a fuel. Pyrolysis is a complex series of reactions initiated when the waste material is heated (to around 400-800°C) in the absence of oxygen to produce condensable and non-condensable vapors and solid residues. The heat breaks down the molecular structure of waste, yielding gas, liquid, and a solid char, all of which can be used as fuels. Gasification and Pyrolysis have primarily been used for single, unmixed waste streams such as tires and plastics, or to process RDF. Neither pyrolysis nor gasification is generally considered suitable for handling mixed, untreated MSW in large volumes at the present.

4. Residual management

Source reduction, reuse, recycling, and recovery should be considered in that order for managing solid waste. But even with best efforts and practices, there may still be a need to dispose of some residual waste. Residual waste management is the final disposal of waste materials that cannot be used in any other way. It was common decades ago to dispose of waste in open dumps. With growing environmental awareness and the development of new concepts, open dumps have been phased out and replaced with sanitary landfills which are designed to fully contain gas and leachate. Modern landfills are also equipped with gas and leachate monitoring systems to monitor any leaking emissions to the environment. As discussed earlier, new trends in waste management tend to gradually decrease the reliance on landfills through waste diversion.

Figure 4 is an overview of the methods and technologies used in a modern waste management system. The combination of methods used in municipal solid waste management in a given city is highly dependent on the composition of waste and the economics of each method. Recycling and recovery activities may not always be financially justified, unless the costs of environmental degradation and natural resource depletion are internalized. Investment in waste reduction, reuse, and recovery can therefore be catalyzed only through government public policies, public-private partnerships, and/or innovative financing and cost recovery schemes.

FIGURE 5 **WASTE DIVERSION TECHNOLOGIES: RISK VS. DEMONSTRABILITY**



MBT: Mechanical biological treatment
MHT: Mechanical heat treatment
CLO: Compost-like-output
Source: Whiting, 2006

STOCKHOLM – EUROPEAN GREEN CAPITAL
Adapted from: Stockholm, 2011

The City of Stockholm has a 100-year old tradition in waste incineration and waste-to-energy management experience. In 2007, the total amount of waste per capita in Stockholm was 597 kg/person-year. The city has a unique waste management system and uses innovative methods such as vacuum controlled underground transportation of solid waste.

Waste management is regulated at both national and municipal levels. Ordinances on producer responsibility, regulation of specific types of waste, waste transport, waste treatment, and other relevant areas are regulated at the national level. Waste collection and disposal for Stockholm municipality, and waste collection fees are regulated by the local bylaws.

The city of Stockholm diverts 100% of its waste as follows:

- **Recycling:** 25% of the waste produced by the citizens in Stockholm is recycled. Packaging materials are collected for material recycling by the contractors for the producer's collection system. Bulky waste from households is collected directly from houses and buildings, or delivered to the recycling centers.
- **Recovery:** 73.5% of the waste is recovered for production of district heating (energy recovery by incineration). Today, more than 70% of the households in Stockholm have access to district heating, partly produced by energy recovered from households' waste. Domestic waste is used for energy recovery at the Högdalen plant in southern Stockholm. The combustion process produces both heat and electricity. The residual products of the combustion process are slag, which is recycled and ash, which is disposed of at a landfill site.
- **Biological treatment:** 1.5% of the waste is biologically treated. Swedish legislation does not allow organic waste to be sent to landfills. In Stockholm, all separately collected food waste is recycled as biogas and fertilizer. The city promotes source segregation of organic waste by providing bins for food waste intended for biological treatment and cornstarch bags available to individual households.

Stockholm finances waste management through a waste collection fee, which has been approved by the Stockholm City Council. The waste collection fee covers the collection and treatment of domestic waste and the administration of waste management in the city. The fee also covers the drop off of bulky waste, electrical, electronic, hazardous, and other wastes at the recycling centers and at other permanent and mobile collection points for hazardous and non-hazardous waste.

The Swedish government has introduced a producer responsibility program for the packaging and newspapers industries because they constitute a major proportion of municipal solid waste that is relatively easy to separate. The responsibility of collection and recycling of packaging lies on every company that produces, imports, fills or sells packaging or packaged goods. Similarly, producers or importers of newsprint and those who print or import newspapers and magazines have responsibility for the collection and recycling of newspapers. The producers of packaging and newspapers have created a cooperative under the name "The Packaging and Newspaper Collection Service" (FTIAB) for managing collection and recycling on a non-profit basis.

Green economies often promulgate policies to promote more sustainable patterns of municipal solid waste management. These green policies can take the form of economic incentives, mandates for extended producer responsibility, regulations in favor of green solid waste management, and cost recovery using, for example, linear garbage rates. The effectiveness of these policies can be significantly increased by sustained campaigns for public awareness, mass education, and social marketing.

When choosing between alternatives for waste diversion, decision makers are faced with a number of questions as to which technology or group of technologies to utilize. Among the key factors are cost, technology risks, and whether the technology is proven. Figure 5 displays a 2-dimensional matrix of waste diversion technologies based on risk and whether the technology is proven. The currently underdeveloped condition of municipal solid waste management in Arab countries requires adherence to proven technologies having low risk. Arab countries cannot afford to take risks or

make trials at this stage. Proven technologies are needed in order to achieve the minimum level of waste management reliably. As authorities acquire and/or develop more capabilities, they can invest in more sophisticated waste management practices.

Having trailed other nations in sustainable development, Arab countries have been on the recipient end of MSW concepts and technologies, utilizing obsolete methods. The Arab world had little to contribute to the field. We see the political changes in the region as a prerequisite for ushering a green agenda. Accountable governments are generally more motivated by the wellbeing of their citizens, which gives hope that sustainable development will become a priority for Arab countries in the near future.

5. Spotlights on selected best practices

Two cities were selected to shed light on best practices from different perspectives. Vancouver, Canada, was selected to demonstrate best practices in waste reduction, reuse, and recycling. Stockholm, Sweden was selected because of the success the city has achieved in diverting its municipal solid waste with heavy dependence on waste-to-energy technologies. Both approaches have been adopted by different countries, depending on their own needs and goals. *(See boxes on p 218-219)*

6. Gains and opportunities

Significant opportunities exist for economic diversification in Arab countries by developing the solid waste sector, which will contribute to job creation and stimulate demand for products, systems, and services in other industries and sectors. Examples of related industries and sectors that can benefit from the development of the solid waste sector are provided below:

- *Manufacturing and after-sale services:* Waste handling, treatment, and disposal require vehicles, equipment, bins, and construction supplies. Additional supplies of specialized equipment are also needed for collection, sorting, and processing of materials. Supplies are also needed for the other service sectors associated with MSW management. Demand for these products and associated maintenance services will escalate with increased service coverage and

VANCOUVER 2020: A BRIGHT GREEN FUTURE
Adapted from: Vancouver, 2009

Vancouver views the low carbon economy of the future as a great opportunity and is planning to build and boost the market for green products, services, and jobs. Vancouver produces over 1.5 tons of waste per capita annually, of which 55% is either recycled or composted. In April 2009, Vancouver issued an action plan for becoming the world's greenest city by 2020. As part of the greener communities plan, the city aspires to divert at least 70% of solid waste from going to landfills by 2015 with a long-term goal of achieving zero waste to landfills. The first step in this direction is to change mindsets so that waste materials are identified as a resource.

The plan prepared by the city of Vancouver is based on reducing the sources of solid waste, gradually moving towards a cradle-to-cradle economy where everything can be re-used, recycled or composted. From an economic perspective, reducing solid waste creates a comparative advantage as scarce resources are freed up for investment, compared to the high capital cost of building incinerators and the difficulties in finding suitable locations for new landfills.

The City of Vancouver decided to prioritize waste reduction through by-laws, education, and expansion of extended producer responsibility programs, and by taxing plastic bags, polystyrene foam food containers, cups, and utensils.

The second priority for Vancouver was to implement city-wide composting programs that include all residents, all businesses, and other institutions, such as schools and hospitals. Work is underway, and should include support for backyard composting, neighborhood-scale pilot projects, and participation in Metro Vancouver's planned regional composting program. The third priority is to improve the recycling program for businesses and multi-unit residential buildings. Vancouver is considering adopting a comprehensive recycling and composting bylaw requiring everyone—single-family residents, multi-family residents, and businesses—to sort their waste into containers designated for recycling, composting, and garbage. Building owners are required to educate tenants, employees and contractors, including janitors, on how to separate materials.

The city of Vancouver plans to build partnerships with industry and other key institutions in a joint zero waste initiative that would share learning and costs, and have a larger, more visible impact. The city is also planning to create new Low-Carbon Economic Development Zones, featuring green infrastructure and financial incentives for entrepreneurs interested in green business models.

MAKING PRODUCTS FROM WASTE PROFITABLY

Boghos Ghougassian

Cedar Environmental, an engineering firm in Lebanon, has eschewed landfills for the disposing of waste and has pioneered innovative processes for recycling municipal solid waste (MSW) since 1999 using its own locally developed methods. The company builds its own composting rotating drums, which ferment organic waste aerobically and reduce the odors to a minimum.

Controlling odors enables Cedar Environmental to operate composting and recycling facilities closer to the communities it serves where waste originates, thus reducing transportation costs and avoiding the logistics of hauling waste over long distances to a landfill.

Cedar Environmental operates waste management and treatment facilities in a closed area, whereby 95% of the received municipal solid waste is recycled into commercially sellable products. The company's goal is to reach "zero waste".

After sorting, approximately 25% of the waste is sorted by weight and is collected for direct marketing as recyclable materials such as metals, paper, cardboard, glass, and some types of plastic. The organic matter, accounting for about 55% of the total waste, is digested aerobically in rotating drums and converted into a marketable organic fertilizer product. The remaining 15% of materials, such as cloth, shoes, and low quality plastic are separated and recycled, or utilized in specific applications. Only 5% of the original waste remains and is sent to a landfill for safe disposal.

The marketable products made by composting the organic components of the waste include:

- Certified organic compost, which is sifted and homogenized to bring it to a uniform structure. It is 99% free of foreign matter. The compost is then matured and packed in 20-liter bags, labeled, and sold in supermarkets and flower shops. Revenues from compost sales allow the company to charge municipalities less for the transport and treatment of their solid waste.

- In 2005, the company adapted its Dynamic Composting Technology to slaughterhouse waste. About 6 tons of digestive tracts, horns, hoofs, and bones of slaughtered animals used to be dumped in rivers or burned in the backyard of the slaughterhouse daily. The company uses composting drums to mix slaughterhouse waste with fish waste, tobacco waste, and coffee roasting waste (which were all land-filled). The waste mixture is then processed to generate a

volume of waste. The rising demand for these products and services will stimulate investments in manufacturing and services to meet the needs of green MSW management.

- *Processing:* Growth in green patterns of waste management will require the development of recovery facilities to produce higher quality final materials for recycling and reuse. The value of recoverable materials can only be fully realized if they can be processed (i.e., segregated, graded, shredded, and cleaned) uniformly, allowing a high-quality bulk material to be produced. These processing needs will create additional investment and employment opportunities.

- *Waste-to-Energy:* Waste incineration has the potential of producing energy that can be converted to electricity. Anaerobic digestion of the organic fraction of municipal solid waste has the potential to produce bio-methane, which can be used as a fuel source. The development of the waste-to-energy sector creates opportunities for companies to provide ancillary services and equipment to the waste management operators.

- *Construction:* Solid waste management requires construction of facilities such as transfer stations, energy and material recovery facilities, incinerators, and landfills. Thus, expanding solid

final compost product that qualifies as a high-grade organic fertilizer. This product is now sold primarily to organic certified farmers at half the price of imported certified organic fertilizers.

- During the composting cycle of the combined slaughterhouse-fish-tobacco-coffee waste, the leachate is collected into fermentation tanks, oxidized, and aerobically fermented for two weeks. When it was originally analyzed in the laboratory it proved to be loaded with 30 different micronutrients, while meeting heavy metal specification standards. This new product is marketed as a liquid fertilizer concentrate to farmers, who can dilute by 100 times with water. The diluted liquid can then be used in drip irrigation or by spraying directly on plants' foliar structure.

- For home and small garden use, the company introduced a 1.5-liter liquid fertilizer bottle. The liquid fertilizer concentrate, produced from the slaughterhouse waste process, is diluted to safe usage levels, bottled, labeled, and marketed along with the organic fertilizer in supermarkets and flower shops.

- Aside from organic products, Cedar Environmental has been involved in research to recycle plastic bags and other plastics that are not currently being recycled such as plastic cups, plastic dishes, cutlery, compact disks (CDs), toothbrushes, and toothpaste tubes. The company has developed a process in which all plastic materials are shredded and turned into a thick flat board, which is dubbed "eco-board." The eco-board is used in the making of fencing for outdoor construction sites, shelves, and outdoor furniture such as benches and tables. The company is currently scaling up this process to be able to produce these boards on an industrial scale for commercial sale.

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waste management services provides opportunities for the construction industry.

- *Transportation:* Waste collection and transfer requires transportation of labor, vehicles, fuel, and equipment. In addition, products and by-products of material and energy recovery facilities also require transportation. The waste management sector needs to be served by an efficient transportation sector, whether by truck, train, or ship and the associated infrastructure of roads, railways, and ports.

- *Agriculture:* The recycling of organic waste through composting is a key growth area given the high organic content of waste in Arab countries. High quality compost at an affordable cost can have positive effects on the agriculture sector. Composting creates opportunities for companies providing systems, equipment, and services in this area.

- *Waste consultancy:* More stringent environmental regulations regarding the handling, transport, storage, treatment, and disposal of waste requires the development of an advisory service sector to provide technical assistance to waste companies who must meet these regulations and fulfill the specific terms of their operating contracts. Advisory consulting companies are also becoming

RESTORATION OF WADI HANIFA WETLANDS

Based on on-site review reports by Mohammad Al-Asad and Wael Al-Samhouri

The Wadi Hanifa watershed is an oasis located in the heart of the Najd Plateau in the Kingdom of Saudi Arabia. It is a natural water drainage course for an area of over 4,000 square kilometers and a unique geographical feature in this dry region. Its basin and many tributaries form a unique 120-kilometre-long ecological zone that descends from the Tuwaiq escarpment in the northwest to the open desert southeast of Riyadh. For centuries, the Wadi Hanifa watershed system provided sustenance for communities along its length, where a balance prevailed between the wadi's resources, natural processes, and human interventions. The Wadi Hanifa is inextricably linked to Riyadh's history.

In the late 18th century, the first Saudi state strategically located its capital at Addiriyyah on the west bank of Wadi Hanifa, taking advantage of water and arable land. Subsequently, Riyadh (or in Arabic, Arriyadh), the new capital of the modern Saudi state, developed to the east of Wadi Hanifa, which was used as a sustainable source of water and food for the city. Beginning in the early 1970s, Riyadh expanded westward towards Wadi Hanifa, after which it was overexploited to satisfy the increasing demand for water and mineral resources to meet the massive construction needs arising from rapid growth.

By the 1980s, Riyadh's explosive growth towards Wadi Hanifa led to the rise of ground water, dumping, environmental degradation, and loss of natural functioning and ecosystem productivity. Illegal building, flooding, and wastewater and industrial dumping led to further deterioration exacerbated by increased urbanization and encroachment. In response, the Arriyadh Development Authority (ADA) began the implementation of a comprehensive long-term strategy in 2004 to develop Wadi Hanifa into an environmental, recreational, and tourist resource, restore its natural beauty, and rehabilitate and harness its water resources.

The reclamation project has included the introduction of landscaping, conservation of the natural environment, enhancement of agricultural land in the valley, managing water quality, restoring flood performance, the construction of dams to regulate water flow, and the planting of reed to further purify water from contaminants. An environmentally sensitive wastewater treatment facility was constructed, providing additional water resources for the rural and urban inhabitants of the region. The works involved the removal of almost 1.25 million cubic metres of construction waste, along with inert and non-inert waste that had been dumped in the wadi over many years. Another component of the wadi development was the restoration of the wadi channel as preparation for a 20-year flood plan. Prior to this, there had been widespread flooding due to the rubble and illegal building within the wadi.

The bio-remediation facility is one of the most impressive features of the project. The facility incorporates a series of weirs, riffles, pools, aerating pumps, bio-remediation cells, artificial periphyton and benthic substrates, and riparian planting. Together, the elements of this design have developed the appropriate aquatic and riparian conditions to assimilate contaminants and further purify the water through a community of natural organisms that aggregate to form a food web. This has contributed to the improvement of the environmental quality of the wadi and has greatly enhanced public perception and recreational use.

involved at the design stage of waste management. As waste management operators begin to adopt greener and more innovative waste treatment, processing, and recovery technologies, there will also be an increasing demand for research and development services in the sector.

Hence, waste management provides business opportunities in many service sectors of an economy such as construction, manufacturing, transportation, retailing, professional services, and administrative services. It also provides an opportunity to revive stagnating economies with the potential for creating jobs. The solid waste sector in Arab countries offers significant investment opportunities.

The Arab world has an existing practice of material reuse due to cultural beliefs and social practices that can be promoted on a larger scale. Recyclables have an existing market that can grow with increasing recycling rates, and can catalyze associated processing and manufacturing industries. Organic waste accounts for 40-70% of all municipal solid waste in Arab countries (AFED, 2008; GTZ et al., 2003). Composting

Today Wadi Hanifa is a "living valley" recovered and fully integrated into the life of Riyadh. The restoration project has regenerated a clean, green, safe, and healthy environment, providing continuous parkland that connects city and wadi. Combined residential development, farming, recreation, cultural activities, and tourism inhabit an oasis that extends the full length of Riyadh and beyond, into the surrounding rural areas.

Preservation of the wetlands of the Wadi Hanifa has resulted in restoring the productive capacity of the ecosystem to provide multiple services including purifying contaminated water, restoring flood performance, providing habitat for biodiversity, and creating opportunities for recreational, educational, and aesthetic experiences. Wadi Hanifa has become a popular destination for recreational activities such as fishing and picnicking and has also become a stop for migratory birds. Use of the parks for recreation, farming, and tourism generate income and support regional employment.

The Wadi Hanifa Wetlands reclamation project offers an alternative model for urban development. It demonstrates that the productive resources of an ecosystem can be balanced with the socio-economic needs of the people living around it to create a sustainable relationship.

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The text was edited by Melissa Vaughn.

segregated organic waste to produce manure (for agricultural use) and/or anaerobic digestion to produce biogas (to replace fossil fuels) present outstanding investment opportunities. Recovery of energy from waste is still in its infancy in the Arab world with a significant potential for expansion. Providing incentives for green solid waste management practices is needed to attract investment in the sector. These green initiatives in MSW management can generate saleable emission reduction credits, which can be traded through the Clean Development Mechanism (CDM).

V. CHANGE FROM CURRENT PRACTICES TO BEST PRACTICES

It is often said in Japan that it took one generation to change people's habits on MSW management and that the awareness should start with school children. Change in Arab countries can be brought about provided there is a political commitment on the part of policy makers to do so, a public awareness program is in place, and concerned stakeholders are cooperating. With these catalysts in place, we can expect to see green waste management

practices expand as waste minimization takes root in Arab societies.

A. The Objective

In the modern world of high competitiveness, the elements that make a community healthy also make it wealthy. There is no doubt that solid waste management has direct impact on human health, the environment, and the economy. Therefore, embracing investment in green waste management practices is essential for achieving welfare as well as socioeconomic sustainability in Arab societies. The ultimate objective should be to develop a sustainable solid waste management strategy that relies on waste minimization and diversion as well as resource conservation, and catalyzes investment in a green economy transition. This can only be achieved by regarding waste not as a costly liability but as a resource, and building business models to capture its value economically and environmentally.

B. Routes for Change

Many developed countries realized that along with technologies and sophisticated treatment processes, there are other necessary aspects to a sound MSW management system, particularly the 3 R's of waste minimization, namely, reduction, reuse, and recovery.

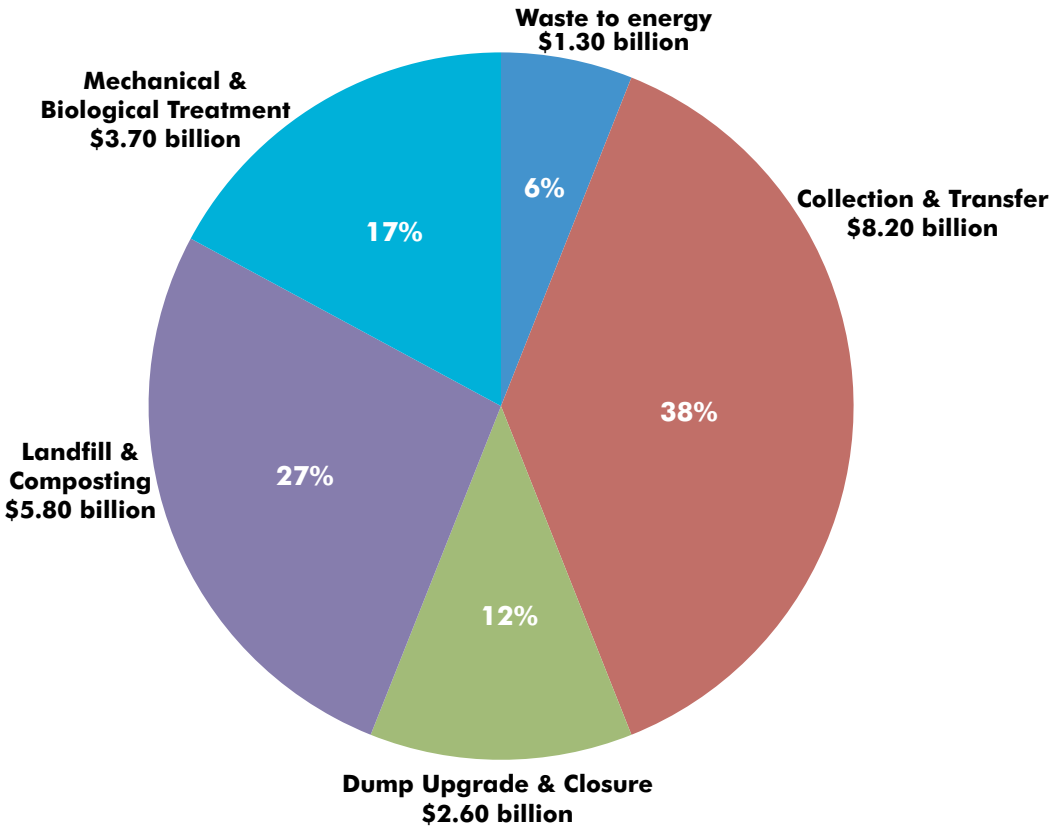
As the examples of best practices in Stockholm and Vancouver illustrate, there may be several routes to transform waste management. One approach is through capital investment utilizing advanced technologies to maximize waste diversion while gradually implementing 3R policies. This has been the model adopted by Stockholm where much of the investment is directed towards waste-to-energy diversion. The other alternative is to start with the 3R policies to gradually divert waste away from landfills. This option may be more suitable for developing economies where the availability of capital is limited. It also utilizes more desirable alternatives of waste diversion. There is not a single solution for waste diversion. A hybrid approach combining features from these two models may be more suitable in some circumstances. The chosen route towards a green waste management sector needs to be customized to suit the circumstances of individual municipalities and communities. It is however very important to learn from the experiences of cities that have gone through this transition.

Lessons learned from other countries

1. MSW management: Vision, strategy, guidelines and plans

While MSW management remains mostly

FIGURE 6 INVESTMENT NEEDS IN WEST ASIA AND NORTH AFRICA OVER THE NEXT 10 YEARS



the responsibility of local authorities, it is the responsibility of the central government to determine the overall quality of MSW services, and to safeguard public health and the natural environment at the national level. These goals should be enshrined in the vision statement for MSW management as well as in the sector's strategic and master plans.

In the developed world, many countries have adopted national policies and national strategic plans solely for MSW management. Japan has called for a Sound Material-Cycle Society, and the New Zealand Waste Strategy raises the challenge of moving towards a zero waste and a sustainable New Zealand. Hong Kong, Malaysia, Singapore, and the UK all have similar MSW strategy documents.

Many Arab countries have adopted visions and strategic plans to guide their economic development. Some examples are Bahrain - Vision 2030, Qatar National Vision 2030, Abu Dhabi 2030, and Oman - Vision 2020, in addition to national 5-year plans. These development plans have incorporated environmental issues to a large degree but are very sparse concerning the MSW sector.

It is recommended for Arab governments to:

a. Make a strong visionary statement about waste minimization and recycling.
b. Prepare technical guidelines and standards to guide and monitor private operators.
c. Prepare integrated SWM master plans and action plans.

2. MSW institutions and legal frameworks

This component deals with the administration and legislation related to MSW management. Privatization of MSW services is a common strategy for improving the services provided in the GCC countries as well as in other developed countries. But it should be noted that privatization should not relieve the central government and

FIRST SECURITY GROUP – DUBAI

When the management of First Security Group's staff accommodation realized that they were spending more than AED 4 million a year on sewage tankers, they knew something had to be done, and fast.

For one, it was a fairly expensive endeavor to have twenty sewage tankers haul sewage away every day. Secondly, organizing the logistics of these tankers was proving to be tedious. Finally, since this problem surfaced at the peak of Dubai's construction (and traffic) boom, oftentimes, tankers would not arrive at all, resulting in leakage, spillage, and septic sewage.

All of this could easily be managed by installing an onsite sewage treatment plant, aside for small issue: space. The staff accommodation was situated in an industrial area in Dubai, and comprised of many buildings which left little room for a sewage treatment plant, however necessary.

The problem was solved using a packaged sewage treatment technology, with a somewhat unconventional mode of installation: the modules of the sewage treatment plants were installed in an empty walkway between the site buildings, thus making good use of existing space.

The treated water is being currently used for irrigation within the facility and also for vehicles washing, resulting in reduced water consumption.
Averda water using package sewage treatment solutions, like the one at First Security Group, can provide financial as well as environmental benefits to its clients.

THE BENEFITS

- Major savings on sewage disposal and transportation
- Major savings on water consumption bill
- Leasing opportunities of packaged STP's
- Low maintenance costs (no mechanical parts)
- Low operation costs (no sludge, no chemicals)
- Quick return on investment
- Preservation of water resources through reuse
- Reduce of groundwater contamination from illegal dumping
- Elimination of health hazards caused by sewage odors
- Decrease of fuel emissions, traffic jam and noise pollution caused by sewage tankers

Area	Amount Spent for Water Consumption, before STP (AED per year)	Amount Spent for Water Consumption, after STP (AED per year)
Toilets	875,448	0
Laundry	125,064	125,064
Irrigation	156,330	0
Kitchens & Shower	2,219,886	2,219,886
Discharge of wastewater by Suction Tanker	4,380,000	0
Discharge of treated water	0	1,022,000
Total consumed per year	7,756,728	3,366,950
Savings	AED 4,389,778	
ROI	0.7	

local authorities of their responsibilities towards public health and environmental protection.

Most countries that went down the path of privatizing MSW services have first laid the institutional foundation necessary to govern the privatization of these services. Responsibilities of all stakeholders were properly defined. Waste types and categories have been classified and those responsible for their management clarified.

Arab countries need laws pertaining to various MSW subsectors to be enacted, including:

a. Containers and packaging recycling law.
b. Home appliance recycling law.
c. Construction and demolition materials recycling law.
d. Food recycling law.
e. End-of-life vehicle recycling law.
f. Laws regulating green public purchasing.

In order to bring about legal and institutional reforms, Arab countries need to:

a. Define waste categories.
b. Define stakeholders' responsibilities.
c. Promulgate laws that encourage waste minimization.
d. Set in place an accounting system for MSW management.
e. Combat illegal waste dumping.

3. Financial sustainability

Financial sustainability of MSW management is a major issue for cities all over the world. Unlike other service sectors, it is difficult to recover the

cost of waste management services. Consumers are willing to pay for essential services such as water and electricity, but solid waste management services are not necessarily regarded as worth paying for, particularly in low and middle income countries. Although solid waste may account for a high proportion of the recurrent budget of a municipality, in the range of 20-50%, collection service coverage remains low and disposal standards are generally poor in such countries.

In order to achieve financial sustainability, the important first step is to develop an understanding of the actual cost of MSW services. Once the cost is defined, the financial gap can be calculated and target revenue levels can be defined.

Revenues can generally be raised from local taxes, special solid waste management tariffs on service bills, or charges by the service provider. Tariffs and charges can recover some of the cost of service. Thus, much of the full cost may still have to be covered by the central government. Most developed countries have introduced alternative sources of funding to close the gap. These include carbon financing through CDM, landfill taxes, and producer responsibility schemes. These financial tools along with additional financial incentives can be used as leverage for changing consumption patterns.

It is important to determine the available resources and financial demands in order to prioritize investments. With a clear vision of costs and revenues, policy makers can take decisions based on what is affordable, particularly pertaining to deploying technologies with high capital or running costs.

4. Public awareness

While the public has a right to demand effective and efficient MSW services, it is also necessary for the public to have an understanding of MSW management and share in the responsibility of reducing waste generation. The starting point is to provide role models and education to school children. In many countries children participate in recycling activities and in campaigns to clean their schools and public beaches and parks.

In Arab countries, public awareness about MSW management is limited to a few billboards and signs stressing the need to keep cities clean. While these are welcome signs, much more needs to be done. Public awareness about MSW management should be oriented towards:

a. Explaining and promoting waste minimization.
b. Introducing source separation of waste materials.
c. Collecting MSW service charges.
d. Understanding MSW management rules and regulations and decreasing illegal practices.

5. Human resources development

More recently, the capabilities of officials responsible for MSW management in Arab countries have seen improvement. Waste management services could be further improved by developing in-house expertise and/or acquiring skills in the following areas:

a. Monitoring the growing number of private MSW service providers.
b. Developing better understanding of more sophisticated MSW treatment systems.
c. Formulating MSW management laws to regulate the sector.
d. Promoting public awareness.
e. Operating more cost effective services.

6. Information management systems

Solid waste management is not an exact science. The waste is not homogeneous and there are daily and seasonal variations in the quantity of waste generated and its composition. But these two characteristics, the amount and composition of waste, are the data points upon which the planning and administration of waste management services depend from waste collection and transport to facilities design and budget setting. Therefore, it is necessary to develop a data information system for data storage, retrieval, and analysis.

MSW service providers in the developed countries maintain operation records and monitoring systems for environmental pollution. Financial data is also properly recorded and categorized by cost item.

C. Realistic Objectives

The development of a green MSW management sector in Arab countries will require the implementation of both soft and hard measures. The hard components will entail the implementation of capital investment projects and operation of intermediate treatment facilities as well as improved industrial processes. This

in turn will require larger budgets for MSW management. It needs to be stressed that the implementation of the 3R concepts will provide some revenue, but in most cases it will be difficult to cover all the capital and operating costs.

As for soft measures, Arab governments will need to set objectives based on the priorities of each individual municipality. This can be realized by articulating a national MSW management policy, based on which a national MSW strategic plan and regional level MSW master plans should be prepared. National policies as well as strategic and master plans should all be consistent and based on the waste management hierarchy (Figure 3) introduced earlier. The target of these plans is to change consumption and production patterns towards waste minimization and reduction as per the 3 R's concept.

It is often said that the privatization of MSW services may lead governments to take a hands-off approach to the sector. In fact, the introduction of privatization to the MSW management sector should not be considered as a substitute to government coordination, monitoring, and regulation. The proper role for governments is to develop the institutional framework for MSW management that would inform the actions of concerned stakeholders.

D. Proposed Route for Arab Countries

For Arab countries to develop a green MSW management sector within the wider context of a green economy, a set of proposed actions is needed as follows:

1. Vision and strategy

a. Develop a vision statement for MSW management as well as a strategic plan for making this vision a reality, recognizing waste as a resource and emphasizing waste minimization.
b. Include the MSW sector in the country's national development plan.
c. Generate "National Guidelines" for MSW management.
d. Prepare the MSW master plans for the country's capital city and for other municipalities.
e. Establish a National MSW Task Force

to oversee implementation of the above activities.

2. Institutional and legal frameworks

a. Entrust the central government authority responsible for the environment in each country with the portfolio for MSW management at the national level.
b. Identify the shortcomings of existing laws and regulations for MSW management.
c. Prepare a law on the management of construction and demolition waste.
d. Review trade agreements in order to extend the responsibility of foreign producers to manage the packaging and waste of electronic and electrical equipment (WEEE) generated from their goods exported to Arab countries.

3. Financial sustainability

a. Separate waste management budget to identify the actual cost of MSW management.
b. Prepare a sustainable financial plan for waste management.
c. Negotiate compromises with different stakeholders to balance budget limitations and spending needs.
d. Consider financial resources through extended producer responsibility, carbon credit, and landfill taxing.

4. Public awareness

a. Develop and implement a sustained public awareness campaign.
b. Promote a Clean Week where the public, service providers, and government officials participate in MSW management activities.
c. Promote a Clean City competition with financial rewards, to motivate municipalities to act.
d. Introduce educational content about MSW management in elementary school curriculums.
e. Promote awareness about MSW management at the work place of large waste generators such as shopping malls and office buildings by setting up MSW plans at these locations by facilities managements.

5. Human resources development

a. Develop training and executive education programs about MSW management and governance targeting officials from central and regional governments.
b. Organize information exchange trips for MSW officials in Arab countries to share experiences, coordinate policies, and learn about new green policies and processes.
c. Introduce MSW management in educational and research programs of universities.

d. Allocate funds for capacity building in MSW.

6. Information management system

a. Set up mechanisms for collecting information on solid waste quantities and compositions nationally.
b. Establish an operational and environmental monitoring program in each MSW facility.
c. Unify the practices for collecting MSW data among the various solid waste facilities within the country, and among Arab countries.
d. Set up a government-run MSW web site and upload MSW data on a regular basis.

E. Policies and responsibilities to support the change

There is a major need for investment in municipal solid waste management in the region for environmental sustainability as well as economic growth. Policies and incentives need to be developed to promote profitable investment initiatives in the waste management sector. However, weaknesses in the framework of municipal solid waste management in the region increasingly constrain investment in the sector. The following section discusses existing constraints in the sector.

1. Constraints

Policy makers in Arab countries need to be aware of existing weaknesses in the waste management sector that constrain a shift to green practices. Such constraints need to be addressed when planning for the transition to a green economy. The most important barriers in the region are summarized as follows:

a. Increased quantities and changing composition of MSW.
b. Increasing cost of waste management.
c. Inadequate financing and weak cost recovery.
d. Limited waste management policy framework.
e. Undefined roles and responsibilities in solid waste management.
f. Lack of political priority.
g. Lack of reliable data for planning purposes.
h. Shortage of well-trained staff and technical expertise in MSW management.
i. Lack of public awareness about MSW.

2. Proposed policies for change

The following policy changes are proposed to overcome these constraints:

a. Promoting the adoption of sustainable integrated solid waste management (ISWM) strategies with emphasis on a preventative waste management hierarchy.
b. Developing policy, legal, and institutional frameworks supportive of ISWM.
c. Developing financial frameworks to reflect full cost accounting.
d. Using market incentives to develop a recycling industry.
e. Promoting waste avoidance, reduction, reuse, and recycling (3Rs) by waste generators and consumers.
f. Building institutional capacity of municipalities for improved management of

the MSW sector.

g. Encouraging private sector participation and stewardship in ISWM activities.
h. Promoting sustainable production practices in manufacturing and other industries.
i. Raising public awareness about sustainable consumption and production and the economic, social, and environmental consequences of inadequate solid waste management.
j. Developing effective capacity for safe and sound management of hazardous waste.
k. Promoting on-site sorting and separation of various waste streams.
l. Fostering regional cooperation in research and development and the sharing of experience in the fields of MSW management and hazardous waste management.

F. MSW management economy

The solid waste management sector is an important service sector with a significant economic weight compared to other utilities and service sectors. The size of the world's waste management industry in 2010 was estimated to be approximately $433 billion compared to $1,715 billion for the electric utilities industry and $515 billion for the water utilities sector in 2008 (Whiteman, 2011). These estimates indicate the economic significance of the waste management sector. At the local level, MSW management consumes a large portion of municipalities' budgets. It is common for developing and transitional country cities to spend 20-50% of their available recurrent budget on solid waste management (UN-HABITAT, 2010). Yet it is also common for one half of the urban solid waste to remain uncollected and one half of the city population to be unserved.

In Arab countries, more investment is needed in the sector to expand coverage and improve health and environmental standards. Estimating investment requirements is difficult because waste management is one of the industries with the fewest pieces of available hard data to allow modeling of market needs. However, Whiteman and Soos (2011) extrapolated limited existing data to assess the indicative investment needs of the world's countries for municipal waste management only. They estimated that the worldwide investment needs in MSW management over the next 10 years is between $214 and $499 billion. Municipal solid waste management investment needs over the next 10 years in West Asia and North Africa (mostly Arab countries) was estimated at over $21.6 billion. These investment needs are related to the waste management chain and broken down as follows: collection and transfer (38%), dump upgrade or closure (12%), landfilling and composting (27%), mechanical & biological treatment (17%), and waste-to-energy (6%), as indicated in Figure 6. The estimated investment needs for some Arab countries (Algeria, Egypt, Jordan, Lebanon, Mauritania, Morocco, Palestinian Territories, Syria, Tunisia, and Yemen) is $6.5 to $9.3 billion (Whiteman, 2011).

The estimated investment projections are based on assumptions on the potential infrastructure requirements and investment expenditures of a notional unit urban population using different investment projection scenarios for different countries at different stages of development. Investments are also required for other (special) waste streams not included in the estimates including hazardous waste, healthcare waste, waste of electronic and electrical equipment (WEEE), tires, and other waste streams. Investments in downstream processing of collected recyclable materials are also not included. Therefore, these are considered rough estimates, which need to be revaluated on a country-by-country basis to account for local special conditions.

VI. CONCLUSION

The main recipe for success in improving waste management in Arab countries is the political will. It is much needed to rearrange the priorities and take the actions needed to provide an enabling environment for green investment in the sector. If actions are taken to develop a framework for municipal solid waste management with clearly defined roles and responsibilities, a foundation platform can be in place to support more sustainable practices in the sector. Such actions will trigger the development of policies and strategies, legal and regulatory reforms, financial plans, the development of regional or local master plans, the prioritization of investments, and stakeholder interactions. Such reform should foster investors' confidence in the sector and stimulate green transformations in the economy.

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