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Tadweer: improving municipal solid waste sustainability practices

Badreya Gharib Al Bloushi, Syed Zamberi Ahmad and Manar Fawzi Bani Mfarrej

In June 2019, Dr Salem Alkabi, Chief executive office (CEO) of Tadweer, the Abu Dhabi center of waste management (CWM), was in a thoughtful mood. He had called together his top management team, responsible for various departments including strategy, operations, projects and licensing, to discuss Tadweer's future direction and strategy for mismanagement of solid waste, and particularly dumping into landfills in Abu Dhabi. Those attending the meeting included Abdulrahman Albloushi, the executive director of strategy and business development, Ibrahim Alali, projects and facilities manager and Hussain Alamoodi, licensing and tariff manager.

Abu Dhabi CWM, known as Tadweer, is a governmental entity under the Abu Dhabi Executive Council. Tadweer is responsible for managing every aspect of municipal solid waste (MSW), including collecting, transferring, segregating, treating, recycling, reusing and tracking. Its main challenge is the issue of dumping into the landfill (Oxford Business Group, 2019).

Mr Abdulrahman Albloushi, executive director of strategy and business development at Tadweer, had suggested to Alkabi that Tadweer could improve its waste management practices, making it more sustainable. In particular, the center could get more benefit from waste through reuse and recycling, instead of losing it to landfill. However, there were some difficult questions to address, particularly how effective it is to collect waste from where it is generated and move it out of sight. Alkabi also wanted to evaluate the possible business scenarios that could help Tadweer to scale up operations and had begun to think about some new strategic waste management approaches that would assure the successful operations and management of Tadweer in Abu Dhabi.

Setting out the problem

In July 2018, Salem Alkabi, CEO of Tadweer, attended the inauguration of Abu Dhabi's first construction and demolition (C&D) waste (mobile) crushing station. He stated that the emirate of Abu Dhabi would be diverting 85 per cent of waste away from landfills and transforming it to energy by 2030. He made the bold statement that "waste does not exist since we consider it as a raw material."

Tadweer was, therefore, working to change the waste management framework from its current traditional practices toward a more holistic and comprehensive approach (Environment Agency-Abu Dhabi, 2016).

Reports were showing vast numbers of illegal waste dumping sites in Abu Dhabi (Plate 1). These had made it clear to Alkabi that the Emirate needed a new and practical approach to solve this challenge. This issue is not the sole responsibility of Tadweer, but a complex issue that requires shared efforts between government entities, businesses and society

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The success and outcome of this case study required guidance and assistance from many people. We wish to thank Dr. Salem Khalfan Al Kaabi, the CEO of Tadweer for providing us with an opportunity to write the case study of Tadweer and providing us with all the relevant support and guidance. We would also extend our thanks to Mr. Abdulrahman Albloushi, Ahmed Alhosani, and Ibrahim Alali of Tadweer for their encouragement and moreover for their timely support and guidance until the completion of this case study. We also thankful to many staff in Tadweer for their timely assistance.

Disclaimer. This case is written solely for educational purposes and is not intended to represent successful or unsuccessful managerial decision-making. The authors may have disguised names; financial and other recognisable information to protect confidentiality.

Plate 1 Dumping in landfills

Source: Tadweer internal information

more generally. However, it had led him to decide to speed up the finalization and approval of the Abu Dhabi waste management master plan, to put a proposal in place to move toward a more sustainable and brighter future.

Tadweer

During the past three decades, waste management in the Emirate of Abu Dhabi has been a government service provided by municipalities in Abu Dhabi, Al Ain and the Al Dhafra region. MSW was collected manually by laborers on a daily basis from mixed containers located in public and residential areas and sent to landfill. The increasing population and urbanization led the government of the Emirate of Abu Dhabi to decide to give the Environment Agency – Abu Dhabi (EAD) a supervisory and regulatory role in 2008 and to establish Tadweer to centralize waste management operations in the Emirate.

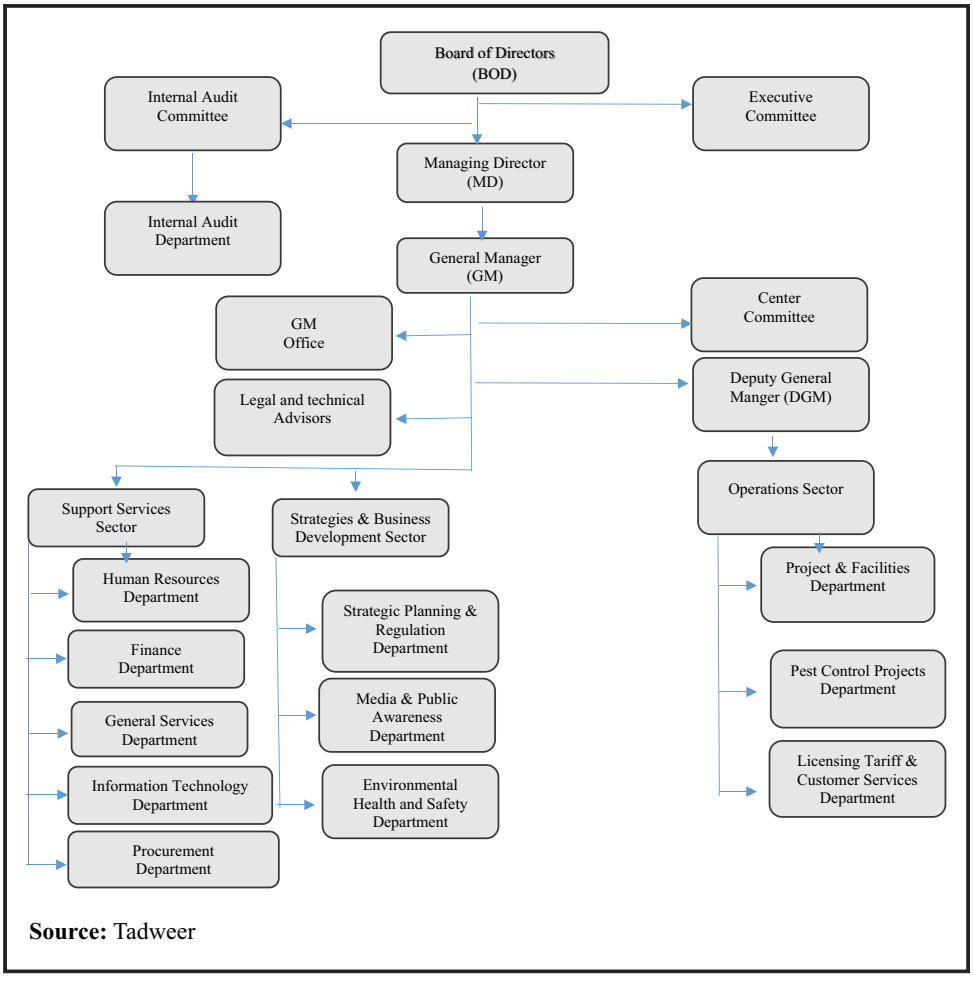
EAD is, therefore, the competent authority on waste management in the Emirate of Abu Dhabi. However, waste management responsibilities are split. Tadweer is responsible for municipal solid, commercial, medical, agricultural, industrial, C&D waste, and Abu Dhabi National Oil Company is responsible for oil and gas. This division of responsibility presents a challenge in developing regulations and enforcement.

Tadweer is, therefore, the operational entity that collects, transports, treats and safely disposes of most types of waste. It is covered by regulations and an enforcement regime set out by regulatory authorities including the Ministry of Climate Change and EAD. It is responsible for the policy, strategy and contractual systems for waste management across Abu Dhabi Emirate and works in parallel with EAD to enforce legal dumping and making sure that all types of waste are transferred to the right facilities inside Abu Dhabi.

The Emirate aimed to divert 85 per cent of its waste from dumping by 2018. The plan was to stop dumping in landfill within five years, with targets set to achieve zero waste. The program included education, tipping fees, green bins, community awareness and regional renewable energy targets. Aggressive targets were set by 25 per cent by 2030 and 75 per cent by 2050. All renewable energy sources have to be exploited to reach these targets. Landfills are one of the largest sources of human-related methane emissions. Renewable energy initiatives include actions on sustainable living, converting methane emitted from landfills to energy, solar parks, electric vehicles, wind energy and waste reduction strategies that include incineration and the generation of energy from biogas.

Tadweer drew on international standards to build and implement integrated waste management and pest control systems, with an optimal investment of assets, specialized human resources and world-class technology solutions. Its aim is to convert wastes into valuable economic resources for the Emirate of Abu Dhabi, and therefore, contribute toward a sustainable society. Figure 1 shows the Tadweer organizational chart.

Figure 1 The Tadweer organizational chart



Source: Tadweer

Dr Salem Alkabi is the CEO of Tadweer. He was previously the director of the public health department at Al Ain municipality between 2008 and 2012. Alkabi holds a doctorate in environmental engineering from Carleton University, Canada, where he specialized in the extraction of methane gas from waste and its application in arid and semi-arid areas. During his tenure at Al Ain municipality, he contributed to the development of a strategic waste management plan for the city of Al Ain. This covered the collection, transportation and treatment of waste, and its disposal in a landfill. The program also aimed to educate the public about how waste management can support sustainability (Tadweer, 2019). Alkabi's vision was that Tadweer would be recognized as a world leader in building a sustainable integrated waste management and pest control system by 2030. His vision was supported by values including sustainability, passion for change, social responsibility, customer-centricity, excellence and innovation and empowerment and attention. From its earliest days, Tadweer's objectives were to protect the environment through the process of sorting and recycling. Its goals also included changing the perceptions and behavior of citizens on sorting and recycling, through education and awareness programs and facilitating and influencing legislation about the environment. To do so, it had to establish presence, strength, commitment and success.

Tadweer is responsible for waste collection and transportation from all three regions of Abu Dhabi (87 per cent of the total area of UAE) and serves around 2.7 million people. The

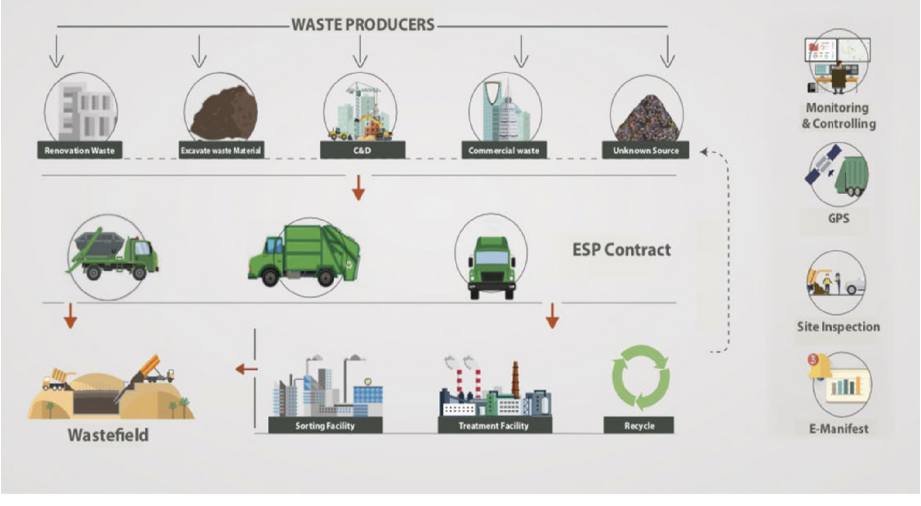
collected waste of Abu Dhabi is estimated to weigh approximately 6,180 tons each day, equivalent to the weight of 1,000 elephants. The department of collection and transportation projects collects waste from specific locations in Abu Dhabi. Once collected, wastes are transferred to sorting stations where it is sorted into streams and sent to recycling facilities distributed across Abu Dhabi (Oxford Business Group, 2019). Unrecyclable wastes are sent to the transfer station and then to landfills. The landfill operator segregates some additional materials from wastes, and the rest is buried.

As the first agency to have lead responsibility for controlling and coordinating waste management activities throughout Abu Dhabi, Tadweer has worked hard to protect the environment by adopting programs on recycling and waste segregation at the source. Tadweer's services go beyond collection to designing and operating sophisticated waste segregation and recycling for different types of domestic solid wastes. Statistical studies were undertaken on types of debris, to determine the type and capacity of the machinery required, and therefore, minimize the rejected materials sent to landfill (Oxford Business Group, 2019). Figure 2 shows Tadweer's services for different types of domestic solid wastes.

The concept of circular economy (CE) conceives of a production and consumption system with minimal losses of materials and energy through extensive reuse, recycling and recovery (Ellen MacArthur Foundation, 2013; EEA, 2014). The material efficiency and the improvement potential of a society can be quantified through a material flow analysis (Haupt *et al.*, 2017).

When looking back to Abu Dhabi, in the past, the economic development in Abu Dhabi was an extensive model, high input, high consumption mode of production brought a negative impact on the environment. If it continues to follow the traditional mode of economic development, resources and environmental capacity in Abu Dhabi may not support the future high-speed economic development. Recognizing the nation's sustainable development needs a well-coordinated economic growth and environmental protection,

Figure 2 Tadweer's services



Notes: Abbreviations: C&D: construction and demolition; GPS: global positioning system; and ESP: environment services provider
Source: Tadweer internal information

Abu Dhabi's top administration heightened attention on ecological modernization, green growth and low carbon development with a national CE strategy (Environment Agency- Abu Dhabi, 2016).

The development of CE is an important way to implement the strategy of sustainable development, to achieve coordinated economy, social development and resource environment, which is also an important step of the economic structural adjustment, have important real significance and far-reaching historical significance to the UAE economy and social development. At present, Abu Dhabi Government proposed the development of CE, promoting the sustainable development strategy, and carried out exploration and attempt in the process of developing CE (Environment Agency- Abu Dhabi, 2016).

As promoting CE is considered as strategy choice for UAE's twenty-first century sustainable development, rather than as a short-term action; therefore, to develop CE is listed up in the UAE national agenda for 2021 (Oxford Business Group, 2019), where the pilot projects of clean product in a manufacturing level were clearly put forward. This requires firms such as Tadweer to be engaged in clean products inside the manufacture and reduce resource consumption from the very beginning. This can be considered as the first level of design and practice clean product based on a CE concept. Furthermore, at the second level, especially to implement pilots of constructing eco-industry parks, a CE model collecting all the potential manufactures where the waste/resource comprehensive utilization is promoted within inter-manufactures (Oxford Business Group, 2019).

Tadweer's initiatives to improve waste recycling in Abu Dhabi

Tadweer awarded recycling certificates from EAD based on the performance of corporations on a set of requirements for recycling and disposal. These certificates helped to improve Tadweer's corporate image and emphasize its contribution toward a cleaner environment. Tadweer also served as an online marketplace to connect companies with available waste and recycling services in Abu Dhabi. For the informal waste industry, Tadweer offered services for decentralized waste collection, processing, and consumption. It attempted to improve the efficiency of this unbroken waste value chain by using technology to connect transporters with secondary waste collectors, streamlining billing and waste reporting. It also created a number of specific initiatives. These included:

Tadweer worked with Al Ain municipality to crack down against people who harmed the environment, with fines of up to AED 100,000

Authorities in Al Ain aimed to end the makeshift dump yards in the city and warned that they would apply fines of AED 1,000-100,000 for offenders. Al-Ain Municipality and Tadweer carried out a nine-month campaign to raise awareness among residents of the correct way to handle and dispose of wastes. Nael Rashid Al Shamsi, Tadweer's Al Ain branch manager, said that the campaign focused on preserving the general appearance of the city, and included educating residents on dumping waste in undesignated areas, segregation of household wastes and pest control. An official from Al Ain municipality explained that an awareness campaign was held in 2017, which led to a success rate of 70 per cent in the 55,600 sectors that were monitored (Gulf news, 2018).

Tadweer opened the first civic amenity in Abu Dhabi to promote waste segregation at source

On July 4, 2018, to promote community participation in segregating waste at source, Alkabi, Dr Thani bin Ahmed Al-Zeyoudi, Minister of Climate Change and Environment, Saif Badr Al Qubaisi, general manager of Abu Dhabi Municipality and H.E Falah Al Ahbabi, chairman of department of urban planning and municipalities and chairman of Tadweer, opened Tadweer's first civic amenity for recyclable waste next to Khalidiyah Park in Abu Dhabi

(Zawya, 2018). This was a facility that allowed the public to participate in the segregation of recyclable waste by allocating colored bins for different types of wastes and reusable materials. Tadweer rolled out the scheme in six more residential areas of Abu Dhabi. Color-coded waste bins were provided to collect more than 12 different types of recyclable waste, including glass, plastic, metal, electrical devices, paper, cartons and bulky waste. The bins have instructions on the type of waste collected and are attractively designed to best-in-class industry specifications to encourage the public to use more frequently. This was a major contribution toward Tadweer's aim of building a recycling society, supported by awareness-raising activities. Tadweer's Envirocare Department's vision went beyond the commercial, to increase awareness of waste reduction, recycling, and resource conversion issues, through educational partnerships and industry leadership (Environment Agency-Abu Dhabi, 2015).

Tadweer implemented global positioning system tracking for the waste transportation sector to track waste from the point of origin to treatment and minimize environmental violations

Tadweer equipped over 6,000 waste vehicles with state-of-the-art GPS tracking solutions to assure proper tracking of waste from the point of origin to treatment. The fleet management solution infrastructure was deployed on Tadweer premises, where it was virtualized to improve the efficiency and availability of IT resources and applications and eliminate the "one server one application" model. Tadweer also built business continuity through enhanced disaster recovery solutions and increased energy efficiency. Alkabi decided to establish a workshop in Mussafah City, in the central region, some 20 km (12 miles) south-east of Abu Dhabi City, for installation and maintenance of tracking devices. This was staffed by a team of 12 qualified staff, including a workshop manager, supervisors, technicians and welders. The workshop had four lanes for vehicles 18 m long and the capacity to carry out 60 installations per day. Tadweer (2015) also established a unit for mobile services and onsite customer operations.

Tadweer replaced its existing landfill tipping fees collection with electronic gates

Tadweer implemented an electronic gate (e-Gates) system using the latest technology to control access to waste-receiving facilities such as landfills, transfer stations, incinerators and fertilizer plants (Gulf News, 2019). This project aimed to automate vehicle entry to the landfill for authorized vehicles and ensure operators complied with contractual aspects, guidelines and regulations. Tadweer implemented a robust guided inspection model and minimized the number of environmental violations. It also built a comprehensive statistical database to help future planning and used the fleet management and tracking solution remote operations asset management (ROAM) as a way to minimize the final disposal of waste to landfill by using the waste hierarchy and innovative practices and technologies. Plate 2 shows Tadweer's e-Gates project (Tadweer, 2015).

Plate 2 Tadweer's e-Gates project

Source: Tadweer internal information

Municipal solid waste management in Abu Dhabi

Tadweer's 2019 report stated that Abu Dhabi generated about 9.5 million tons of waste in 2016. This was a notable improvement on the nearly 12 million tones it produced in 2013 but remained a significant environmental issue as 99 per cent of it was a non-hazardous waste. Of this, 47 per cent was waste from C&D, 28 per cent industrial and commercial waste and 25 per cent municipal, agricultural and other types of waste, including from the sludge, oil and gas sector. The development of waste disposal infrastructure in Abu Dhabi continues to lag behind the need. According to the Abu Dhabi strategic plan 2016-2020, facilities included one small sanitary landfill, 10 legal dumping sites, 4 recycling facilities, 2 incineration plants and 4 composting facilities. There were also an estimated 23,000 illegal dumpsites. Approximately 28 per cent of solid waste generated in Abu Dhabi that year was recycled (UAE Government, 2019).

Abu Dhabi has been developing an integrated waste management master plan to achieve sustainable waste management over a period of 25 years. In January 2018, Tadweer signed five contracts with firms operating in the sector to develop waste management infrastructure. The projects were worth a combined AED 165m (US$44.9m), and included the development of energy from gas at Al Dhafra landfill, the first such project in the Middle East. According to local press reports, the plans also involved the construction of medical and hazardous waste incinerators in Abu Dhabi and Al Ain, and cooking oil processing plants. Tadweer and EAD published a guide in 2017 to "Sustainable Construction and Demolition Waste Management in Abu Dhabi," which explains how building firms can reduce the amount of waste they generate on-site. According to EAD, Abu Dhabi had reduced waste generated per capita per day to 1.46 kg in 2017 down from 1.9 kg in 2015, already exceeding the target of 1.5 kg set out in its 2016-2020 plan. The Abu Dhabi Scheme calls for 60 per cent of total waste generated in the Emirates to be treated by 2020 using environmentally and economically sustainable methods.

Sanitary landfills

Tadweer wanted to find a technique for the final disposal of solid waste in the ground that is environmentally friendly and caused no nuisance or danger to public health or safety. One possible technique uses engineering principles to confine the waste to the smallest possible area, covering it daily with layers of earth and compacting it to reduce its volume. It also anticipates problems that could be caused by liquids and gases produced by the decomposition of organic matter. This is known as sanitary landfill. A sanitary landfill unit of construction is called a cell, in which each day's solid waste (or the waste from a shorter period if the daily amount of waste is too high) is deposited in compacted sloping layers and covered with a layer of earth that is also compacted. The cell is built against a retaining wall that can be a preexisting natural elevation, a berm previously formed with compacted soil or other cells. Cells are constructed next to each other, each one supported by the previous one, creating a "landfill level." The landfill can have two or more levels, depending on project requirements (Prashar, 2019).

There are some essential criteria to use in determining the dimensions of a cell. The width of a cell's work face should accommodate safe maneuvering of machines/vehicles, the height should be between 3 and 6 m depending on the amount of waste to be dealt with, the advance should be calculated using daily waste volume, width and height of the work face and dimensions are adjusted depending on the stability and availability of the land. A sanitary landfill consists of operational and support units including MSW cells, waterproofing of the bottom (obligatory) and the top (optional), collection and treatment system for percolated liquid (leachate), biogas collection and burning (or use) system, rainwater drainage and channeling system, environmental, topographical and geotechnical monitoring systems, storage area for materials, fence and vegetation barrier, access and service roads, weighbridge for trucks and

waste checkpoint, entrance checkpoint and administrative offices, mechanical and tire workshops. The sanitary landfill pre-operational process consists of the selection of the site, obtaining the necessary licenses, formulating the project master plan and installation. To make an appropriate calculation of the minimum total area required for the installation of a sanitary landfill in square meters, some experts multiply the quantity of waste collected daily in tones by a factor of 560. This factor is based on the following landfill project parameters: useful life = 20 years, landfill height = 20 m; operational occupation of land = 80 per cent and the slope should be 1:3 (vertical: horizontal). However, the functional usage as a percentage of the total area will depend on the particular conditions of each site (for instance, topography, hydrology and geometric shape) (Prashar, 2019).

Calculating the effectiveness of waste reduction and recycling

The development of a waste management plan is essential in establishing the commitment to waste reduction and recycling. The purpose of a waste management plan is to predict the quantities and types of waste that will be generated, to identify the destination of that waste and to estimate waste management costs (EPA, 2019). In preparing an effective plan, actual revenues of recycling, energy recovery, and the volume of reduced wastes should be considered (EPA, 1999).

Waste reduction measurements can tell how much the organization has saved in another green area, the environment. Among the environmental benefits of waste reduction are reductions in greenhouse gas emissions, mitigation of climate change and the consumption of natural resources and energy (EPA, 1999).

Waste to energy (WTE) technology is a critical component of the waste management plan. The energy produced from incineration, for example, is important to estimate the effectiveness of the WTE technology to produce energy and to reduce the usage of fossil fuels. There are different methods to calculate the estimated energy. The equations below are usually used (Tchobanoglous, 2002):

$$\textit{The energy in collected solid waste} = \textit{Energy per lb solid waste} \times \textit{Population} \times \textit{daily amount of collected solid waste}\ \text{per capita}.$$

$$\textit{Number of barrels of oil equivalent} = \textit{energy in collected solid waste} / \textit{energy in 1 barrel of oil}.$$

Calculating the estimated financial benefits of waste recycling including total revenues are a part of the waste management plan. Revenues will vary considerably depending on factors such as geographic location, season and market price fluctuations. For example, the below equation is used to verify a decision regarding setting targets of the best season of collection to get the expected recycling revenues (Tchobanoglous, 2002; EPA, 1999):

$$\textit{Per cent reduction in revenues} = (\textit{Expected yearly amount of glass (tons/year)} - \textit{Real amount of glass (tons/year)}) / \textit{Expected yearly amount of glass (tons/year)}.$$

Solid waste volume reduction is a part of any waste management plan. It can take place at several points in the waste management process. The main goal is to save the space in landfills as the landfill waste costs continued to rise (Watson, 2017). Volume is reduced before dumping in the transfer stations. The reduction in volume is calculated based on the change of specific weight of waste using the equation below:

$$\Delta \textit{Volume} = (1/\textit{density}_{\textit{Original}} - 1/\textit{density}_{\textit{New}})/1/\textit{density}_{\textit{Original}}.$$

Theoretical background and underpinning

There are a number of theories and approaches that are important for Tadweer. These include both waste management theories and management theories.

Integrated sustainable waste management

Integrated sustainable waste management (ISWM) is a multi-dimensional model allowing the study of a combination of systems in an integrated (Susana Database, 2004). ISWM is particularly useful in studying three dimensions of sustainable waste management, stakeholders, elements or stages of the final disposal and the aspects. This model starts with the stakeholders because they are the category with interests in managing solid waste. It moves on to identify the stages and elements of the waste materials flow movement and how to treat them. The last phase is to look at the final disposal of waste. Overall, the model shows and acknowledges the importance of all three dimensions in solid waste management (Zuilen, 2006).

The waste hierarchy

The waste hierarchy provides the guiding principles to achieve the core objectives and to develop integrated waste management programs. It is a tool used in the evaluation of processes that protect the environment and reduces resource overexploitation and energy consumption from most favorable to least favorable actions. The regime establishes preferred program priorities based on sustainability. To be sustainable, waste management cannot be solved only with technical end-of-pipe solutions. Instead, an integrated approach is necessary. The waste management hierarchy gives an order of preference for actions to reduce and manage waste and is usually shown diagrammatically in the form of a pyramid. The regime captures the progression of a material or product through successive stages of waste management and shows the latter part of the life-cycle for each product (United Nation Environment Programme, 2005). The waste hierarchy process is:

- Avoidance, including action to reduce the amount of waste generated by households, industry and government;
- Resource recovery, including re-use, recycling, reprocessing and energy recovery, consistent with the most efficient use of the recovered resources; and
- Disposal, including management of all disposal options in the most environmentally responsible manner (Muller, 2002).

The waste hierarchy aims to extract the maximum practical benefits from products and generate the minimum amount of waste. The proper application of the waste hierarchy can have several advantages. Tadweer used this system to help prevent emissions of greenhouse gases, reduce pollutants, save energy, conserve resources, create jobs and stimulate the development of green technologies. The waste hierarchy principles should support the initiation and implementation of waste management sustainable practices. It encourages waste reduction at source and reuse and recycling among the public, commercial and industrial sectors.

Different countries, and even different states within countries, define their waste management hierarchy differently (Table I). For example, the US Congress defined a waste management hierarchy in the Pollution Prevention Act (1990) as: "[…]pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or other release into the environment should be used only as a last resort and should be conducted in an environmentally safe manner" (Seadon, 2010). Table I shows how different countries and states have defined waste hierarchy. Whatever the precise terms used; the guiding principle is that actions at the top are better than those at the bottom.

These hierarchies provide a guiding framework to consider waste minimization in a systematic manner. This was recognized in the UK, where the waste strategy for England and Wales described the hierarchy as a guide (Department of the Environment, Transport and the Regions, 1995). However, the guiding framework of a waste management hierarchy has its limitations. In

Table I Examples of waste management hierarchies in selected countries

NZ	*EU*	*USEPA*	*South Australia*	*Queensland and Australia*
Reduction	Prevention or reduction	Reduction and reuse	Avoid	Avoid
Reuse	Reuse	Recycling/composting	Reduce	Reuse
Recycling	Recycling	Energy recovery	Reuse	Recycle
Recovery	Recovery	Landfill and incineration without energy recovery	Recycle	Energy recovery
Treatment	Disposal		Recover	Disposal
Disposal			Treat	
			Dispose	

particular, the context of the system in which a hierarchy operates must also be considered. For example, New Zealand and Ireland, with similar population sizes, have quite different constraints. New Zealand is isolated from its primary European, Asian and North American markets and suppliers, has a low population density and low industrial development. Ireland has more compact geography, a population density four times greater than New Zealand, more intense industrialization and is very close to its major markets in Europe (Central Statistics Office, 2008). New Zealand generates small quantities of waste that are very dispersed and so needs to attract a much higher return than Ireland to provide for economic processing. Waste in Ireland comes under the EU Landfill Directive, which compels member states to reduce biodegradable waste sent to landfill and increase recycling and recovery rates of household waste (Burnley, 2001). To achieve targets in the Landfill Directive, costs for disposal have increased. If the targets are not met, then financial penalties will be imposed (Burnley, 2001). This is a far more regulated and financially incentivized program than that operating in New Zealand (Seadon, 2010).

Other limitations also need to be considered when dealing with a waste management hierarchy. The simplicity of a hierarchy does not consider using a combination of options. For example, The Ark Computers (2009) work with New Zealand businesses to use computers that have reached the end of their lives. Some computers are used for parts, to refurbish other computers for reuse, and some parts are disposed of because they are obsolete. This combination of recycling, reusing and disposal is not covered well by a single classification under a waste management hierarchy. McDougall *et al.* (2001) added that waste management hierarchies had little scientific or technical basis. However, they are widely used, and therefore, relatively useful (Seadon, 2010).

Contingency theory

In previous decades and during the industrial revolution of the past century, management focused on structure, productivity and efficiency, as companies grew from a handful of employees to thousands, and revenue increased exponentially. Now, with the first digital revolution, new possibilities and requirements for leadership have arisen. The developments in technology and society have given us the possibility to redesign our work/life integration, and we can work anywhere, anytime. We now can talk directly to our CEO via social media. This creates a need to redesign leadership (Ostergaard, 2018).

Contingency theory is a leadership style focused on dreams, as well as strategic goals, networks, as well as hierarchies, and experimentation, as well as planning. It is based on people and their engagement, including customers, shareholders, society and employees. This kind of leadership is about juggling two opposing elements, e.g. hierarchy and networks. It is, therefore, about understanding how to manage these, and particularly how to balance and apply those two leadership styles (Ostergaard, 2018). Contingency managers typically pay attention to both the job and their styles and make efforts to ensure the two interact efficiently. Alkabi is a good

example of a leader who tries to apply this principle. He is very people-oriented, and does not separate employees from customers in his thinking. He used five key design principles:

1. He focused on purpose and ensured that he made work meaningful for all employees.
2. He encouraged innovation and experimentation.
3. He was driven by results.
4. He delegated leadership to those who had the will, skill, ability and desire to lead.
5. He formed a new and modern leadership mindset, focused on ensuring the organization will stay relevant in the modern world.

As a result of these principles, Tadweer is agile, adaptable and focused on responding to change rather than following a plan.

Stakeholder theory

Stakeholders are those interested in a project or organization and its proceedings, and maybe within or outside the organization (Cragg, 2002). Stakeholder theory rests on an observation that all corporations and organizations have stakeholders. The activities of the organization affect individuals and groups both negatively and positively. The interests of these groups may revolve around basic needs such as food, water or shelter or may involve issues of health or safety. They may also concern the capacity of those involved to accomplish their goals and objectives or to experience a decent standard of living or quality of life. The activities of organizations, therefore, give those they affect a "stake" in those activities.

Stakeholder theory posits that an organization will only be successful when it delivers value to its stakeholders, and that value can come in many forms beyond financial benefits. For example, one value recognized by stakeholder theory is greater organizational productivity. If employees feel that they are valued, they are likely to work harder and be more productive. This also means that the organization will have greater retention of employees, and probably also customers. If productivity increases, then the product or service delivered to the customer will be improved. That will improve customer loyalty, and encourage recommendations.

Tadweer had a key focus on stakeholders, as the first of the three dimensions of waste management under ISWM. It used yearly public awareness plans to raise awareness of different stakeholder groups about waste management. Figure 3 shows the waste management stakeholder groups (Tadweer, 2019).

A sustainable system of waste management under the waste hierarchy principles requires encouragement of waste reduction at source in addition to reuse and recycling strategy among the public, commercial and industrial sectors. Stakeholder awareness is, therefore, vital (Tadweer, 2019).

How to move forward?

Tadweer is an experienced organization aiming to improve waste sustainability practices in Abu Dhabi and to make it part of the social lifestyle by changing the behavior of residents and companies. Society needs to be aware of the need for change, including being given convincing reasons to change day-to-day habits. These reasons may be in the form of financial incentives or enforcement of legal commitments. The current laws and regulations do not control the waste flow, and changes to the law may be necessary to move toward strategically appropriate disposal and treatment options. Several waste flows are currently not properly regulated at the generation point or even through proper disposal and segregation (Environment Agency- Abu Dhabi, 2017). That encouraged Alkabi and his team to start developing a new waste management strategy for Tadweer. However, this means that Alkabi and Albloushi have to grapple with some challenging issues. These include:

Figure 3 Waste management stakeholder groups

Source: Tadweer internal information

- Should there be more regulations, laws, and enforcement related to waste management?
- Should waste reduction plans should also be part of the government strategy?

The widespread deficiencies in the management of MSW mean that Tadweer will be able to position itself to appeal to its residential and corporate clients. There are likely to be clear economic and environmental advantages for housing societies choosing the integrated route developed by Tadweer. For businesses, Tadweer aims to save operational costs and help clients maintain their corporate image. Both decentralized waste management projects designed by Tadweer have the potential to create value for clients by discouraging land disposals and encouraging recovery and recycling. There could, however, be some bottlenecks that need to be addressed. For example, in Abu Dhabi, the government is responsible for the provision of free domestic waste collection services to the public, and people are, therefore, reluctant to pay a user charge for the services of private MSW management providers. Next, inculcating the habit of segregating waste at source is a considerable challenge. The decentralized approach to MSW management also requires land in cities for waste treatment plants. The growing urbanization and mounting cost of land mean that it is getting difficult to find space in cities (Environment Agency- Abu Dhabi, 2017). Alkabi commented: "the general indifference of society towards waste management is a concern in the country. This attitude also decreases the chances of employment in this segment and jeopardizes the whole process."

There is a need to improve accountability and the level of service through non-governmental organizations and private sector participation in solid waste management services to improve overall performance. This should be encouraged in the door-to-door collection of domestic waste, commercial waste, hospital waste, hotel waste, construction waste, yard waste and setting up and operating/maintaining compost plants and other treatment plants, as well as common disposal facilities. Involving more organizations will check growth in establishment cost, bring economy in expenditure and introduce an element of healthy competition between the private and public sectors in solid waste management (UAE Government, 2019). Tadweer believes that actions are required in two main areas, awareness campaigns and financial incentives/penalties. Communication and awareness campaigns are essential to make people aware of the importance of changing waste management practices. Communication has to focus on targeted groups and the desired change. Public awareness campaigns have usually focused on general knowledge about waste, sorting, segregation and recycling. Educational plans should be extended to include advocacy programs for public authorities, decision-makers and Tadweer employees. Critical communication and awareness areas need to be developed to achieve behavioral change among stakeholders. Suitable communication channels could include television, radio, journals, the internet, street boards, events and mobile applications (Tadweer, 2016; Guerrero, 2013).

Specific communication and awareness campaigns are also necessary for companies and organizations. It is essential to clarify what is expected of them and what they can contribute, and specific awareness campaigns are likely to be more effective. Examples of suitable

communications include "best available technology" overviews, seminars, training and network activities of industrial ecology. By developing a dedicated communication toolbox, private investment in collection facilities and treatment plants can be accelerated. Examples are lectures at international waste forums, setting up a full-day venture and documents highlighting the business case. Advocacy programs must target decision-makers, local public authorities' employees and Tadweer staff to create strong ownership and belief in the change and its success (International Solid Waste Association, 2012).

Tadweer was able to deal with these bottlenecks to some extent by raising community awareness through educational campaigns. However, the company aimed to expand its services to public sector organizations. To achieve this, the team plans to use advanced technologies such as load sensors, bin sensors, radio frequency identification readers and GPS tracking devices. The organization plans to continue investing in research and development in newer waste management solutions for decentralized waste processing such as the Smart Bin Air, a handy composter suitable for processing the waste for a family. Tadweer will also offer third-party auditing services to measure the work of private contractors by recording data such as frequency of bin cleaning, amount of waste collected/disposed and attendance of field workers (Tadweer, 2017). Alkabi noted "waste is an issue created by us as a people. We want to make our country an exemplar of a greener and a safer world."

Financial incentives and penalties could be key to changing the behavior of groups. Abu Dhabi Emirate may be able to help achieve waste management targets by contributing to this concept. Financial incentives and penalties could be used to boost the rate of landfill diversion and encourage waste segregation at source. Well-sorted streams can readily be recycled or composted. One way to do this is to make residual waste disposal more expensive for residents. Next, the consumption of waste-intensive products could be made more expensive, to decrease the amount of waste generated per capita. Third, service charges and taxes could be used to generate revenues to improve waste management cost recovery. Waste collection charges could be based on household size, use of energy, water, and property size or value (pay as you throw principle). The taxes would typically be levied per household or residential unit and could be collected with electricity or water bills to enforce the payment of charges. These variable costs generate some revenues but the primary objective is to induce behavioral change. However, waste pricing has risks. Individuals will be tempted to avoid payment by illegal actions (UAE Government, 2019; Tadweer, 2017).

The waste is collected from two types of the bin, a black bin for general waste (including food waste) and a green bin for recyclable materials. Waste segregation also requires discipline. If the collected waste is mixed and the "sorted" waste streams contain significant pollutants, treatment facilities will not be able to generate the targeted revenues from selling recyclables. For example, large quantities of organic waste destroy the value of high-value recyclables such as paper or glass. It also makes the flow chaotic, so that the sorting of recyclables will not be optimal, and only impure and low-value recyclables will be generated (Tadweer, 2017).

Several initiatives and projects have, therefore, been carried out to solve Tadweer's main challenge. However, Alkabi and Albloushi are aware that they still face a question of how effective it is to collect wastes from the source of generation and move them out of sight.

Keywords:
Environmental issues, Environmental management, Environmental management strategy, Strategic management/planning, Business development, Municipal solid waste, Segregation, Sustainability, Sanitary landfill, Mismanagement dumping, Business management, Waste management

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