

Investigating Solid Waste Supply Chain: A Proposed Framework for Achieving the Environmental Sustainability Case study Alexandria, Egypt

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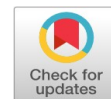
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Abstract: Solid Waste Management (SWM) is becoming the most important public health and environmental concern in municipal areas of many developing countries. The condition in Africa, particularly in the wealthiest cities is critical. With an increasing population, enlargement, and development the solid waste management has become the main threat to all responsible systems and consultants in unindustrialized and developing countries all over the world. There is a deep need for the garbage or wastes to be collected at the right time from the right places in clustered manners this will improve the quality of waste collected which will be reflected in the end recyclable product quality. The research aims to propose a frame work for Solid Waste Supply Chain (SWSC) new design with illustrating some best practices to overcome the challenges of applying the new supply chain design. This aim will be conducted through Nahdet Misr for Modern Environmental Services case study. Nahdet Misr is the responsible company for waste collection and treatment in Alexandria governance. This new framework design can be adopted with Alexandria governance in Egypt. Appling this framework allows the new environmental services companies concerning with waste collection practices and environmental sustainability issues to manage the performance of its current situation of their supply chain in order to meet overall improvement of the waste collection process. The research follows an exploratory methodology that aims at discovering the current status of the Alexandria Governances solid waste supply chain. An exploratory methodology was followed due to the remarkable lack of information on the Alexandria solid waste supply chain. The inductive approach was applied in the a case study through the comprehensive analysis of qualitative data related to the topic that has been published in various sources in addition to a number of semi- structured interviews that were conducted with some officials in the Solid Waste Authority, Ministry of Environment and managers from a company specialized in environmental services called Nahdet Misr and has become the responsible company for waste collection and treatment in Alexandria governance.

Keywords: Solid waste supply chain, Municipal waste management, Alexandria governorate, Environmental sustainability

Received: 14 February 2017 / Accepted: 19 April 2017 / Published: 30 June 2017



INTRODUCTION

Over the past few eras, Africa has begun to increase people's awareness about not only the management and disposal of waste but also about difficulty of reconciling the advantages of a healthy environment with the economic costs. A keystone of sustainable development is the establishment of affordable, effective, and truly maintainable waste management practices in developing and unindustrialized countries (Abbasi, 2017).

The SWM has become a critical and challenging issue throughout the world, in both developed and developing countries. As the world population grows, so do the solid waste generation increases as well, especially in municipal areas (Busse et al., 2017). Management of such a huge amount of waste effectively is a difficult problem and a large amount of money and technical know-how are needed for the management of the solid waste (Dam & Petkova, 2014). Besides, poor solid waste management brings with it serious health and environmental problems (Singh & Trivedi, 2016).

Alexandria is the second largest city in Egypt (2,118 km²) with a population of about ten million. Alexandria extends about 32 km along the coast of Mediterranean Sea (Griffin, Lont & Sun, 2014). The

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total annual municipal solid waste in Egypt has increased more than 36% since 2000 to the current level of 20.5 million tons (MT) per year where 1.35 MT/year is generated in Alexandria (Busse, Schleper, Niu & Wagner, 2016).

In Alexandria, the delivery services problem and travelling distance in timing and function in each phase are the main problems (Kim & Davis, 2016). Therefore, if the garbage or waste is collected at the right time from the right places in a clustered manner; in addition to a logistics system as shown in figure 1, which is made up of a set of facilities linked by transportation services are sites where garbage is treated, recycled or dumped, transfer stations, collection points, treatment facilities, garbage incinerators, and dump sites should be created (Correia, Carvalho, Azevedo & Govindan, 2017):

- Improving the quality of waste collected which will be reflected in the end recyclable product quality.
- Minimizing the travelling distance of wastes through collection at the right time and place.
- Delivering fresh wastes.
- Reducing the fuel consumption.
- Providing a healthy environment with a lesser carbon footprint

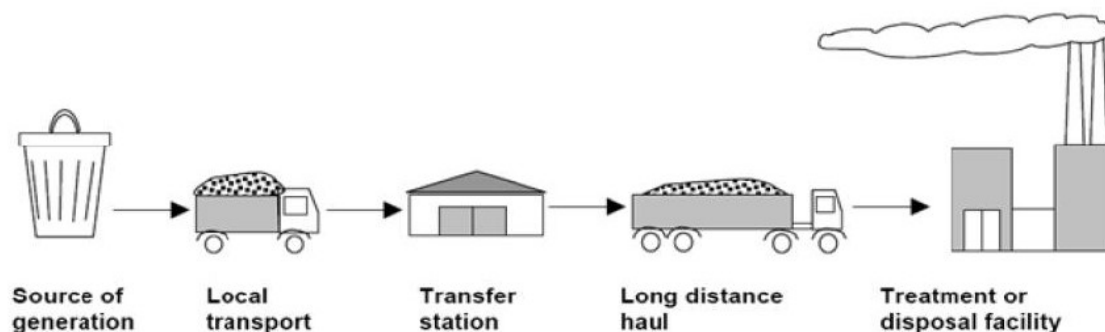


Figure 1. Logistics system in waste collection
Source: (Zaki, 2010)

Accordingly, it was rare to find a solid waste management studies in Egypt that focuses on specified governance and its available capabilities to help in eliminating the massive waste quantities thrown in streets. Therefore, this paper will investigate the solid waste supply chain through a proposed framework for achieving environmental sustainability in Alexandria governance through accompanying a case study (He, 2015).

LITERATURE REVIEW

SCM is the process of systematic, and dynamic which is responsible for the flowing of the functions of traditional business and tactics across business functions within a particular company through companies within the supply chain, for the purposes of long-term individual company performance and raise awareness of the supply chain as a whole (Varzandeh, Farahbod & Zhu, 2014).

The efficiency of the Municipal Solid Waste Management (MSWM) can be value-added by adopting supply chain management technique (Wan Ahmad, de Brito & Tavasszy, 2016). The consideration of sustainable and integrated Municipal Solid waste management planning aspects including environmental, social, cultural, institutional, political and legal aspects and also the role of stakeholders (rag -pickers, informal recycling sectors, small scale enterprises, women heads of households and other elements of the waste management system such as prevention, reuse, recycling, collection, and disposal). Supply chain management should be very strong to make MSWM very effective and efficient (Beske & Seuring, 2014).

According to Rueda, Garrett and Lambin (2017), in Developing countries like Egypt Governorate, the biggest waste collection accumulations exist in rustic areas and informal defrayals. Barriers and difficulties to providing a sustainable waste collection service include;

- Limited road access and infrastructure: In specific areas, the roads are not well-structured which

leads to a difficulty in collection of waste from those households. Where road infrastructure exists, the streets are often inaccessible to conventional waste collection vehicles due to steep slopes and narrow roads with sharp curves, deep potholes, and dongas (Haavisto & Kovacs, 2014).

- Extensive travel distances: Transportation costs in municipal settings where households are sparingly spread over long distances obstruct a weekly waste collection service, thereby contributing to rampant illegal dumping (Signori, Flint & Golicic, 2015).

Launching and improving facilities for collection, recycling, treatment, and disposal for MSW management can be very costly. For example, building and operating sanitary landfills and incineration/burning plants require huge investments and suffer substantial operation and maintenance costs (Blome, Paulraj & Schuetz, 2014). We live in a world of increasing scarcity of natural resources. Thus, there are limited financial resources that are often insufficient, and securing land for final disposal is getting more difficult (Mani, Agrawal & Sharma, 2015).

Therefore, Alexandria waste problem is not just created when people throw items away but also, throughout the life cycle of a product or package from extraction of raw materials, to transportation, to processing and manufacturing facilities, to manufacture and use; besides lesser people awareness and the confusion of the waste benefits through an appropriate supply chain management and facilities (Busse et al., 2017). Thus, an appropriate coordination and new practices are needed through the entire solid waste supply chain. It will improve and enrich the entire supply chain performance and increase environmental sustainability.

RESEARCH METHODOLOGY

This research follows an exploratory methodology that aims at discovering the current status of Alexandria Governances solid waste supply chain. The interviewees were general managers with a range of experience between 10 and 20 years. The interviewees were first contacted by phone, and then a copy of the interview questions was sent by email prior to the actual visits. Interviews were scheduled over a two-week period and conducted on site, and each interview lasted between one and one and a half hour. Its merits mentioning that includes open-ended questions in the semi-structured interviews was intended to give the interviewer ample chances to discuss matters with the interviewees, a necessary prerequisite to exploring the whole issue, with particular emphasis on the Alexandria Solid Waste Supply Chain's current situation. Therefore, research will focus on investigating the challenges and practices that face the solid waste supply chain and its treatments in Alexandria (Varsei, Soosay, Fahimnia & Sarkis, 2014; Ahi & Searcy, 2015).

Phase 1, will illustrate solid waste management importance and its impact on environmental sustainability through Secondary data collected from previous studies, records, and statistical data for highlighting the vital roles of solid waste management in developing countries and how to overcome the waste problems.

Phase 2, is to describe the challenges and obstacles faced by solid waste supply chain in Alexandria through developing a semi-structured interview, which are known as respondent interviews for a short period of time and taken in a conversational manner, but at the same time, they follow a certain set of questions derived from a case study protocol. The case study is about a specialized company in environmental services called Nahdet Misr and has become the responsible company for waste collection and treatment in Alexandria governance since Veolia contract ended.

Phase 3, is to propose a supply chain design of solid waste management practices that enables the environmental sustainability in Alexandria governorate to help in improving the waste accumulation situation.

Table 1 illustrates the Stages of creating the research framework that summarizes the research objectives at each stage along with the research tools and the research outputs.

Table 1: The Stages of creating the research framework

Research Stages	Objectives	Approach	Output
Stage 1	To illustrate solid waste management's importance and its impact on environmental sustainability.	Literature Review	Highlighting the vital roles of solid waste management in in developing countries and in developing countries and how to overcome the waste problem
Stage 2	To explain the current situation of Solid waste management practices in Alexandria To assess the degree of the readiness of solid waste management Supply chain chain in responding to the waste management practices in Alexandria.	Literature Review and Statistical Record Measures Semi-Structured Interviews	Determine the main challenges and barriers of solid waste supply chain in Alexandria Identify the limitations and obstacles of suggesting new solid waste Supply chain design.
Stage 3	To describe the challenges and obstacles faced by solid waste supply Chain in Alexandria	Case study	Assess the current Solid Waste Supply chain (SWSC) performance and practices
Stage 4	To propose a supply chain design of solid waste management practices that enables the environmental sustainability in Alexandria governorate	Focus Group	Formulate and propose the new design or theoretical framework of SWSC.

FINDINGS AND DISCUSSION

The research findings focus on the factors that hinder the development of the Solid waste supply chain in Alexandria Governances. In addition, they describe Alexandria current solid waste supply chain through the use of a framework.

An overview of Alexandria SWSC's current situation

This section gives an overview about the overall solid waste supply chain of Alexandria through conducting Nahdet Miser for Modern environmental Services as a case study. In addition, it illustrates Solid Waste Supply Chain's (SWSC) characteristics, highlights its current position and determines the problems and challenges that occur internally and externally and how suggesting some practices will help Alexandria to overcome the uncontrollable waste accumulated in different districts.

According to Ahmed Gozhlan, Treatment Department follows up Manger in Nahdet Misr company (Personal Communication, 15 July 2016). He stated that in Nahdet Misr Company until October 2011, Veolia was the responsible company that collected and treated solid waste in Alexandria. At that time, Veolia was ready with its plans, machineries, equipment, resource, labor, and trucks; all facilities were ready for the mission which was collecting and treating the solid wastes. After the 25th revolution, the country started to face unexpected scenarios that resulted in double increase of the waste quantity and lack of garbage bins, thus created an increase in the services distance taken by the collection trucks.

After a while, Alexandria started to face a new phenomenon that appeared rapidly which is called horizontal expansion of slums and illegally built houses over the agricultural land. Also, an increase in residential floors and illegal apartments created a new phenomenon called Vertical expansion. These new unexpected scenarios put Alexandria city into a critical situation in which the company started losing control on collecting the waste quantity; as in normal and stable country situation, the Alexandria

governance used to collect 2800-4000 tons per day while after the revolution and the sudden increases in the illegal apartments, a huge gap existed.

From that, Veolia started to decide to stop working on waste collection due to absence of security and lack of governmental support to help in dealing with the force majeure impact. Therefore, Arab Contractors company was handed Veolia contract that ends in 2016, therefore, it established a child company specialized in environmental services called Nahdet Misr and has become the responsible company for waste collection and treatment in Alexandria governance since then.

Barriers facing SWSC in Alexandria governance

There are numerous problems and difficulties facing Alexandria solid waste supply chain. At this point, it was claimed by Ahmed Tewfik - Nahdet Misr Owners Representative - (personal Communication, 15 July 2016) that in this period of time, challenges and barriers started to be very challenging and Alexandria governance was handed the obstacles; starting with

- Garbage bins being stolen, so people throw the waste along the streets at no specific locations. Before revolution, there was a definite route; time, distance, and collection points (scientifically known by collect on node route).
- The truck capacity creates a big constraint in the collecting processors; besides, collect routes must be very clear by many bins for a better optimum utilization design and should not only consider the geographical location.
- Adaptation of collecting the waste from houses itself which will create an increase in labor costs for the visit shifts.
- People do not accept the existence of the bins to be placed in front of their houses and homes because of the unwillingness of cleaning the bins regularly and delay in garbage collection most of the time.
- Transfer station accumulations.

Furthermore, the second point which was illustrated and highlighted as a barrier is solid waste stream classifications. Alexandria waste stream classification is as follows:

Table 2: Alexandria waste stream classification

Types of Waste	Percentage
Organic	50-60%
Cartoon	8-12%
Plastic	10-15%
Glass	1-3%
Metal	1.5-2%
Textile	2-3%
Paper	11-18%

This actual solid waste stream classification in Alexandria but the real situation is that such a percentage doesn't reach the treatment factories because of scavengers "Zabalen/ Farreza" who segregate most of the good and valuable waste such as plastics to be sold in the black market. Thus, 20% of the wastes collected are rejected and unable to be recycled.

Therefore, Amani Mohamed Mustafa Advisor of Alexandria former Governor for Waste Management and Business Support Supervisor at ship and C.R.E.W for Stevedoring and Container Repair and Transport (Personal Communication, 25 July 2016) criticized, the main obstacle that was discussed is the big gap and the problem in the waste collection as illustrated before is that Alexandria city pumps daily 4500-5000 tons of wastes, and the facilities available in Alexandria area are able to collect 2000-2500 tons daily which creates a big gap and a problem in the waste collection service. That's why Alexandria's current situation is not able to be served in that proper supply chain sequence.

Alexandria proposed SCWSC framework

According to Amani Mohamed Mustafa Advisor of Alexandria former Governor for Waste Management and Business Support Supervisor at ship and C.R.E.W for Stevedoring and Container Repair and Transport (Personal Communication 25 July 2016), the importance of redesigning the collection part lies in both its cost and position in the chain.

It is the first process in the chain, and it serves a push demand, so it is very critical to be done on time whenever and wherever needed, otherwise, accumulations as shown below proposed design diagram would exist and a shortage of supply would occur at the remainder of the chain processes.



Figure 2. Proposed Solid waste supply chain

Hence, there is a deep need for the garbage or wastes to be collected at the right time from the right places in a clustered manner. That's why, the proposed SWSC design needed to be modified to improve the waste collection process through an effective and efficient supply chain.

Focus group framework verification

Based on the focus group done with the experts, Amani Mohamed Mustafa Advisor of Alexandria former Governor for Waste Management and Business Support Supervisor at ship and C.R.E.W for Stevedoring and Container Repair and Transport (Personal Communication, 25 July 2016), Ahmed Tewfik -Nahdet Misr Owner's Representative - (Personal Communication, 15 July 2016), Tarek Zaki - Business Development Manager at Nahdet Misr (Personal Communication, 26 July 2016), to Rania Zidan, Advisor at Environmental Ministry Authority Alexandria (Personal Communication, 23 July 2016), found that the supply chain flow of the Solid waste in Alexandria was suggested to be facing several challenges and problems.

They investigated that all the interviewees agreed on the suggestions illustrated in the previous model with taking into consideration the solutions suggested by the focus group to be abdicable and verified; in order to somehow decrease the defections and inappropriate supply chain operations. It is concluded that the magnificent change of the supply chain design would take place in the collection process, in order to deliver the aimed objectives and obtain a sustainable supply chain.

Furthermore, it has been examined that the importance of redesigning the collection part lies in both its cost and position in the chain. It is the first process in the chain, and it serves a push demand, so it is very critical to be done on time whenever and wherever needed, otherwise, accumulations would exist and a shortage of supply would occur at the remainder of the chain processes. Therefore, according to the interviewees' opinions, full implementation of the SWSC model is expected to reduce city collection truck travel, by reducing the amount of truck travel associated with MSW disposal, the City could lessen smog, noise, traffic congestion, and air pollution.

In addition, there should be increasing Public education to inform people about their options to reduce waste generation and increase recycling and composting; moreover, pricing mechanisms, such as product charges can stimulate consumer behavior to reduce waste generation and increase recycling and consumers would pay for the waste management service. However, it may not be practical in many areas in developing countries, particularly in those where there is communal collection points associated with multi-unit households (such as apartment user charges tied to quantity or volume).

Thus, verified model objective is to determine SWSC's sustainability collecting municipal waste while:

- Minimizing the total distance traveled by vehicles.
- Collecting fresh waste with high quality to ease the recycling process.
- Collecting waste in a clustered manner.
- Using the smallest possible fleet of vehicles to cover all the municipal waste stops.
- Serving each stop within its time window.
- Reducing the fuel consumption.

The SCWSC model presented in Figure 3 considers minimization of the operating cost of a vehicle which includes fuel cost, maintenance cost, and the depreciation of vehicles. In case of serving any customer, after the latest allowed time that will result in paying penalties to the governorate for every uncollected bin and every street hasn't been cleaned, and in case of arriving at the stop before the lower bound of its time window, this waiting time is considered to have a penalty equal to the operating cost. The waste quantity of each stop is deterministically known, and all waste must be collected.

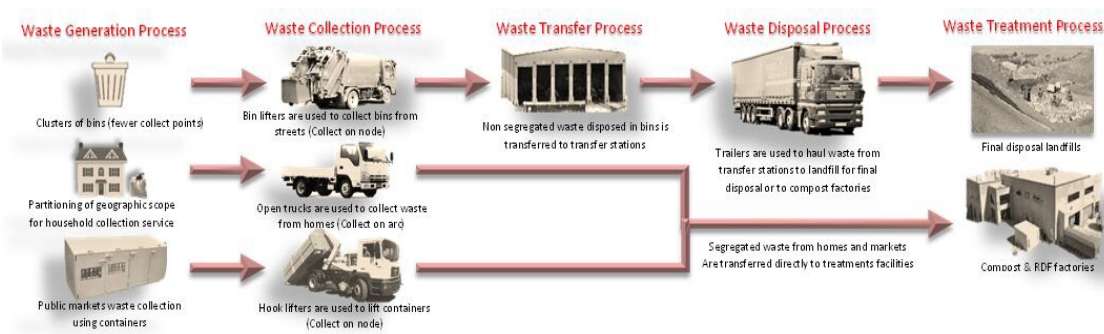


Figure 3. Verified solid waste supply chain frame work

FINDING SUMMARY

The urgency of significant adaptation of the new SWSC design in Alexandria was pointed out. Supply Chain Management plays a critical role in the recovery of the Alexandria Solid waste obstacle. Furthermore, the challenges and problems Alexandria faces and how to overcome them were concluded by the experts that for a new SWSC, a new framework should be adapted to deal with challenges and suggested best practices.

The paper figured out many factors that hinder the development of SWSC at Alexandria Governances. The absence of local and foreign investors, the difficulties in different aspects e.g., technical, logistical, legal, and operational in the enriching, and improving the waste collection system are making the utilization and adaptation of the new proposed SWSC design inefficient. In addition, a comparison of Alexandria Solid Waste Collection System with the use of a conceptual model shows the ideal SWSC provided.

Then the research proposes suggestions and solutions for the previously mentioned obstacles for SWSC in Alexandria. Furthermore, this paper is focusing on illustrating and emphasizing the importance of SWM in the overall SC performance for Alexandria governance. The research revealed that it is extremely important to enhance the overall SC operations and practices in order to provide consumer with a healthy and sustainable environment.

Finally, the research provides an authentic contribution to knowledge by proposing a procedure to identify the challenges encountered during the process of solid waste supply chain adoption which can lead to further research in the area of SWSC's adaptation particularly in the developing countries.

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