

*Full Length Research Paper*

# Municipal solid waste management systems in the Kingdom of Bahrain

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**Waste management has been acknowledged as one of Bahrain's biggest challenges due to its impending effects regarded as detrimental to the country. Data gathered within the past thirty years have all revealed significant increases on waste quantity generated in the country along the categories of residential, commercial, institutional, construction and demolition, municipal services, public areas, treatment plant sites, industrial, and agricultural wastes. The limited land area, characterised by Bahrain's small geographical space, is the biggest factor that contributes to the problem of managing the increasing waste accumulation of the country and finding sustainable systems of waste management. As such, the growing need to refurbish the current system of municipal solid waste management utilised in the country is the focus of this study. Sustainable waste management systems through the adoption of Integrated Solid Waste Management (ISWM) is analysed as a probable solution towards solving the hazards and complexities posed by current waste management problems. Existing literature inclusive of all available sources of information used to analyse current waste management systems in the country, as well as a series of interviews and household surveys, have been utilized to develop an ISWM system that fits the current trends and needs of Bahrain.**

**Key words:** Kingdom of Bahrain, integrated solid waste management, municipal solid waste, solid wastes, sustainable development.

## INTRODUCTION

When failed to contain and manage, solid wastes pose a very big environmental problem to large cities, most especially to developing countries (Kanat, 2010). As such, the need to develop alternative methods of managing municipal solid wastes (MSW) such as composting, separation, and recycling have been used adeptly to meet these growing concerns (Haque et al., 2000; Kanat et al., 2006; Nunan, 2000). Despite such alternative methods, however; situations within countries vary due to different parameters which may cause certain effects on such activities; thereby causing more difficulties or complexities which may expand the extent to which these concerns are to be addressed. Within the country of Bahrain, a number of parameters have been identified which makes municipal solid waste management more complex in its adaptation within the country. Due to limited geographical waste, rapid industrialization, population growth, deficiency of

appropriate legislation and lack of efficient enforcement mechanisms, solid wastes (both increasing in quantity and quality) have led to a significant adverse effect on the country thereby polluting environmental resources (Ministry of State, Municipalities and Environmental Affairs, 2002) and posing threats to sustainability.

## LITERATURE REVIEW

Wastes, according to Tchobanoglous et al., (2002), are discarded tangible products of human activities that are regarded as unwanted and useless. However; despite such notions about these materials, wastes can be reused and can become sources of industrial production and energy regeneration if allowed to be managed appropriately. The managing however presents a challenge especially in our current era where numerous

factors have added constraints and complexities to the process. The efficient managing of wastes has further turned into one of the most significant problems of our time due to adjacent concerns regarding the preservation of lifestyles, protection of the environment and the promotion of public health. Municipal solid wastes (MSW), the focus of many existing researches, are specifically defined as wastes coming from private households collected by local authorities from any available source (Strange, 2002). A more exact characterisation, however, of MSW, is reliant on the current nature or structure of the municipality, the state or of the country itself. With reference to Bahrain, MSW is inclusive of residential, commercial, institutional, construction and demolition, municipal services, public areas, treatment plant sites, industrial, and agricultural wastes.

Traditionally, wastes are recognized as extraneous to production and are therefore only managed when the demands to resolve the problem is greater than the expediency of disposal (Seadon, 2010). Waste management has long been under such a rationale and has resulted to a number of impractical ways of dealing with increasing numbers of waste and decreasing capabilities of waste management systems. As such, sustainability is one factor that has not been met efficiently as reflected in researches that have reviewed waste management systems around the world. The factor of sustainability, which is often more enclosed in the phrase: "sustainable development" carries the following widely-known definition by the Brundtland Commission (1987) which states that "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition therefore sets the foundation that systems created for the benefit of our current environments must be planned with a definite perspective that reaches out to the advantage of future generations as well. Municipal solid waste management systems must therefore address not only present complexities and underlying conditions but must also negotiate a long-term efficacy.

### **Municipal solid waste management in Bahrain**

Current municipal solid waste management systems in the country are carried out through waste collection and disposal at the existing landfill Site located at Manama, Bahrain. A total of 659,847 tonnes of wastes are generated in the kingdom of Bahrain. With further reference to the population of the country in the same year, an estimated 1.4 kg of wastes are proportioned to every person living in the country. The most dominant component of these wastes are domestic in nature, accumulating to about 45% of the total while further data reveals that commercial wastes are consequently

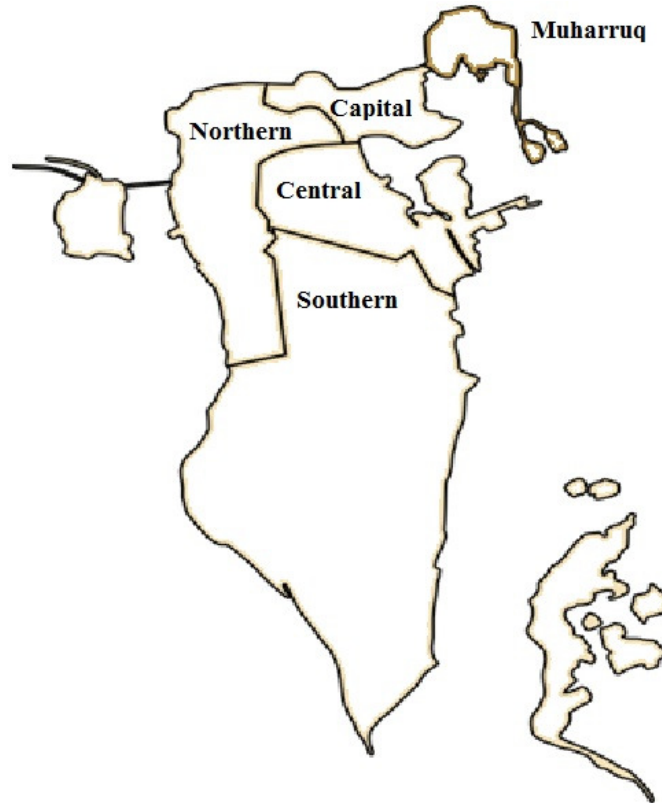
increasing due to rapid urbanization taking place within the country. These increases are therefore reflective of more complexities that may arise as the country continues to solve existing problems within its waste management systems.

Currently, two private contractors are responsible for waste collection and waste transportation systems in the country, serving the five governorates of the Kingdom of Bahrain (Figure 1). Gulf City Cleaning Company (GCCC) is responsible for waste collection and transportation in Muharraq and Manama (capital) while Sphinx Services is responsible for these activities in Southern, Middle, and Northern Areas. These firms stems from the idea of privatization cleaning activities. Landfilling of within the existing Landfill Site covers the "cellular tipping method" wherein waste is tipped within a contained area or dell confined by a pre-constructed bund, is practiced. However, such practices present growing concerns. Reflective of these methods and processes are the following problems that need to be addressed in the site: (1) absence of planned development within the site; (2) lack of funding in the investment of new landfill equipment and site improvements; (3) lack of cellular tipping methods; (4) lack of available covering materials; (5) generation of landfill gases; (6) generation of leachate; (7) fire hazards; and, (8) birds hazards. With such a waste management system in operation, it is definite that efforts of sustainability are in question, as well as impending environmental problems and public health hazards. As such, the need to revamp the current municipal solid waste management system adopted by the country is regarded as paramount. The key objective of this assessment and evaluation is to therefore develop an integrated solid waste management (ISWM) system that is applicable to the current situation in Bahrain, inclusive of all the concerns, complexities and problems that were mentioned.

### **METHODOLOGY**

The Survey and Questionnaire method on the other hand was adopted through household questionnaire surveys which aimed to obtain the perspectives and feedback of residents within the country regarding current systems of solid waste collection with corresponding reference to the performance of private sector contractors. Taking into account a sample size of 350 households, the questionnaires were distributed randomly throughout the five governorates of the Kingdom of Bahrain: Manama, Muharraq, Middle, Southern and Northern. The questionnaire used in the survey assessed and evaluated the existing municipal waste management system in Kingdom of Bahrain and also revealed the satisfaction levels of residents regarding municipal waste storage, collection and transportation within the various localities.

Structured interviews through face-to-face interviews were carried out to gain a thorough understanding of both the quantitative and qualitative aspects of MSW management within the country as well as to clarify and further develop the concept of "sustainable waste management" which is vital in the development of an ISWM plan. A number of stakeholders were interviewed throughout this process with each interview having its own set of



**Figure 1.** Map of the Kingdom of Bahrain with the boundaries of Governorates.

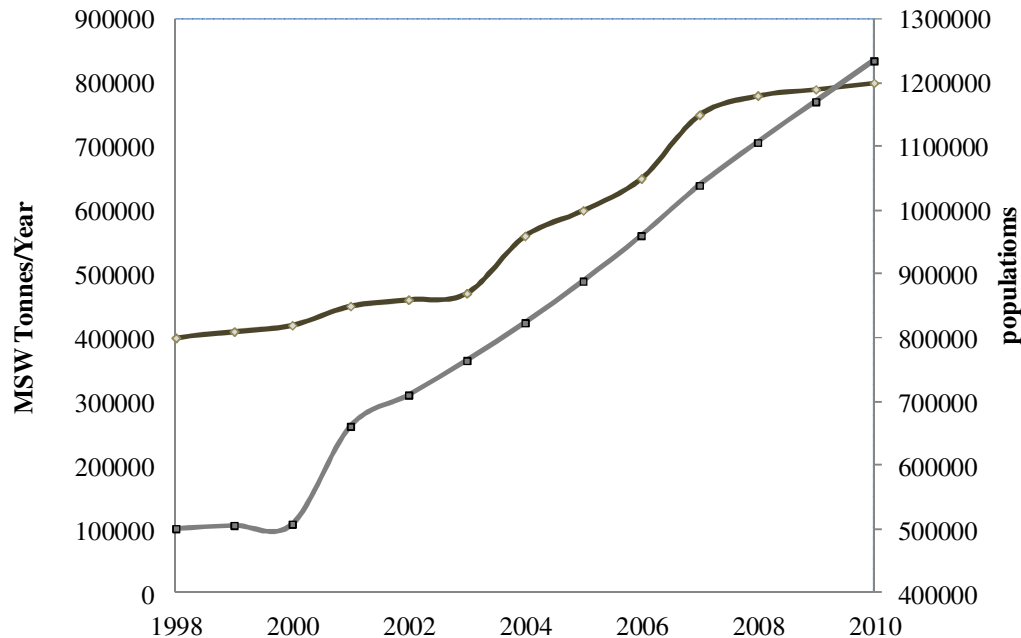
objectives deemed as its primary focus. Firstly, interviews with the officials were conducted in order to gather the preliminary data regarding solid waste collection and disposal. Further objectives were aimed at understanding: (1) the public-private partnership (PPP) agreement of the system; (2) whether the involvement of private sectors has brought a significant improvement on the country's solid waste management system; and, (3) how municipal authorities have regulated the activities of such private sectors in accordance to supervision and monitoring of the quality of services delivered. Next, operational managers responsible for waste collection, disposal and transportation in the kingdom of Bahrain were also interviewed to gather added information regarding waste collection procedures as well as to determine the limits or boundaries that hinder these private contractors in further promoting good quality services in their areas. Interviews with officials were held to determine: (1) the environmental-related regulations followed in municipal solid waste management; and the main problems reported regarding the services offered by the private contractors. Non-Governmental Organizations (NGOs) were carried out to determine: (1) the scope of participation of these NGOs with governmental authorities and private sectors; (2) any financial programs that aim towards the promotion of waste management and recycling initiatives; (3) the existence of any awareness programs on waste management and recycling that are partnered with governmental authorities; and lastly, (4) the existence of any waste-management-related training programs that have been provided to the members of the society.

Lastly, the observation method was used to analyse the existing SWM system available in the Kingdom of Bahrain. This method allows the researcher to gather a perceptible view of the overall

condition of the country's SWM system; as such, factors and other variables that were not met through the other methods were investigated within this course of the study. Results of all these methods were then analysed and converted to graphical representations such as charts and tables for easier evaluation and interpretation. Other information was subjected to SPSS analysis to determine relationships through correlation levels between key variables.

## RESULTS AND DISCUSSION

Potential factors related to municipal solid waste regeneration were the primary result of the content analysis method; resulting to the evaluation of variables that had somehow affected trends within the MSW management system of the country. These underlying factors were evaluated due to lack of extensive reviews of these variables in existing literature. Population growth, Gross Domestic Product (GDP), National income, and MSW from trade, commerce, industry and public services were determined as factors that have been overlooked in previous researches and publications and have therefore been subjected to further assessments. Population growth as underlying factor affecting MSW was analyzed due to a close relationship identified in parallel researches done in other cities or countries



**Figure 2.** Population Growth vs. MSW generation (1997-2010).

(Rafia et al., 2011; Saeed et al., 2009; Sjoström and Ostblom, 2010; Sha'Ato et al., 2007; Dyson and Chang, 2005). Trends in population growth have been identified as a primary factor that has resulted to a number of significant problems within countries such as poverty, health and environmental problems, and more. A conversion of available data on MSW generation in Kingdom of Bahrain and population growth in the country 2010 to graphical representations (Figure 2) have revealed a positive and directly proportional relationship between these two variables, thereby implying, that as Bahrain's population increases, further stress is put on MSW management in the country due to the proportionally increasing number of wastes.

Economic growth which is further represented through Gross Domestic Product (GDP) is another factor subjected to analysis due to parallel studies that have also revealed a significant relationship between both factors (Constantini and Monni, 2008; Shan-Shan and Carlos, 2004; Rafia, Keisuke and Rabaah, 2011; Arrow et al., 1995). Economic growth within the last century has been matched by a significant increase in the amount of wastes that a country produces (RTAB, 2001). To further identify whether such notions are relevant to Kingdom of Bahrain, GDP, a measure of domestic output of goods and services (Field and Field, 2002), has been reviewed and evaluated against MSW generation in the country. Similarly, results have showed that a positive and directly proportional relationship exists between both variables as shown in Figure 3. These results are therefore reflective of implications that as the country progresses in terms of the economy, significant effects on the environment such

as yielding to higher quantities of waste are possible, thereby causing more stress on MSW-related complexities.

National Income as an indicator of economic growth has also been noted as a significant factor that affects waste generation—this is particularly manifested within developed countries whereby higher waste generation rates compared to that of developing countries are evident. For instance, cities in the United States have rates equivalent to that of 1.4 kg of wastes per person per day compared to cities in Africa with rates of 200 g per person per day; thereby suggesting that national income, represented through Gross National Product (GNP), is an inherent factor that affects changes within the environment.

Figure 4 presents an application of this conception to data available for Kingdom of Bahrain. The chart shows that both GNP and MSW generation elicit a positive and direct relationship whereby increasing quantities of waste are positively affected by an increasing national income; as such, supporting the view that economic growth and development within a country causes difficulties in waste management.

With the increasing urbanization and economic growth identified through data presented, it is important to note that wastes generated from such services are also as significant as domestic wastes. While domestic wastes account for about half of generated wastes in the country, the other half is reflective of wastes generated from the identified services. Implications therefore reveal that waste generated from other services have parallel influences on problems of the existing waste

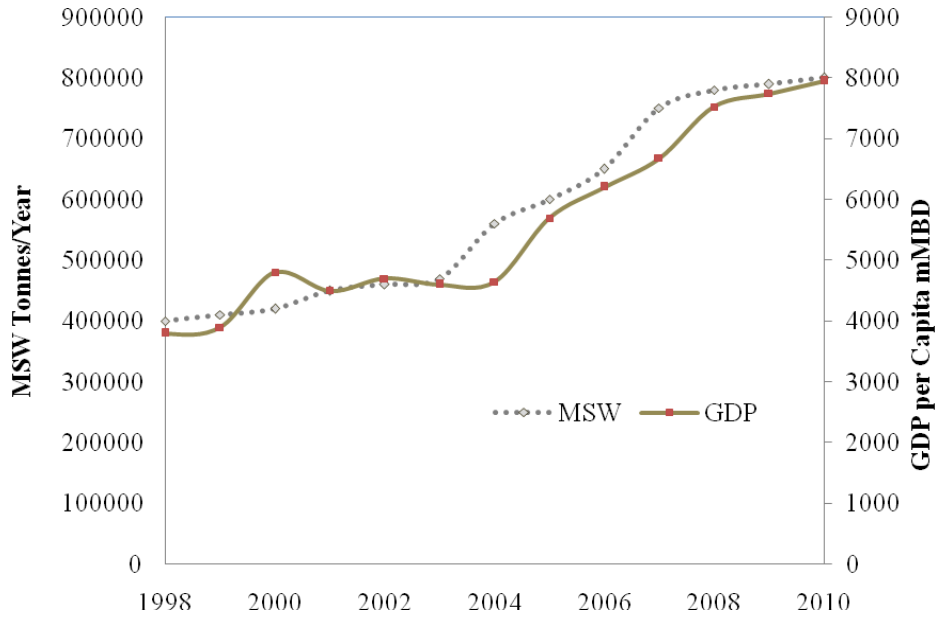


Figure 3. Gross Domestic Product vs. MSW generation in Kingdom of Bahrain (1998-2010).

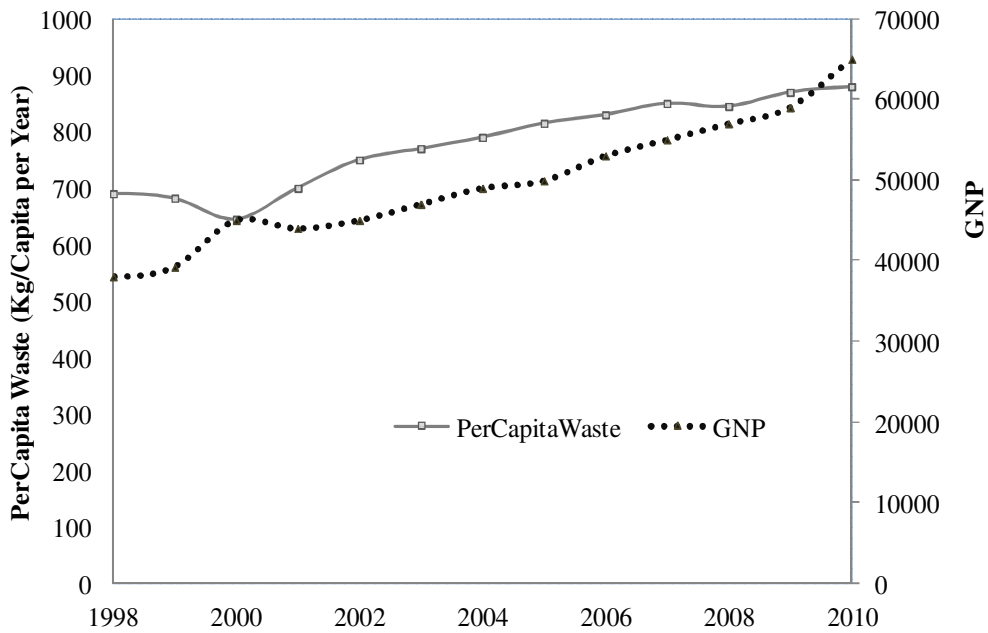


Figure 4. Gross National Product vs. MSW generation in Kingdom of Bahrain (1998-2010).

management system of the country.

As such, policies developed, integrated and applied within the country with reference to MSW management must recognize these services as parameters needed for formulation and adoption of policies.

Economic growth as presented by GDP and GNP also

showed significant correlations with reference to MSW generation in the country with values of  $R = 0.892$  and  $R = 0.863$  respectively.

These results further prove the notion that as a country advances towards economical growth through globalization, industrialization, and other routes; waste

**Table 1.** Condition of municipal garbage containers in Bahrain as perceived by its residents (2010).

No	Condition of Municipal container	Manama	Muharraq	South	Middle	Northern	Total	
							No.	%
1	Excellent	12	18	18	7	-	55	16
2	Good	22	32	27	35	32	148	42
3	Fair	28	12	16	23	38	117	33
4	Poor	8	8	9	5	-	30	9
Total		70	70	70	70	70	350	100

generation significantly increases. MSW from trade, commerce, industry and public services also revealed a positive value of correlation ( $R=0.481$ ). Despite difficulties of separating waste generation from these services, the assumptions that these services affect SWM in terms of formulation of policies is still accepted as reflected through the significant value.

The survey carried out within the five governorates of Bahrain significantly revealed perspectives and satisfaction levels of residents on the current solid waste management system of the country.

The level of service provided through the current SWM system was assessed through identifying: (1) status of garbage filling within the containers; (2) status of municipal garbage containers—whether or not these containers were emptied properly; (3) condition of municipal garbage containers—whether they were in excellent, good, fair or poor condition; (4) the need for more municipal garbage containers; (5) observations of foul smells from municipal garbage containers; (6) satisfaction with the services provided along with reasons of dissatisfaction. Data collected on garbage filling shows that majority of households (66%) have witnessed that garbage containers are often full and overloaded. The nature of the response provided was confirmed through random visits to municipal garbage containers around the country, thereby resulting to implications of lack of containers due to increasing quantities of waste and also implications of probable negligence on the part of private contractors. Data on the status of municipal garbage containers, on the other hand, revealed the frequency of garbage collection from the perspective of residents. About 68% of the total number of surveyed households responded that garbage containers are emptied on a daily basis; results are reflected all throughout the country, except for the Northern governorate wherein 60% of its residents have replied that garbage containers are emptied about once in two days. Implications of these data are again reflective of probable negligence on the part of private contractors responsible for garbage collection in the country, and also reflective of probable lack of funds due to high costs of transportation. Perspectives of residents on the condition of municipal containers were also assessed through the survey. Results show that majority of respondents (42%)

observed a generally good condition for municipal garbage containers. This result is consistent among the governorates except for the northern governorate whereby majority of residents viewed the condition of their municipal garbage containers as fair. The data collected within this category is further presented in Table 1.

The need for more municipal garbage containers according to the perception of residents was also assessed whereby 74% of surveyed households agreed that there is a need for additional containers within their vicinity. In the southern governorate, however; 66% of surveyed households expressed that garbage containers within their areas are already adequate in number—this may be due to the fact that population in the southern governorate is relatively low compared to that of the other governorates, thereby facilitating easier waste management processes in the area. Foul smells were also evaluated and results showed 59% of respondents agreed to the presence of foul smells and the other 41% of the respondents disagreed. The figures gathered are apparently close to each other, as such, notions of the location of the households from municipal garbage containers were taken into consideration in the interpretation of this result, wherein, foul smells are dismissed as generally subjective due to the extraneous factor of proximity. Lastly, the degree of satisfaction of residents with the current municipal solid waste management system of the country has been evaluated as presented in Table 2. It is apparent that majority of the population is satisfied with the current SWM system, thus implying that services provided were able to meet the demands of residents despite growing concerns on waste management. The satisfaction of residents met by private contractors may be due to the efficacy of managements to adjust to the difficulties posed by increasing population, economic growth, and other environmental concerns.

On the other hand, reasons of dissatisfaction were further inquired from the rest of the surveyed residents. The following reasons for dissatisfaction were revealed by the survey: (1) less number of garbage containers provided in the area and might be due to the exponential increase in the number of resident; (2) lack of repair and maintenance of the containers as it should be purchased

**Table 2.** Satisfaction of residents with reference to SWM services in Bahrain 2010.

No.	Satisfaction Status	Manama	Muharraq	South	Middle	Northern	Total	
							No.	%
1	Yes	51	58	63	21	28	221	63.1
2	No	19	12	7	49	42	129	36.9
Total		70	70	70	70	70	350	100

new rather than repair;(3) unplanned methodology for containers replacement over calculated time (4) garbage containers are distanced from the houses; (5) interference of the areas that residence are reluctant to reach; (6) unhygienic conditions in and around garbage containers that allows untamed animals( such cats or dogs) to cohabitate in such areas; (7) organic foully smells originate from garbage containers leading to unhealthy environment around the area; (8) irregular collection frequency by private contractors; (9) overloaded garbage containers due to the capacity of the containers; (10) presence of insects near to garbage containers because no such chemical treatment organized to sterilization and disinfection of containers; (11) absence of container covers due to stolen or purposely damaging the covers; and, (12) continuous of the deterioration of the containers; (13) No regular road cleaning services provided by private contractors due to poor supervision and lack of follow up in the light of privatization.

As a follow-up to the surveyed level of satisfaction present among the residents, suggestions for improvement of the current SWM services provided were also sought. The replies received are as follows: (1) provision of additional garbage containers within locations where waste accumulations are present; (2) improvement in the quality of garbage containers done through repairs, and regular replacements; (3) provision of repairs and maintenance services for garbage containers; (4) regular inspection services for garbage containers; (5) placement of garbage containers at convenient locations; (6) organization of more area sweepings and utilization of more garbage collection marshals on streets and open areas; (7) regular cleaning and disinfection of foul smells from containers; (8) organization of more monitoring and inspection activities of storage, collection and transportation systems provided both by private and public sectors; (9) provision of covers for garbage containers; (10) initiating community awareness to create better civic sense within the population.

The opinions of stakeholders were also taken into account within the course of the study through the process of structured interviewing. This section provides the highlights of the interviews initiated with several offices to further gather data on current SWM systems in Bahrain. Data was gathered through a process of

structured interviews with stakeholders—each interview was accustomed to the roles of the stakeholders within the waste management system process. Interviews with Private Waste Management Contractors revealed that on the basis of the contracts signed with the Municipalities Affairs, all required services within their respective areas of concern have been met whereby all necessary tools, equipments, machineries and vehicles were provided and utilized for operation. Moreover, workshops, and repair and maintenance facilities were established and optimized to their capabilities in order to meet efficient collection, transportation and disposal of wastes. Staff trainings for effective handling of municipal wastes are also completed on a regular basis. As to community-related activities, private contractors has also instigated public awareness campaigns through media and other organizations wherein leaflets in different languages were distributed throughout its areas of control (South, North and Middle governorates). Interviews were held with NGOs that were selected carefully to satisfy the needs of this study. Results of the interview revealed an overall lack of waste-management-related activities established within the country. Firstly, any means of support from departments and organization as well as funding for any activities or programs related to waste management and/or recycling were inadequate or virtually absent. Finally, no coordination or cooperation among local NGOs, private sectors and public offices has also been highlighted, thereby adding to the inadequacies related to the current SWM system of the country. Aside from these results of the interview, sustainability of the current SWM system in the kingdom of Bahrain was also assessed through different sets of sustainability indicators. Sustainability and sustainability factors were observed within this course of the study whereby attention was drawn towards sustainability according to the perspectives of users (stakeholders), municipalities, NGO's and private contractors. Rates of sustainability based on these perspectives were also assessed according to the following categories: not sustainable, partially sustainable and sustainable. Additionally, an assessment of sustainable waste management indicators mentioned within the Agenda 21 for the situation in the Kingdom of Bahrain was also made. It is important to note, however, that these indicators vary from one assessor to the other due to differences in the involvements of these offices in the

**Table 3.** Assessment of sustainability indicators.

Assessor(s) Rate of Sustainability	Users/ Stakeholders	Municipalities	NGOs	Private Contractors	Agenda 21
	Not Sustainable	--	--	Reliability, Sustainability	--
Partially Sustainable	Area Improvement, Convenience, Complaints System, Sustainability	Area Improvement, Impact on Municipal Services, Complaints, Sustainability	Area Improvement, Fulfillment of specific aims	Sustainability, Sustainable Livelihood, User Satisfaction and Recognition	Rate of waste recycling and reuse, Municipal Waste Disposal
Sustainable	Affordability, Frequency and Reliability, Extra Waste	Municipal support, Staff satisfaction	--	--	--

current waste management system in the kingdom of Bahrain.

These indicators are therefore reflective of the experiences of the assessors themselves. For instance, sustainability assessed by users differs from the sustainability assessed by NGOs; similarly, sustainability assessed by private contractors differs from the sustainability assessed by municipalities. The results, presented in Table 3 shows that different indicators are found within the ranges of sustainable, partially sustainable and not sustainable rates. A focus will be drawn on indicators that have been rated as not sustainable within the following discussion. NGOs have assessed reliability and sustainability as not sustainable. Reliability, with reference to NGOs, was assessed according to the provision of private contractors of a reliable model for further projects; while sustainability was assessed according to the sustainability and existence of a well-defined withdrawal plan given that NGOs would withdraw assistance towards the privatization of waste management in the country. On the other hand, with reference to the Agenda 21 indicators of sustainability, generation of municipal solid waste and household waste disposed per capita were assessed as not sustainable due to significant increases in both factors over a period of seven years reflecting greater threats to human health and the environment.

The observation method was primarily used to fill in the necessary information needed by the researcher to plan a conclusive and definite ISWM system for the kingdom of Bahrain. As such, a number of additional assessments on the current waste management system as well as other related concerns were done in order to position primary bases and foundations for the ISWM plan. Main factors that had direct effects on the waste management

system in The kingdom of Bahrain, constraints and shortcomings of the current SWM system, aspects of the ISWM, Environmental impacts of current SWM system, waste management system performance, and, status of sustainability and sustainability indicators were all observed and evaluated within this course of the study. Factors that had direct effects on the kingdom of Bahrain's SWM system were first identified and evaluated; several factors determined are as follows: population density, limited area for service corridors, absence of squatter settlements, privatization of waste collection services, presence of sewage system and limited recycling facilities. Population density has a definite significant impact on the country's SWM system due to high population rates and limited geographical space, thereby creating a denser population with references to available land mass. Presently, the country's main habited Island of Manama houses about 85% of the total population of the country which results to a density of over 1000 people/km<sup>2</sup>, thereby resulting to bigger demands within waste collection, transportation and disposal that must be met by private contractors as well as public offices and other civic organizations. Limited area for service corridors, on the other hand, is characterized by congested roads and alleys and limited space provided for waste collection services. Lack of enough space for facilitation of waste collection, transportation and disposal activities have consequent effects on the SWM system wherein difficulties of successfully meeting the daily requirements of waste management are apparent. Movement of vehicles and walking areas are also restricted due to waste accumulations within garbage collection sites. Foul smells which result to the pushing of communal bins to inaccessible locations is another added difficulty to the



maintenance of effective waste management within the country. Squatter settlements, however; are virtually absent within the country, thereby causing more ease and positive outcomes for effective waste management to take place in the country. Privatization of waste collection services also has direct effects on the current status of the SWM system of the country. The quality of the services provided by both of these private contractors as well as their ability to meet the demands of waste collection, transportation and disposal guarantees either a negative or positive bearing on the country's overall ability to maintain an effective SWM system. Sewage systems available to about 70% of households in the kingdom of Bahrain is another defining factor for SWM system due to the parallel activity of sewage systems in the preservation of a clean and healthy environment within the country. As such, absence of sewage systems present a detrimental effect to the country as well as a bigger burden to the management of wastes since lack or absence of sewage systems will definitely give rise to waste generation. Lastly, limited recycling facilities have also been identified as another factor affecting SWM system in the country. Recycling is acknowledged as one of the primary means of effective waste management; the lack therefore of any related means of pushing for such an activity would present a problem for an ISWM plan. Informal sectors are currently responsible for collection of collection of recyclables and recycling activities – the extent to which these activities are facilitated, however, is limited due to strict control and licensing procedures by the government. Constraints and shortcomings in the form of the involvement of stakeholders and waste system elements have also been investigated. A limited involvement of stakeholders within the current waste management system has been identified to be a constraint in the further development of the country's SWM system due to the impact that they have on the continuity and facilitation of waste management activities. An observation of stakeholders revealed that only private waste collection contractors and public sectors are actively involved within the waste management situation of the country. Thereby, a lack of support from other parties and organizations is apparent, creating inadequacies and adding to hindrances within the country's SWM system. An observation on waste management elements has also revealed a general lack of concern towards elements such as waste minimization, reuse and recycling. A lack of concern towards these elements presents bigger challenges for the incorporation of an ISWM since greater adjustments must be allotted for these elements. Aspects of an Integrated Solid Waste Management system were also noted as foundations for the development of the ISWM plan. Environmental aspects, political and legal aspects, institutional aspects, socio-cultural aspects, financial and economic aspects, waste management hierarchy, and integration with other urban services were all reviewed by the researcher in

order to gain a better perspective of the parameters that need to be established within the planning of the ISWM.

### **Proposed ISWM system for the Kingdom of Bahrain**

Aspects of an Integrated Solid Waste Management system were also noted as foundations for the development of the ISWM plan. Environmental aspects, political and legal aspects, institutional aspects, socio-cultural aspects, financial and economic aspects, waste management hierarchy, and integration with other urban services were all reviewed by the researcher in order to gain a better perspective of the parameters that need to be established within the planning of the ISWM.

### **Environmental impacts of waste management systems in the Kingdom of Bahrain**

Environmental impacts of the ISWM were also assessed according to waste storage, collection, transportation and disposal through the use of parameters based on EIA scrutiny developed by the Public Commission and based on the researcher's own assessments. It has been discovered that ISWM soil quality, traffic, dust generation, odour, air pollution, bird hazard, pest and vermin and ground water can cause adverse effects to the country. ISWM also causes noise, forms leachate, and affects the landscape. Occupational health, adjacent properties, meteorology, geology, ecology, tourism, litter, and landfill gas were also considered in determining the effects of ISWM in the kingdom of Bahrain. An assessment of the current waste management system according to technical performance, environmental performance, financial and economic performance, social and cultural performance, institutional and organizational performance and policy and legal performance has also been made to gather pertinent findings on the current status of SWM in the country. Parameters were assessed according to three indicators: Good, Satisfactory and Poor. Results of the assessment have revealed a number of poor findings within these parameters. For instance, waste minimization and segregation at source and waste recycling and resource recovery were found to be poorly addressed within technical performance while environmental performance also had a number of poor assessments reflected by pollution due to waste disposal at landfill site, hazardous waste separation, poor environmental awareness and lack of recycling and resource recovery. Financial-economic performance was poor in terms of cost sharing by stakeholders while Social and cultural performance was poor in terms of the involvement of stakeholders, the cooperation of municipalities with stakeholders and the status of communication among stakeholders. Finally, institutional and organizational performance parameters were all

found to be at satisfactory levels as well as with the parameters of policy and legal performance. From the results of investigations carried out through the four methods of data collection presented in the previous section as well as the implications that have been reviewed from such results, a proposed ISWM system for the kingdom of Bahrain has been developed. The highlights of the proposed ISWM system are reflective of various principles such as environmental principles, political or legal principles, institutional and organizational principles, financial and economic principles and technical principles. The following principles summarize the proposed details of the ISWM proposal and further describe the necessary steps and procedures needed to be addressed in order to create an ISWM system that is effective and conducive for the kingdom of Bahrain. Moreover, it highlights all the qualifications that need to be met to fully accomplish the objectives of developing a waste management plan that will alleviate growing concerns on environment and public health and other hazards while addressing the potential factors that could delineate the proficient facilitation of ISWM.

### **Principles for the proposed ISWM system for the Kingdom of Bahrain**

#### ***Environmental philosophy***

The degree of harmful effects of waste management on the environment is mitigated through effective utilization and disposal of wastes, thereby creating avenues through which the environment could further achieve a state of stabilization and sustainability. All available resources and facilities in environmental resource management are aggregated as a means to add to the available resources of waste management, fostering integration between both constructs in order to achieve a healthy balance for the community. The 3R's: Reduce, Reuse, and Recycle should be introduced and reinforced as a means of mitigating the amount of wastes generated within households, commercial establishments, industries, public places, agricultural facilities and more, thereby promoting an efficient use of our raw materials and resources. The inherent use of waste segregation should be pushed as a means to ease disposal procedures wherein wastes segregated into non-recyclable bins would be properly disposed of while wastes segregated into recyclable and biodegradable bins may be subjected to further use. Wastes at proximities close to sources of waste generation should be treated thereby reducing the probability of the spread of certain hazards within communities. Specifically, healthy methods of waste disposal within the current facility should be promoted, such as methods which are highly innovative and are able to contain and address increasing problems of waste management. In particular,

sites of waste disposal in manners should be revamped through which long-lasting effects (both positive and negative) to the environment is highly considered. In addition, the allocation of effective equipments and facilities within the system should be promoted, which will further be reflective of preservation and care of the environment.

#### ***Policy/legal/ political philosophy***

In the legal framework, policies reflective of intelligible and comprehensive studies that have delved into the current situation of waste management in the country should be created, thereby pushing for a betterment of all means of achieving effective waste management systems. There is a need for creation of policies that address waste management not only according to collection, transportation and disposal facilities but also to consider policies on segregation, recycling and resource recovery. Policies that address the safety and health of the people of the kingdom of Bahrain will be created, thereby promoting an understanding of their needs and of the services needed to meet them. Such policies will be fully enforced in the most effective way possible, in a manner through which all sectors and all constituents of the country of the kingdom of Bahrain would be actively involved. A full communication and cooperation is created between all concerned offices, private or public, governmental or non-governmental, in the act of making, planning and applying sustainable policies adaptable for effective waste management in the country. Tasks among sectors in the full administration of policies are fully delegated, promoting optimization of all available sources of management and authority. Different forms of media will be adapted as a means of reaching out to the public and as a means of garnering attention and participation to fully recompense the purposes of policies created.

In the policy and political framework, waste management should be first recognized as an environmental issue with impending effects and hazards on health and community and to further acknowledge the importance of attending to the concerns that have rooted from this system. Waste management should be recognized as a top priority in policy making due to the bearing it has on the environment and on the safety of the country and its people. An easy process of decision making is adapted and easy process of application and adaptation of policies created especially those concerned with financial matters and those that create foundations for the frameworks of the facilitation of a revamped waste management system. There should be an allocation of ample amount of funds that will meet the needs and that will fully cover for all the necessities required for the new waste management system—targeting goals of erasing financial grounds as a barrier to the advancement of

waste management facilitation in the country. All potential stakeholders will be strategically involved by renewing policies to a position wherein involvement is not only voluntary but pushing for its necessity. Other urban services will be integrated such as sewerage, drainage and electricity into the planning of the waste management facility such that no overlapping happens and such that all the concerns of each service are equally attended to and promoted.

The work and contributions of private waste collection sectors will be given importance through evaluating ways in which the government could help them strengthen the quality of work they provide and also to give extra attention to the people (workers) responsible for everyday waste management in the country.

### ***Institutional and organizational philosophy***

In human resources development, Trainings will be provided for all staff members who have concerned themselves with the facilitation and managing of the waste system, thereby adding new knowledge and sharpening skills that are needed. A merit and performance-basis system should be incorporated whereby staff members are able to achieve incentives and bonuses for the quality of work that they do and provide, thereby, integrating a motivation strategy that will increase the potential of the waste management system.

When it comes to organizational development, the task of each stakeholder are reiterated through effective dissemination of information regarding the policies created, giving focus to the roles of each stakeholder that must be fully carried out. Competitive bidding should be encouraged among private sectors on waste management projects thereby promoting a healthy competition and connection between private sectors and further involving them within the environmental impacts of the waste management system. The participation of small businesses and organizations will be promoted in contributing to the facilitation of the waste management system, thereby reinforcing the number of people involved and the number of communities that support its cause.

In institutional development, the number of services associated with the waste management system should be proficiently distributed in order to allow municipal and urban services to take part in the allocation of funds and regulations in order to improve waste management services.

### ***Socio-cultural philosophy on users and operators***

Equal services are to be provided to all members of the population regardless of categorical divisions such as socio-economic status, thereby maximizing and

optimizing the extent of application of waste management system all over the country. Services according to the needs and demands of communities are allocated and considering them as the first priority rather than public authorities. Attention should be given to the minimization of risks within public health by effectively promoting sanitary practices within the community and giving out useful information that they may use in further cooperation with the goals of the waste management system. Management frameworks should be utilized to initiate a good correspondence with the community, thereby creating a healthy and fruitful link between users and operators. Environments that will help staff to avoid unsafe and unhealthy conditions should be provided in their dealing with wastes. Employment rates within the country should be increased through introducing recycling facilities or supporting current recycling facilities helpful to the further management of wastes in the country.

### ***Financial-economic philosophy***

ISWM plans should be evaluated according to effective use of finances and effective optimization of budgets – thereby removing financial barriers/hindrances to the integration of the waste management system. Financial evaluations should be based on assessments of current financial limitations of the waste management system. All sectors involved within the waste management system should be allowed to express their concerns on budgets allocated to the services and tasks that they provide within the system.

Costs will be quantified and analyzed according to each element of the waste management system in order to promote a careful allocation of funds, ensuring that the budgets will cover all essentialities of the waste management system. Appropriate funds will be quantified and released only when a full appraisal of each element has been carried out, checked and reviewed and then subjected to further analysis. All beneficiaries are identified and share responsibilities that will improve the financing of projects and operations. All available resources will be optimized in order to maintain the efficacy of the system and to promote further its sustainability.

### ***Technical philosophy on technologies and systems***

Appropriate technologies used in waste management system should be selected according to certain parameters such as local knowledge and practices; availability of spare parts; heavy-duty, resilient, supple and long-lasting technologies; conduciveness to physical environment and topography of its surroundings or locations. Different systems are established to promote

the optimization of all available equipments, machineries and facilities, as well as high, adequate, and preventive maintenance procedures to ensure the sustainability of the equipments, machineries and facilities.

## CONCLUSIONS AND RECOMMENDATIONS

The study was initially aimed at evaluating the current SWM system in the kingdom of Bahrain, along with the factors that have led to the difficulties of its efficient facilitation. Moreover, it sought to develop an Integrated Solid Waste Management (ISWM) plan which will address growing concerns on the environment, public health and other hazards posed by the current SWM System. To achieve a full report and analysis of the current waste management system, a number of procedures were carried out such as content analysis of available literature, household surveys, and interviews with stakeholders, and observation methods all throughout the country. Results of the investigation have revealed that a number of inadequacies are apparent within the current SWM system thereby causing the incapacity of different sectors to fully meet the standards of a good and efficient SWM system. Lack of cooperation, legislation, funding and other important variables were highlighted within the discussion of the study. As such, the need to revamp and refurbish current modes of transaction is a need that was set as a parameter in the planning of the ISWM proposal. The ISWM proposal therefore takes into consideration a number of important dimensions throughout its development: waste management including stakeholders, waste system elements and sustainability aspects. Additionally, potential factors that have impending effects on waste management were taken into account; as such, population density, GDP, GNP, and wastes generated from other sources other than households were addressed accordingly. The benefits therefore of the proposed ISWM plan is reflective of lower costs of management, lesser environmental pollution, conservation of raw materials, better coordination between urban services, raised awareness among residents, lesser health hazards, better cost management, higher cost recovery and better image of the city.

With such an integrative proposal developed within the study, the researcher highly recommends that it be considered for future planning of waste management systems in the country. It is apparent that decisions on how to manage waste accumulation within cities and countries is increasingly growing in difficulty, as such, the need to address the issue as soon as possible is a need to be met by both public and private sectors. The proposed ISWM therefore holds a framework that has been studied, evaluated and analyzed for the waste management of Bahrain, its adaptation, however, is

reliant on people with the corresponding authority. It is stressed therefore that efforts that continually address the needs of countries, be it environmental, economical, etc., will only be acknowledged given the right amount of attention and participation provided by the country's leaders. Sustainable development is therefore reliant on the ability of the entire nation to cooperate and procure a system that is helpful for its success.

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