Strategic Policies for Achieving Concept of (Zero Waste to Landfills) through Gradual Plan in The Gaza Strip

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Abstract—In fact, the solid waste management (SWM) is a purely engineering function from jurisdiction of engineering and management of infrastructure. And today, the solid waste (SW) issue is one of the largest environmental challenges and problems that facing all communities around the world. But the solid waste problem in the Gaza Strip is a complex problem from a different kind, where the scarcity of land prevent establishing a new sanitary landfills instead of the current saturated landfills after exceeding of its design period. Existing landfills are rehabilitated from time to time in order to receive more quantities of SW that reached to high limit (1.333 million tons yearly) from the following sources: 1. MSW: Households, Commercials, Governmental and NGO’s, 2. Construction and Demolition Waste, 3. Agricultural Waste, 4. Industrial Waste, 5. Health Care Waste). The problem become worse due to rapid population growth and real estate developments that creeping toward existing landfills. Hereafter, strategic policies are proposed which covering all aspects of SWM system in order to minimize the solid waste going to landfills gradually at the short term and even reach up to (Zero Waste) at the long term. Where each policy are created from suggested key actions and appropriate motivation system by proposing a set of financial and non-financial incentives in order to prompt the waste generators toward respecting the well healthy activities for implementing these proposed strategic policies within an integrated framework for SWM (i.e. ISWM Model) in the Gaza Strip. These proposed policies were examined using (Qualitative research) through a questionnaire containing exploratory and attribute questions, where sample of 113 questionnaire were investigated. Results showed that there is a clear willingness from waste generators in the Gaza Strip for implementing of the policy of (Source separation of SW), which considered as the backbone of any successful program for waste recovery that followed by recycling, composting or energy recovery. Also, the selected sample were accepted to deal with the proportional payment for waste service which known as (Pay As You Throw- PAYT) if it’s equitable. Finally, it’s recommended to make (Pilot Study) within the frame of these proposed strategic policies in the appropriate places for each SW source from mentioned sources previously. The pilot study can be done after further exploratory survey for larger strips in the Gaza Strip to going deeply into these issues in the frame of the guidelines of this research results. The study also recommended to create suitable instruments, laws and specifications for SWM in the Gaza Strip, through re-formulating of the Palestinian Environmental Law 1999 No.(7).

Index Terms— Solid waste, landfills overloading, strategic policies, source separation, recovery, recycling, composting, PAYT, ISWM, Gaza strip.

I INTRODUCTION

General: In recent years, one of the most important current issues that concerns humanity is the environment and its protection. Today, the progress of human beings and the society is measured by their ability to control the environmental elements. And, the solid waste consider basically source for pollution of the environment.

Solid waste (SW) issue is one of the largest environmental challenges and problems that facing all communities around the world [1]. But the solid waste problem in the Gaza Strip is a complex problem from a different kind, where the scarcity of land prevent establishing a new sanitary landfills instead of the current saturated landfills after exceeding of its design period.

Waste can be classified by physical state (solid, liquid, gaseous), and then within solid waste by: original use (packaging waste, food waste, etc.), by material (glass, paper, etc.), by physical properties (combustible, compostable, recyclable), by source (household, commercial, agricultural, market, etc.) or by safety level (hazardous, non-hazardous).

Problem Statement: Currently in the Gaza Strip, (1.8) Million inhabitants live in a narrow strip of land on the Mediterranean coast. It borders (Green Line) to the east and north and Egypt to the south. It covers a total area of 365km². Landfilling is the only option available for waste disposal in the Gaza Strip. But in future, landfilling are not the appropriate method for waste management [3]. While there is continuously expanding of the residential areas in the study area, which goes along with increasing waste collection areas. Together with these changes, SW has also undergone rapid changes in recent years (more plastics, papers, etc.). Unfortunately, SWM system never could keep pace with these changes, which lead to enormous waste problem in the Gaza Strip. After reviewing the implemented projects of SW sector in the past years at the Gaza Strip, unfortunately the decision makers in SW sector have been launching projects that only left the door open to keep waste landfills and con-
sidering landfills as a unique mean to eliminate SW, but the question is for how long?, or until full saturation of these landfills?, and hereafter the problem is where there is no land space for opening new landfill sites in the Gaza Strip.

The overall severity of SW situation in the Gaza Strip is confronted with number of problems and limitations, including (MoLG, 2010)\(^5\):

- Rapid population growth, growing industrial sector and real estate developments, have impacted the environment of the region and caused an increase in waste generation, where landfills have reach near capacity.
- Scarcity of land for extension of old landfills and constructing new landfill locations.
- Absence of consistent local waste management legislation, strategy and action plans.
- Absence of financial incentives and effective cost recovery mechanisms.
- Lack of awareness and narrow venues for public participation in decision making.
- Shortage in infrastructure for SWM and poor performance of SW collection services.
- Risks to public health and threats to environmental resources.
- There is no real integration between all stakeholders in SWM which leads to an absence of a unified vision.
- Lack of reliable databases for the SW characteristics.
- Deficit in trained personnel.

**Aims**: This research aims to introduce and suggest (**Strategic policies for achieving zero waste to landfill**) in the Gaza Strip, the zero waste to landfill consider the most modern concept that applied in many countries in the world such as (USA, Canada, England, Australia, New Zealand, India, Lebanon, United Arab Emirates, etc.) to solve this problem gradually at long period.

**II. LITERATURE REVIEW**

The quantities of waste collection in cities, villages and refugee camps are usually estimated based on the number of people served, the equipment in operation, loads transported to landfills, and professional judgment of experts (El Baba & Smedt, 2012)\(^6\). The following Table (1) shows the quantity of SW in the Gaza Strip, according to previously published data at 2010 collected from various local sources:
Per capita waste generation in the Gaza Strip can be presented in the next Table (2):

<table>
<thead>
<tr>
<th>Reference</th>
<th>Gaza landfill</th>
<th>Middle landfill</th>
<th>Rafah landfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MoP, 2010)[6]</td>
<td>1kg/day</td>
<td>0.65kg/day</td>
<td>0.8kg/day</td>
</tr>
<tr>
<td>(UNDP, 2012)[5]</td>
<td>1.06kg/day</td>
<td>0.69kg/day</td>
<td>0.72kg/day</td>
</tr>
</tbody>
</table>

The composition of the MSW in the Gaza Strip can be presented in the next Figure (2) to show its components based on some different studies:

### III. METHODOLOGY

The adapted methodology explained hereafter used an integrated manner to achieve the objectives of this research. Where the following methodology depends on using primary data that collected by meetings with some of the SWM experts and stakeholders in the Gaza Strip to investigate several factors affecting and controlling at waste stream (i.e. at generation, composition, collection, transport, recovery and disposal). After this, the next step is conducting strategic policies which covering all aspects of SW system in the Gaza Strip as follow:

- **Policy #1**: Source reduction of generated solid waste.
- **Policy #2**: Source separation of solid waste.
- **Policy #3**: Collection of separated and non-separated solid waste.
- **Policy #4**: Recovery of solid waste.

<table>
<thead>
<tr>
<th>SW source</th>
<th>Daily generated waste Ton/day</th>
<th>Annual generated waste Ton/year</th>
<th>Percent from Total SW amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal solid waste (MSW)[1]</td>
<td>822</td>
<td>568,000 (a)</td>
<td>42.3%</td>
</tr>
<tr>
<td>Construction and demolition waste (CDW)[2]</td>
<td>150,000(b) m³/yr x 2.00t/m³ = 300,000</td>
<td></td>
<td>22.7%</td>
</tr>
<tr>
<td>Agricultural waste (AW)</td>
<td>1200</td>
<td>438,000 (a)</td>
<td>33.0%</td>
</tr>
<tr>
<td>Industrial waste (IW)</td>
<td>49</td>
<td>18,000 (c)</td>
<td>1.40%</td>
</tr>
<tr>
<td>Health care waste (HCW)</td>
<td>24</td>
<td>8,760 (c)</td>
<td>0.60%</td>
</tr>
<tr>
<td><strong>Total Solid Waste at 2009</strong></td>
<td><strong>3,652 Ton/day</strong></td>
<td><strong>1.333 Million ton / year</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**Sources:**

- b. Workshop Documentation by Dr. Maike Hora with GTZ at 2007 [8]

**Notes:**

- (*) MSW include SW generated from household and commercial, institutional places.
- (**) CDW inserted in this table include only CDW from normal construction projects and Don’t include demolition waste due wars on the Gaza Strip.
a widespread element of national and regional approach and is often considered as the most fundamental basis of modern SWM practice. The hierarchy ranks waste management operations according to their environmental or energy benefits from higher priority to lower, as follow (UNEP, 2005) [9]:

- Prevent the production of waste, or reduce the amount generated.
- Reduce the toxicity or negative impacts of the waste that is generated.
- Reuse in their current forms the materials recovered from the waste stream.
- Recycle, compost or recover materials for direct or indirect inputs to new products.
- Recover energy by incineration, anaerobic digestion, or similar processes.
- Reduce the volume of waste prior to disposal.
- Dispose of residual SW in an environmentally sound manner, generally in landfills.

IV. PROPOSED STRATEGIC POLICIES FOR SWM IN THE GAZA STRIP

1. Willingness of implementing source separation for SW in the Gaza Strip

About 86.5 % of the respondents were willing to implement source separate SW if they have good training and awareness about source separation practices, whilst 4.8% Not willing and 8.8% Not sure.
1) **Organic waste** (e.g. agricultural crops remains and animals manure)

2) **Plastic materials** (e.g. damaged crates damaged covering plastic roll of greenhouses, damaged watering tubes and pipes, empty bottles and gallons of toxin pesticides and empty packaging bags of fertilizers).

On the other hand, this sample of contractors gives clear high percent 83.3% to willingness to execute source separation of CDW (if company staffs are trained) to the following streams:

1) **Soft inert materials** such as soil, earth and slurry
2) **Hard inert materials** such as rocks, broken concrete and asphalt
3) **Non-inert materials** such as metals, wood, glass, plastics and packaging
4) **Hazardous materials** such as asbestos, tars, paint residues, adhesives agents

2. **PAYT financial system for managing SW service in the Gaza Strip**

The study supposed that using PAYT system where bill charges in such a system are assessed in accordance with the number of kilograms of waste that is put out for collecting in standardized polyethylene bags with corresponding (ID on bag tie) to the waste generator, then opening these bags and weighting on scales at MRF. Finally, MRF users record weights readings of waste generated in ISWM database for billing calculating based on PAYT system. The sample of waste generators accept with 81.4% using PAYT financial system for SW service in the Gaza Strip, whilst 18.6% reject PAYT system as shown in Figure (5). This can be explained by who reject PAYT are thinking that there is no law enforcement and legislation will manage ISWM under supervision of local authorities. Similar survey study was done by MAALEM Group at 2012 [11] in the Gaza Strip, results were more than half of the surveyed cases are willing to pay higher cost for improved services. The percentage was the highest in well-off areas.

![Figure (6) : Overall Waste generators' Opinions toward PAYT system for SW Service in Gaza Strip](image)

3. **Motivation of waste generators toward SW separation at source in the Gaza Strip**

The participation rate and separation efficiency in source separation of SW will be influenced by the level of motivation which affect by quality, general environmental awareness/concern, peer pressure, legal requirements, availability of alternative disposal routes, and cost reduction/rebate for producing less waste. Each of waste generators (households, commercials, institutions, farmers and construction companies) in this sample gives importance level to the proposed incentives in this study according to his special considerations and the findings are prioritized as follow:

![Diagram](image)

3.1 - **Incentives for households, commercials, institutions** (Ranked by sample)

1. Helping citizens by provision of free indoor colored storage bins and financial governmental support or subsidize to colored bags.
2. Taking care with consideration the public health, environmental and aesthetic issues at curbside and indoor waste storage.
4. Conducting free training courses for citizens to choose best space for placement of bins and how to minimize the time involved in the separation process.
5. Offering discounts for each tonne from MSW that separated at source as motivation for waste generators executing officially source separation principle.
6. Restructure MSW taxation (bills) system in Gaza Strip based on unit pricing system (Pay as you throw) where charges is based on the number of kilogram of collected waste by known your ID from bag tie.
7. Exchange each existing central collection container with drop-off point to enable waste generators from bringing their waste and separated manually at colored containers by themselves or by waste collector.
8. Remove existing central collection containers to increase door to door collection and thus increasing the walking distance for those who do not want to participate in waste separation at source.
9. Impose fines on waste generators in case of misbehavior such as mixing waste or high contamination level (i.e. low separation efficiency).

3.2 - **Incentives for farmers in agricultural sector**

1. Free redistribution of improved fertilizers with required chemical additions on farmers which produced by composting the separated AW and animals manure.
2. Free training courses for farmers on source separation of AW waste.
3. Offering discounts for each tonne from AW that separated at source as motivation for farmers who executing officially source separation principle.
4. Rewards for each pilot (on site composting).
5. Provide farmers with required tools for making (on site composting) more easily.
6. Restructure AW taxation system in Gaza Strip based on unit pricing systems known as (Pay as you throw or Weight-based systems) where charges in such a system are assessed in accordance with the number of tone of AW.
7. Impose high penalties or fines in case of disposing AW at illegal dumpsite or at curbside streets or burning AW.

3.3 - Incentives for construction companies (contractors)
1. Include proper item in projects tenders to cover costs of works related to source separation of CDW that will be done by contractors under monitoring by supervision engineers.
2. Offering discounts for each tonne from CDW that separated at source as motivation for contractors who executing officially source separation principle.
3. Provision separation containers and bins to be rented from SWMC’s or their private entrepreneurs.
4. Reduce tax on more durable construction materials.
5. Insert financial privileges in project contracts for contractors that meet this policy.
6. Include proper language in contract requiring compliance with the source separation for CDW.
7. Remove barriers on reusing CDW in construction projects.
8. Free training courses contractors’ staff (engineers, labors, etc.) on source separation of CDW.
9. Restructure CDW taxation system in Gaza Strip based on unit pricing systems (Pay as you throw or Weight-based systems) where charging are based on the number of tone of waste.
10. Impose high penalties or fines in case of disposing CDW at illegal dumpsite or at curbside streets.
11. Impose fines on contractors in case of mixing waste or high contamination level (i.e. low separation efficiency).
12. Impose high tipping fees on each tonne for CDW disposal in landfills to prompt construction companies to change their behavior toward source separation.

V CONCLUSION
The main achievements of this research includes:
- The primary aim of this research to adopting the proposed strategic policies for progressing step by step gradually to achieve high diversion rate from landfills in the Gaza Strip. The proposed model for managing SWM consider as the cornerstone in a sustainable SWM program. Including:
  - **Policy #1:** Reducing of waste generation at source.
  - **Policy #2:** Source separation of solid waste.
  - **Policy #3:** Collection of solid waste.
  - **Policy #4:** Recovery of separated and non-separated solid waste.
- In general, there is **good potential - based on willingness of selected sample** to implement the proposed source separation for 3-categories in 3-bins or containers to be ready for collecting by authorized waste collectors. There is a dramatic increasing in willingness to implement source separation that consider the cornerstone in the proposed strategic approach in this research. The willingness percent increased from 32% in 2002 to 83% in 2012. And this study at 2015 recorded 96% willingness to source separation of households SW (the larger waste generators in Gaza Strip).
- This research showed that most of waste generators **accepting of Pay As You Throw (PAYT) system** for calculating the cost of SW service in the Gaza Strip. PAYT system based on unit weight will be more controlling in gathering bills from waste generators and therefore achieving high revenues gradually.
- In the Gaza Strip, the waste reduction at source and separating SW at source that followed by recovery (recycling and composting) seem to be the most efficient and sustainable SWM especially to achieve the following benefits:
  - Conserves space in existing landfills in the Gaza Strip by reducing quantity of waste to be disposed at landfills and combustors (i.e. increasing gradually in waste diversion rate from landfills),
  - Reduction in raw materials (mainly through reduce importing)
  - Saving in energy,
  - Reduction in pollution and health problems by removing the major source of leachate, combustible gases, and odours.
  - Jobs creation.
  - Canceling gradually illegal waste dumpsites in the Gaza Strip.
- The research found out that the SWMC is the most suitable leader for managing SW sector in the Gaza Strip. On the other hand, there is clearly decreasing in the role of municipalities due to shortage in waste collection.
- It’s resulted from this research participation of private entrepreneurs in SW sector are also very important because the private entrepreneurs are applying the contract items under monitoring from SWMC’s. This improve the service of waste collection in the Gaza Strip.
VI. RECOMMENDATIONS

- It's recommended to create an adequate legislation, law enforcement, standard specifications and legal instruments - based on the key actions that inserted in these strategic policies within this research - which should be regulated and carried out by SWMC's through waste management committee from qualified experts in SWM in the Gaza Strip. Those experts may be from governmental ministries, authorities and Non-Governmental Organization (NGO's) that related with SWM.

- The researcher recommends that Palestinian Environmental Law No.7 at 1999 needs to many of decrees/articles that should be proper with the new concepts of ISWM and waste recovery in addition to existing Environment Law Articles (7, 8, 9 and 10 for non-hazardous and 11, 12 and 13 for hazardous wastes). Where the Palestinian Authority inherited a mix of legislation from previous systems which, in terms of environmental protection, is weak, piecemeal and sector-based. Further work is still needed to develop coherence in this area. Environmental Law No.7 (1999) that regulating the environmental issues includes the protection of natural resources, forestry, archaeological and tourist sites, and drinking water, and the control of sewage, marine pollution, air pollution, industry, fishing, urban development, municipal and hazardous waste disposal. It also covers environmental planning and enforcement and incorporates the ‘polluter pays’ principle. However, it lacks many specifics, such as environmental quality standards, regulatory standards, economic measures and effectively law enforcement.

- It's recommended to select pilot areas to check the positive results and good willingness that claimed by 113 waste generators (as sample) because the people what that they say, and what they actually do, are not the same. So that participation rates should be examined actually by launching pilot studies for SW separation at the following sources after obtaining on the required funds:
  - One suitable residential area like Al Saudi suburb at Rafah City.
  - One university and school.
  - One construction project.
  - One large farm land.
  - One hospital.

- Installing of MRF’s, recycling plants, composting areas and combustors for SWM in the Gaza Strip is very important item. Especially, installing composting areas for the organic waste which considered the largest component of SW that estimated by up to 60% by weight as mentioned at literature review in this research.

- Private companies and investors should be involved in the mechanism of improvement the SW through waste separation, reuse, recycling and composting.

- Waste generators must be motivated to start source reduction and separation through suitable incentives for ensuring a high level of efficiency and in order to make system more attractive. Also, efficient separation of materials by waste generators will only be sustained if the source separation system is convenient, hygienic and beneficial.

- The researcher recommends executing more exploratory studies on SW reduction and separation at source in various area inside the Gaza Strip for more penetration in SW issues. In addition to more exploring the feasibility of PAYT financial system in the Gaza Strip. Also, studies should be gone deeply into the cost benefit analysis, the responsibilities of all stakeholders, finding solutions for many problems in SWM that have been identified by many previous researchers.

- Educational materials and awareness campaigns should be organized to make SW separation easy and use all communications media to explain what to separate. Education must also continue after the launch of the scheme, in an advisory and supportive manner, through the use of waste advisors and school programmes.

- It's recommended to the coming researchers from department of Computer Engineering and to design a comprehensive ISWM database in the context of this research for assessment of SWM situation in Gaza Strip by decision makers at local governmental authorities (SWMC's). Also, this database should include billing system based on PAYT principle.

- Government and coming researchers should integrate the efforts toward ISWM taking into consideration the results obtained in this research until improving SWM which considered as important part from the strategic governmental plan for developing the Palestinian country.

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