

National Solid Waste Management Strategy and Challenges for Waste Minimization in Palestine

Suleiman Abu Mfarreh and Mitsuo Yoshida

Abstract — Although there are politically unresolved issues such as Israeli occupation in Palestine, an appropriate solid waste management is inevitable requirement for daily lives and is necessary to be conducted under given conditions. Palestinian Authority has been working for improving the solid waste management with various supports by donor agencies. In this regard, the "National Strategy of Solid Waste Management (2017-2022)" has been formulated. Presently, the top priority issue is the minimization of waste amount through introducing the 3Rs (Reduce, Reuse, Recycle) practice.

Keywords— Palestine, Joint Service Council (JSC), National Strategy, Waste Minimization, 3Rs Policy

I. Introduction

Palestine consists of the West Bank (5,655km²) and the Gaza Strip (365km²), where 2,881,687 people are living in the West Bank and 1,899,291 people in the Gaza Strip, according to the Palestine Population and Housing Census conducted in December 2017 [1]. However, about 59% (3,336 km²) of the West Bank, called as "Area C", is occupied by Israel who has a virtual power in administrative and security controls, where a number of Israeli settlements have been constructed ignoring international treaties.

Moreover, among the 4,780,978 people in Palestine there are living in refugee camps; about one million Palestinian refugees in the West Bank refugee camps and about one million and four hundred thousand in the Gaza refugee camps, who have been driven out by the founding of the State of Israel.

Under the given conditions as described above, it is required to collect, transport, and properly dispose of solid wastes discharged by the population of about five million people every day, which is the current mission of solid waste management (SWM) in Palestine.

How has the SWM been undertaken in Palestine so far? What was the problem, and what kind of solution strategies are in place? What are future challenges in SWM? This paper briefly outlines these issues and discuss the strategy for improving SWM over Palestine we are currently working on.

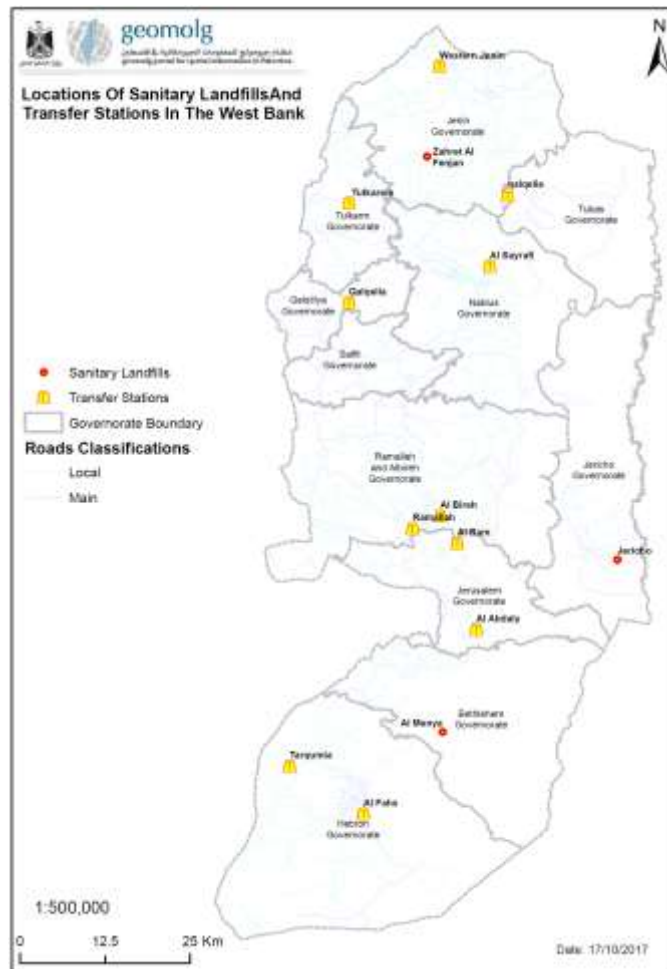


Figure 1: Map showing major infrastructure for solid waste management in West Bank, Palestine [2].

II. Development of Solid Waste Management and Waste Crisis

Under the Oslo Accords I/II and the Cairo Agreement, the Palestinian Interim Self-Government Authority (PA) has begun autonomy in both the West Bank and Gaza Strip. In the above agreements, PA is defined as an organization that executes administrative, legislative and judicial authority.

A. Efforts of SWM for Ensuring Public Health and Sanitation

SWM is just one of the administrative services provided by this government. Previously no proper treatment or landfill procedure has been followed for the collected waste in most of these areas, and open burning of solid waste at open dumpsites has been observed [3]. Ministry of Local Government (MoLG) of PA has attempted to establish a

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sound solid waste management (SWM) system over Palestine with the support of various international donors since late 1990s, and has promoted waste collection services for securing public health, constructed transfer stations, closed random open dumpsites, and built sanitary landfills for environmental protection (Fig.1).

(1) West Bank

As of 2016, regional SWM implementing agency (Joint Service Council; JSC) has been established in all Governorates of West Bank, Palestine, which has significantly enhanced waste collection service. In the West Bank, municipal solid waste generation is estimated at 2,190 ton/day in average, and the per capita generation rate is averaged 0.73 kg/capita/day (= 266 kg/capita/year) in JSC service covered areas (Fig. 2) [2]. What can be said from this diagram is that the waste generation rate in the cities of West Bank, Palestine is much larger than the world average. This means that it is possible to control the generation of solid waste at sources, and it is a challenge to be tackled.

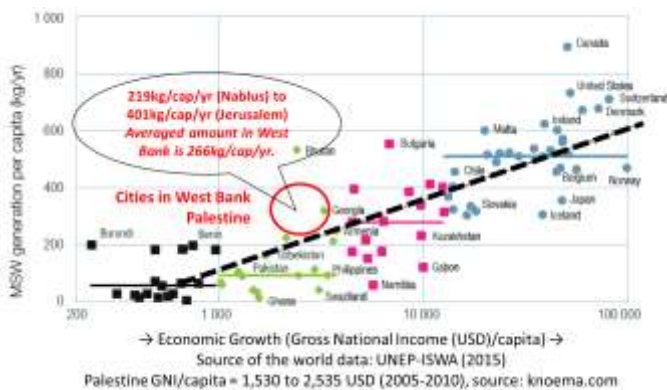


Figure 2. Comparison of waste generation with other countries. The vertical axis shows the waste generation amount (kg/capita/year) and the horizontal axis does the level of economic growth (GNI/capita). Plots indicate each country average and the dashed line indicate world averaged trend from 2005 to 2010. The large circle show the distribution area of data for cities in West Bank, Palestine. The base diagram is adopted from UNEP-ISWA [4].

Even though the waste generation rate is relatively large, the waste collection service coverage is relatively high in West Bank. Around 76% of the generated municipal waste is collected and transferred by the JSCs, and the collection of the remaining parts of waste is under the responsibility of Local Governmental Units (LGUs). Overall waste collection service coverage reaches 91.5% to total population and 92.2% to total generation [5], which is better service level in comparing with the international average at comparable economy [4].

Currently, 1,935 ton/day of waste is being collected, transferred, and disposed to three sanitary landfills, Zahrat Al Finjan, Al Menya, and Jericho (Table 1) [2], without any intermediate treatment, and more than 48 random open dumpsites in northern and southern parts of West Bank area have been closed since 2013 (Fig. 3) [6]. Due to inefficient collection of waste collection service fees from the residents, JSCs or municipalities were forced to sometimes cut the collection service and reduce its labor force, especially in remote areas.

TABLE 1. Sanitary Landfills and Controlled Dumpsites in West Bank and Gaza Strip [2]

Name	Location Governorate	Served Areas	Received waste (t/day)	Management
Zahrat Al Finjan Sanitary Landfill	Jenin	Jenin Tubas Tulkarem Qalqilia Nablus Ramallah- Albireh	1,200	Jenin JSC
Jericho Sanitary Landfill	Jericho	Jericho	55	Jericho JSC
Almenya Sanitary Landfill	Bethlehem	Bethlehem Hebron Jerusalem	1,000	Hebron- Bethlehem Higher JSC
Beit Anan Controlled Dumpsite	Jerusalem	Jerusalem Ramallah	90	NW+N Jerusalem JSC

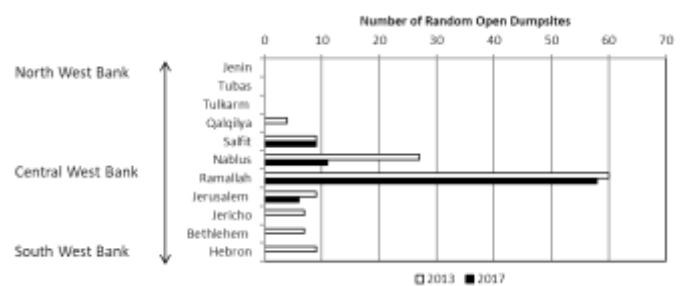


Figure 3. Decrease of the number of random open dumpsites in West Bank, Palestine [6]

Due to unachieved consensus building on siting in Area C with Israel and local communities, the construction plan of a sanitary landfill in central part of the West Bank has not yet realized which causes delays in the closure of remaining 84 open dumpsites (Jerusalem, Ramallah, Nablus, and Salfit Governorates).

The average operation cost of SWM in the 12 JSCs, West Bank is 144 NIS/ton (maximum 248 NIS/ton, minimum 60 NIS/ton; 1 NIS (New Israel Shekel) is about 0.3 USD at the rate in August 2020) [2]. The SWM service tariff has been adopted by most JSCs, and the operational-cost recovery in majority of the JSCs has been achieved.

(2) Gaza Strip

In the Gaza Strip, there are two JSCs for SWM; JSC-KRM (Khan Yunis, Rafah, and Middle) and JSC-GN (Gaza and North Gaza) (Fig.4 and Table 2).

The JSC-KRM is conducting waste collection, transportation, and disposal using two transfer stations and two landfills. The Deir Al Balah landfill has been almost closed, and only newly constructed Safah Sanitary Landfill is well functioned since 2019. However, current capacity of waste collection, transportation and sanitary landfilling are still insufficient for all solid wastes generated in the southern part of Gaza Strip. The service coverage is approximately 53% (population basis, as of 2019 [2]) in the area covered by JSC-KRM.

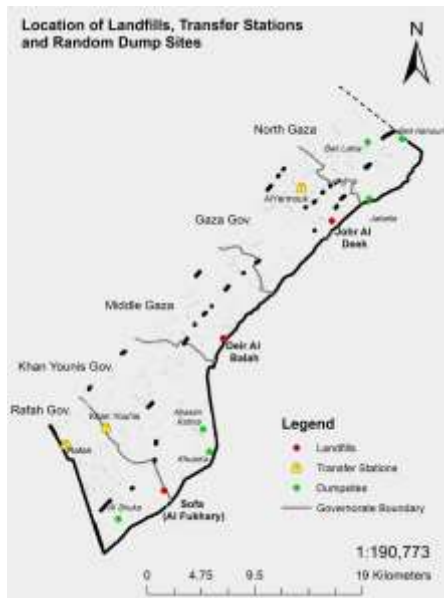


Figure 4: Map showing major infrastructure for solid waste management in Gaza Strip, Palestine [2].

In the northern part of Gaza Strip, the JSC-GN was administratively established but is not fully operational for providing a collection service to some LGUs while the other LGUs provide the service of collection, transportation and disposal. In the area, there are one transfer station and one landfill (Table 2), where the service coverage is about 10% (population basis).

TABLE 2. Sanitary Landfills and Controlled Dumpsites in Gaza Strip [2]

Name	Location	Served Areas	Received waste (t/day)	Management
Juhr Eldik Landfill	Gaza	Gaza and North Gaza	700	Gaza Municipality
Deir Al Balah Landfill	Al Wasta	Al Wasta Khan Yunis	430	JSC-KRM (South Gaza)
Safah Sanitary Landfill	Khan Yunis	Al Wasta Khan Yunis Rafah	500	JSC-KRM (South Gaza)

B. Waste Crisis

Even now, the municipal waste generation rate is obviously high in comparing with the international average at comparable economy, the amount of municipal waste generated will further increase due to population growth and urbanization. Existing sanitary landfills are overloaded, dumpsite collapse is eventually starting, but the remaining capacity of the sanitary landfills is very limited. Nevertheless, it is extremely difficult to construct a new sanitary landfill in the Area C occupied by Israel. Waste recycling practice is still in beginning stage in Palestine, where about 1.5% of generated waste is recycled.

Under these critical circumstances of “Waste Crisis”, the National SWM Strategy (2017-2022) was formulated by the National Team for SWM in Palestine, which was approved by the cabinet of PA.

III. National Solid Waste Management Strategy and Policy for Waste Minimization

The National Strategy for Solid Waste Management in Palestine (2017-2022) is the second national strategy at the national level SWM, which constitutes the framework for all decisions, policies, programs, activities, and medium-term investment plans aiming at developing the SWM sector in Palestine. The strategy was created through a full revision and update of the first edition of national strategy for the years 2010-2014 [8], and applying participatory approach including engagement of all relevant institutions and ministries working in SWM sector under the National Team of SWM.

A. National Strategy

The National SWM Strategy (2017-2022) is composed of 8 strategic objectives; organizational development, institutional development, effective SWM service, sustainable financing, proper treatment of hazardous wastes, public-private partnership, raising public awareness, and information sharing. Under the 8 strategic objectives, 19 policies, and 95 policy interventions were planned (Fig. 5). The details of the strategic goals and policies are summarized in Table 3. The detailed action plans have been developed for most interventions proposed. Currently, the National Team of SWM is monitoring the implementation status of these activities.



Figure 5. Structure of the National Strategy for Solid Waste Management in Palestine (2017-2022).

The main points of the National Strategy are: (i) improvement of public awareness concerning waste problem, (ii) strengthening JSCs for implementing environmentally sound sustainable SWM service over Palestine, (iii) improvement of legal and institutional system related to integrated solid waste management, (iv) promoting public-private partnership in SWM sector for the construction of infrastructure/facilities and the service operation, (v) construction of regional sanitary landfills and safety closure of remaining random open dump sites, and (vi) waste reduction. The National Strategy also set selected Targets to be achieved by 2022, as shown in Table 4.

TABLE 3. Summary of 8 strategic objectives and 19 policies determined defined by the National Strategy (2017-2022) [7]

Strategic Objectives	Policies
1. An effective legal and modern framework for SWM	1) Development and update of legislative framework for supporting integrated SWM
	2) Strengthening the organizational frame of national institutions and supporting their complementary roles in SWM
2. Strong institutions performing its duties and tasks	3) Enhancing institutional capacity building and expertise in SWM
3. Effective, sanitary and environmentally-safe management of SWM services	4) Enhancing and developing the current management systems of waste collection and transport to improve the quality and effectiveness of services
	5) Safe and efficient disposal of wastes to regional sanitary landfills or using proper advanced technological methods
	6) Encouraging the policies and methods of solid waste Reduce, Reuse, Recycle (3Rs) and recovery before final disposal at regional sanitary landfills
	7) Prohibit of random dumping and rehabilitation of random dumpsites
4. Sustainable and financial efficiency of SWM activities	8) Minimizing GHGs emissions from solid wastes and mitigate the climate impacts
	9) Reducing the costs for waste collection and transportation services
5. Principles and mechanisms suitable for safe management of medical, hazardous, and special wastes	10) Achieving cost recovery and self-financing for operation costs
	11) Creating appropriate and unified inventory and tracking system for hazardous waste management
	12) Healthy and sound management of medical wastes according to the polluter-pay principle
6. Increasing the participation of the private sector in SWM	13) Management of special (hazardous, toxic, and infectious) wastes to protect public health and the environment
	14) Raising awareness and setting the basis and necessary procedures to create an enabling investment environment to encourage the private sector participation and investment
7. A more participating and aware community	15) Deepening environmental awareness of community on SWM issue and its impact
	16) Raising student awareness on waste issue and 3Rs education in schools
	17) Providing students tools and equipment for waste recycling
8. Effective information and monitoring systems	18) Establishing a unified national database for solid waste
	19) Developing administrative, financial and environmental monitoring systems

Furthermore, the strategy came in align with the Sustainable Development Goals (SDGs) [9], in particular the Goal 3 (Good health and well-being), Goal 7 (Clean and affordable energy), Goal 11 (Sustainable cities and human settlements), Goal 12 (Responsible consumption and production patterns) and Goal 13 (Action to combat climate change).

TABLE 4. Targets given by the National Strategy (2017-2022) [7]

Description of the target	2017	2022
Percentage of recycled materials to the total waste generated	Less than 1%	30%
Percentage of transferring organic wastes into low quality compost for the purposes of covering soils	2.5%	15%
Waste collection service coverage of residential area	95%	100%
Service coverage by JSCs	76%	100%
Source separation of waste generated in households	0%	20%
Coverage of final disposal of waste at sanitary landfills	53%	100%

B. Waste Minimization Issue in the National Strategy

Among 19 policies in the National Strategy, 6 policies (Nos. 8, 9, 15, 16, and 17) are closely related to waste minimization issue. Palestinian Authority (MoLG) designated 2019 as a “waste minimization year” [10] and decided to work on the following three issues: (1) reducing waste amount at source such as source separation and/or home composting and/or material reusing/recycling, (2) diverting the waste stream such as waste sorting, material recycling, centralized composting, and/or waste-to-energy before landfilling, (3) mitigation of dumped waste and resource/energy recovery from dumpsites (landfill mining, landfill-gas recovery), and (4) Raising public awareness on solid waste problems.

In other word, the practice of waste minimization will be endeavored through introducing the 3Rs (Reduce, Reuse, Recycle) practice over Palestine based on strengthened public awareness on the environment and sustainable development. And it is possible. Because, according to the average composition of waste, more than 80% of it is potentially recyclable in Palestine (Fig. 6).

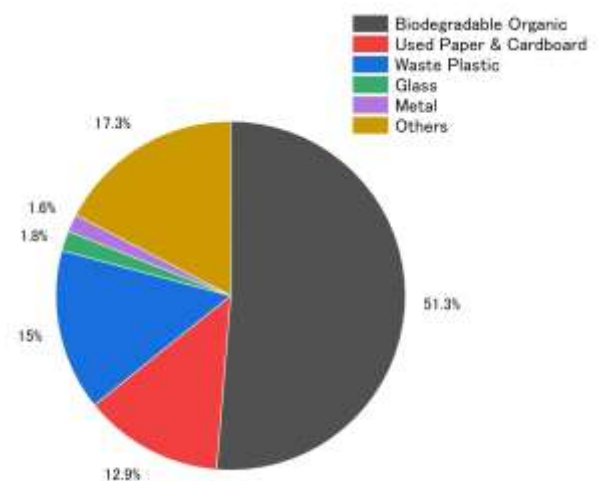


Figure 6. Averaged composition of municipal solid waste in West Bank, 2019 [2]

IV. Towards Waste Minimization in Palestine

Waste minimization is the top priority issue in solid waste management in Palestine.

There are only two ways for realizing waste minimization [11]; (1) Waste reduction at source (Resources saving behavior, Decrease of unit generation rate, Reusing, Source separation for material recycling, Home composting) and (2) Waste Diversion (Composting, Reusing, Material recycling, Waste-to-Energy by incineration or anaerobic digestion) as shown in Fig. 7. The eventual goal of waste minimization is focused on the reduction of final disposal amount of solid waste.

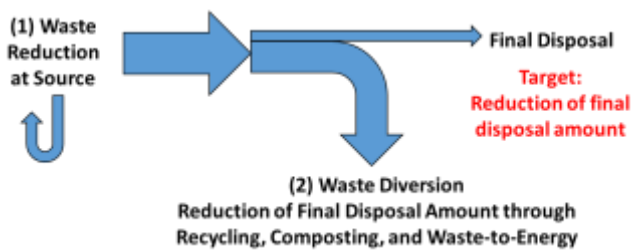


Figure 7. Generalized idea of waste minimization through introduction of 3Rs (Reduce, Reuse, Recycle) policy

A. Waste Reduction at Source

Waste generation rate in West Bank Palestine is high in comparing with the world average. One of the reasons is probably caused by weak public awareness about waste crisis. Raising public awareness on waste issue, more specifically, saving lifestyle to generate and discharge too much waste. Another reason may be the insufficient cooperation with the private recycling industries. Under such conditions, it is necessary to introduce waste source separation/collection while raising public awareness and promoting cooperation with the private recycling industries. Reusing of source-separated waste material within households and home-composting are also recommended.

Regarding home-composting, we have already conducted a pilot-scale research project, and according to the results, if we provide home composters and continuously provide appropriate guidance to households, it will be effective in suburb area, for garden or agricultural uses. According to the results of pilot project in Bethlehem, Hebron, and Jericho, approximately 10% of generated waste (biodegradable organic waste) is expected to be reduced at generation points.

Regarding material recycling at source, in Hebron, Ramallah, and other cities in the West Bank, residents and shops voluntarily cooperate to separate cardboard and waste paper and discharge it into dedicated containers along roadside, in which NGOs and private companies collect and recycle. However the activities are still limited scale and the capacity of paper recycling factories in West Bank is insufficient.

B. Waste Diversion

We have only two options for waste diversion; (1) Material Recycling and/or Centralized Composting and (2) Waste-to-Energy (energy recoveries from solid waste). We have to consider financial issue. Because if we introduce waste diversion, cost inevitably increase.

(1) Material Recycling and/or Centralized Composting

The first step to promote material recycling is to accurately understand the composition of recyclables and amount of each recyclable that actually generates and is landfilled, then to estimate the possibility of recycling in Palestine. At the same time, we must understand the trends of the private recycling industry and market in Palestine and understand available technologies of material recycling. A comprehensive survey on recycling is necessary to be conducted over Palestine.

When introducing material recycling and/or composting, it is essential to separate the relevant recyclable material at the source (= source separation) or to sort the collected mixed waste (= sorting process). In Palestine, several small scale sorting facilities have been installed in Hebron, Nablus, Jenin, and Gaza, by public or private firms. However, due to limitation of recycling market in Palestine and resulting financial problems, a sustainable operation of these sorting facilities has little been achieved so far. Sorting and recycling processes need infrastructures, technologies for operation & maintenance, and investment, so that involvement of private sector is indispensable [12].

Centralized composting is another important option for Palestine. Sorting is also essential for effective and efficient composting, but in addition to this, it is necessary to stimulate demand for compost products. There are several centralized composting in Hebron, Jericho, Nablus, Tulkarem, and Gaza, however all are still in pilot scale, and most project are facing financial problem. Source-specific composting projects, such as livestock waste (Jericho) and vegetable market waste (Tulkarem), enable the production of relatively high quality compost and are considered to be financially sustainable [13].

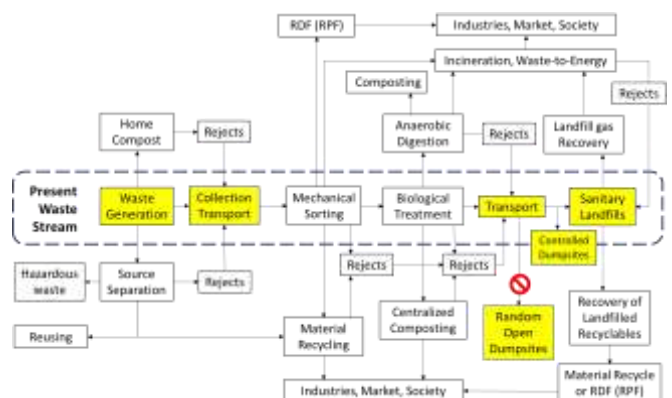


Figure 7. Present waste stream (shown by yellow-colored boxes) and possible technical components for waste minimization (shown by open boxes) in Palestine. These possible technical components cover all that will be considered for introduction in the future, but not all will be actually introduced. Effectiveness and efficiency of each technical component under given conditions will be examined by study and pilot projects. The closure of random open dumpsites is prioritized policy showing the “Stop symbol”.

For relative low quality compost products prepared by mixed municipal solid waste, for which market demand cannot be expected, it is also necessary to consider using them as soil cover materials for landfills rather than using them as soil conditioners. In that case, composting can significantly reduce the greenhouse gas emission potential, and is an effective measure against climate change. Biodegradable organic waste causes gas, foul odors, and leachate, and reduction by composting is also significant as an environmental and sanitary measure. Therefore, centralized composting of collected municipal waste is very important issue that we should tackle in near future (Fig. 7).

(2) Waste-to-Energy

Various methods are known as Waste-to-Energy, such as incineration, gasification, anaerobic digestion, and fuel produced from various types of waste. Except small-scale incineration of infectious waste in medical institutions, no waste incineration project has been carried out, and the other technologies of waste-to-energy has been attempted in Palestine.

The initial cost (investment) for Waste-to-Energy facility construction is extremely high compared to other facilities in SWM, and the operation and maintenance (O/M) costs are also high. Although it is possible to expect an increase in revenues from the sale of generated electricity or thermal energy, it is not always guaranteed because it depends on the market conditions and system performance/efficiency. In addition, active participation and investment of private companies are indispensable in conducting such big business.

Waste-to-Energy is a very attractive option in SWM for countries with a small land and limited energy resources, such as Palestine, but it also has various risks and uncertainties, which requires a thorough assessment from a technical, economic, social, and environmental perspective. For this reason, although some project proposals for the construction of waste-to-energy (waste incineration and power generation) facilities have been proposed by the private sector or local governments, they have not been realized yet.

Currently, the Palestinian Authority has set up a national-level study committee on the strategy to introduce a waste-to-energy facility in SWM system and is proceeding with the study led by MoLG.

C. Institutional Development and Awareness Raising

In order to reduce the amount of waste, it is very important to establish the necessary system to give incentives to waste reduction and waste-diversion, and to make it functional. Waste reduction cannot be achieved only by raising awareness and introducing technologies, but it is necessary to make an institutional development. At the same time, it is necessary to raise awareness of waste management by the residents and the government for ensuring sustainability of SWM systems: attitudes toward separation at the source, behavior regarding 3Rs, and willingness to pay for SWM service, which was verified by social survey in Jericho area [14]. The SWM system is sustainable if three main elements of awareness are recognized by the community: readiness to separate waste at the source,

recognition of waste reuse/recycling and willingness to pay for the SWM service [15].

Institutions required are closely related to the technology to be introduced for promoting (1) waste reduction at source and (2) waste diversion, and the conditions of political economy [16]. The following institutional development measures are being considered under the National Strategy (2017-2022). These components of institutional development can be classified into five category of measures; namely, regulatory, economic, behavioral, awareness raising, and legislation measures (Table 5).

TABLE 5. Proposed components of institutional development for waste minimization in Palestine

Categories	Measures for institutional development & awareness raising
Regulatory measures	<ul style="list-style-type: none"> - Source separation rule and separated waste collection - Licensing to recycling industries - Patrol of illegal dumping
Economic measures	<ul style="list-style-type: none"> - Subsidy or tax exemption to establish recycling business - Monitoring and penalty to illegal dumping - Pay-as-you-throw (PAYT) system - Container-deposit legislation (deposit-refund system) - Application of extended producer responsibility (EPR) - Promotion of public-private partnership (PPP) in SWM businesses including informal sector
Behavioral measures	<ul style="list-style-type: none"> - Awarding for good practice on waste minimization - Certificate for the products using recycled materials
Awareness raising measures	<ul style="list-style-type: none"> - National campaign such as National Waste Day - Waste prevention and reduction campaign in each JSC - Environmental education in schools - Awareness raising of business sector
Legislation measures	<ul style="list-style-type: none"> - Law/Bylaw(s) for the promotion of 3Rs - Bylaws for individual recycling and composting - Guideline/standard for individual recycling and composting - National Waste Minimization Program

V. Conclusions and Recommendations

In Palestine, JSC has almost been established as a system for conducting waste collection and transportation business except for some parts of Gaza Strip, and the collection service coverage rate reaches more than 90% in West Bank. However, the sanitary landfill sites are insufficient in central West Bank and Gaza Strip and the remaining capacity of present landfills is limited. If it is left as it is, the collected waste may be dumped without being properly treated and serious public health and/or environmental problems will occur. Therefore, it is an urgent task to improve the sanitary landfill sites and, more essentially, reduce the amount of waste generated.

Under current situation there are only two ways for achieving the waste minimization in Palestine; (1) prevention of waste generation at source, and (2) waste diversion before landfilling. The key challenge is prompt actions of 3Rs (Reduce, Reuse, Recycle) by all stakeholders.

It is necessary to examine the effectiveness and efficiency of the technical options for realizing the 3Rs described in this paper under Palestinian conditions, and to verify their feasibility. Some previous experience with recycling and composting must be critically reviewed for its successes and failures. In addition, investment in viable technical options should be planned with the cooperation of the private sector.

In order to promote 3Rs practices, it is necessary to continue the institutional building for sustainable SWM, to improve understanding of crucial role of SWM among local decision makers, to enhance the public awareness, to promote private investments for equipment and construction of infrastructure/facilities, and to build a well-organized partnership among government, public agencies, communities, local people, academic, and private sector.

Under the national strategy of Palestinian Authority, future supports from international donors will also play an important role to enhance the solid waste management in Palestine.

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