

# Sustainable Solid Waste Management and Recycling in Palestine

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## Abstract

*The increasing population and economic activities in Palestine, coupled with a reliance on imports and limited local manufacturing, have led to substantial challenges in solid waste management. Despite a high waste collection rate (over 98%), the solid waste management service is of poor quality and unreliable, and the system is inefficient. Primary and secondary collection is often unsanitary and suffers from poor planning, high operation and maintenance costs, and inadequate equipment. For disposal, currently 65% of solid waste is disposed in six landfills operating in West Bank and Gaza Strip, while 32% are illegally dumped and two landfills in Gaza Strips are not properly functioning under present war. Only an estimated 3% of the total amount of municipal waste produced annually is recovered and/or recycled. Under these circumstances, the waste reduction and minimization are of utmost importance in every sense. This study evaluates the current state of waste management in Palestine and outlines strategies for waste reduction and recycling, emphasizing the importance of minimizing waste at the source and improving resource recovery. In conclusions, the generalized waste management flow is presented according to the proposed waste reduction and minimization plan. The findings underscore the necessity for robust policy interventions, formulation of a waste reduction and minimization plan, enhanced infrastructure, and stakeholder engagement for sustainable waste management.*

## Keywords

3Rs (Reduce, Reuse, Recycle), Controlled dumping sites (CDSs), Random dumping sites (RDSs), Sanitary landfills (SLFs); Sustainable solid waste management, Waste reduction and minimization.

## INTRODUCTION

Palestine faces significant challenges in managing solid waste due to its small land area, occupation, limited industrial base, and dependency on imports (Figure 1). Solid waste management (SWM) has historically relied on a "collect, transport, and landfill" linear approach, which is unsustainable given land constraints and increasing waste generation due to population growth, urbanization, and economic development [1] [2] [3] [4] [5] [6]. The National Solid Waste Management Strategy (2017–2023), which was originally planned for 2017 to 2022 but lately extended the period one year (2017-2023) due to the COVID-19 pandemic, outlines a plan to minimize waste and promote recycling. This paper examines the current SWM system in Palestine, identifies challenges, and proposes future strategies, focusing on the 3Rs principle and sustainable practices.

Palestine has a small land area of a population more than 5.3 million living and carry out economic activities, where waste generation is inevitable (Figure 1). On the other hand, Palestine has a small manufacturing industry and imports many daily necessities and foods from foreign countries, and as a result, solid waste after the consumption tends to accumulate. So far, the solid waste management in Palestine has focused on conventional approach; collect, transport, and landfill to ensure public health [1] [2] [3] [4] [5] [6]. However, landfill sites are limited, and it is not possible to continue this approach forever [7] [8] [9]. Under the strategic direction given by the National Solid Waste Management

Strategy (2017-2023) [10], a waste reduction and minimization plan has been issued aiming to reduce the amount of waste and to reuse and recycle as much as possible within the given Palestinian context [11].

Currently, large-scale infrastructure destruction has occurred in the Gaza Strip due to war, and the rapid increase in conflicts in the West Bank has made it difficult to carry out normal waste management operations. Under these circumstances, the waste reduction and minimization are of utmost importance in every sense.

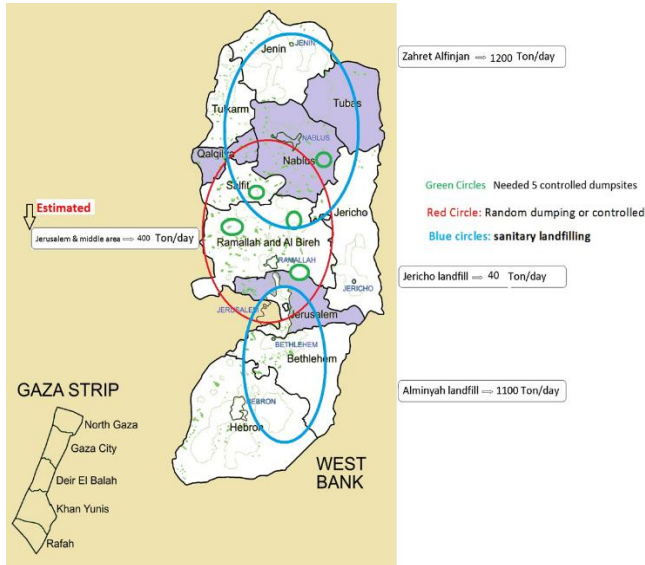
This paper explores the current state of solid waste management in Palestine, outlines strategies for sustainable waste management including waste reduction and recycling measures, and presents future issues for its improvement, and also introduces the waste reduction and minimization plan [11] in Palestine, which was drafted under the Technical Cooperation Project for Capacity Development in Solid Waste Management in Palestine, Phase-III (2020-2024) jointly conducted by the Ministry of Local Government (MoLG), Palestine and Japan International Cooperation Agency (JICA) [12].

## CURRENT STATE OF SOLID WASTE MANAGEMENT IN PALESTINE

Solid waste management (SWM) system in Palestine, consisting of West Bank and Gaza Strip, remains fragmented and weak, with major gaps in collection, transfer, intermediate treatment, recycling, and final disposal. In particular, in the West Bank, there is a lack of land for final disposal sites, and in the middle area, much of the solid waste

generated is dumped randomly at open dumpsites, causing public health problems and environmental destruction (Figure 1). In the Gaza Strip, much of the infrastructure has been destroyed by the war, and the solid waste management system that had been established up until 2023 has ceased to function.

Below, the current state of solid waste management in Palestine, mostly in West Bank area, is briefly described in four technical viewpoints in SWM: (i) waste generation, (ii) collection and transportation, (iii) waste transfer & intermediate treatment, and (iv) final disposal:



**Figure 1.** Situation of the final disposal of solid waste generated in West Bank, Palestine. The blue circle indicates the areas served by sanitary landfills, but the red circle indicates random open dumping or controlled dumping area. To reduce open dumping, five controlled dumpsites (green circles) are required as emergency measures.

**Waste Generation**

Palestine generates approximately 1.78 million tons of municipal waste annually, with 3,289 tons/day in the West Bank and 1,595 tons/day in Gaza [9]. The current situation in the Gaza Strip is unclear, but in the West Bank, the solid waste is generated by 3.3 million people in 417 LGUs (local government units; municipalities and village councils) in 11 governorates, and the average amount generated per resident is estimated to be 2.78-0.93 kg/day in urban/commercial/industrial/tourism areas and 1.14-0.73 kg/day in rural areas [9]. These unit generation rates are relatively large compared to other cities/countries with similar economic conditions [13].

**Collection and Transportation**

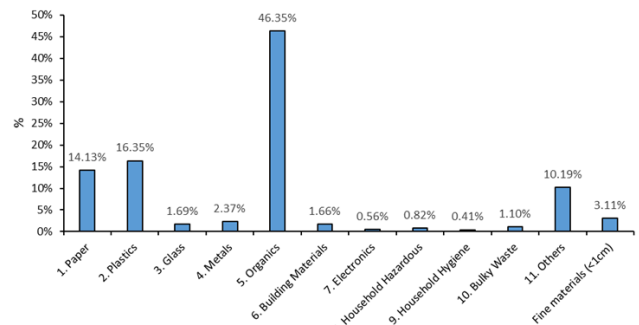
Waste collection and transportation service are provided by JSCs (joint service councils for solid waste management) of which role is providing waste management service for a large number of the LGUs, or it is partially to independently provided by LGUs themselves. In West Bank area consisting of 417 LGUs, 306 LGUs are fully served by JSCs, 51 LGUs

are partially served, while the remaining 60 LGUs independently served by themselves. Waste collection service coverage of residential areas is approx.98% in population basis [9]. Despite high collection rates, services remain inefficient, unsanitary, and costly. Equipment shortages and poor planning exacerbate these challenges, while recycling is limited to small-scale initiatives for plastics, metals, and organics.

**Waste Transfer and Intermediate Treatment**

Collected solid waste are transferred through 13 transfer stations (TSs) managed by JSCs and one TS (Al Abdali) in the East Jerusalem area managed by Israeli side to sanitary landfills.

Intermediate treatment of collected waste currently implemented in West Bank area is sorting (manual and mechanical), bailing of cardboard, grinding plastics, and some pretreatment before selling to private recyclers. However, the percentage of waste diversion (recycling) does not exceed 3% of total waste generated. However, biodegradables (46.35%) and recyclables (paper 14.13%, plastics 16.35%, glass 1.69%, metals 2.37%, building materials 1.66%, and electronic waste 0.56%; total recyclables 36.76%) constitute the majority of solid waste generated (Figure 2), which presents big opportunities for composting or biogas production and material recycling.



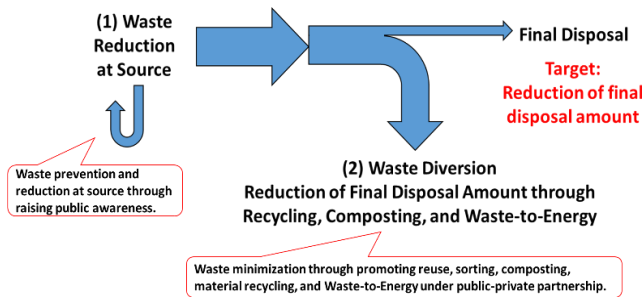
**Figure 2.** Waste composition in West Bank Palestine (Source: Report on waste composition survey [14])

**Final Disposal**

There are three operating SLFs (sanitary landfills) and one operating CDS (controlled dumpsite) in West Bank area, namely Zahret Al Finjan SLF serving the northern area, Al Menya SLF serving southern area, Jericho SLF serving the Jericho Jordan Rift valley area, and Beit Anan CDS serving northwest and north. While 65% of waste is disposed of in sanitary or controlled landfills, 32% is illegally dumped, and only 3% is recycled. There is another proposed SLF named Ramoun SLF, which will be constructed to serve the middle area of West Bank. The Ramoun SLF was expected to receive solid waste that has been illegally dumped at open dump sites in the middle area. However, this SLF has not started the construction due to many political obstacles.

Under the circumstances described above, the only way to eliminate illegal dumping and ensure public health and environmental conservation is to reduce the amount of waste

generated and to minimize the amount of waste to be disposed by the waste diversion (recycling) described in *Intermediate Treatment*, which can reduce landfill dependency and promote resource recovery. In other words, biodegradable organic waste and material recyclable waste can be reduced and reused at the source of waste generation (called “waste prevention” or “waste reduction”) and reduced in volume through recycling and energy recovery after generation (called “waste diversion” or “waste minimization”). (Figure 3).



**Figure 3.** General idea on waste generation, waste reduction at source, waste diversion, waste minimization, and final disposal.

### PROBLEMS AND CHALLENGES

The issues described below are problems on implementing SWM identified in the West Bank, Palestine:

#### Political Problems

- The main problem is resulting from the restrictions on land use by the Israeli occupation especially in what is categorized area “C” where we cannot establish sanitary landfills and other SWM infrastructure. Although Area C is within the territory of the Palestinian Authority, all development projects and construction of facilities and infrastructure by the Palestinian side are restricted, and the area is in a state of occupation, and permission must be obtained from Israeli occupation authorities in order to carry out any project. However, obtaining permission is extremely difficult and requires lengthy negotiations in general.
- The illegal dumping of solid waste generated from the Israeli settlements, those are occupied settlements built in violation of UN resolutions, into the Palestinian areas with no control from our side (including hazardous electronic and hazardous waste).
- Confiscation of vehicles by the Israeli military forces because of the use of random dumping sites at the middle part of West Bank (where the construction of new sanitary landfill is delayed by the Israeli occupation since 2007).
- Restriction of movement between governorates due to either permanent or temporary checkpoints (parries) by Israeli side, which hinders proper collection, transportation, and transfer of solid waste, resulting in an increase in random open dumping.

#### Legal Obstacles

The current legal framework is still not mature, and the institutional development in past decade solved a part of this problem by developing some legal documents to be endorsed by the Palestinian Authority (law, bylaws, and guidelines).

#### Social problems:

- Social problems mainly relate to the practices and behaviors of waste generators, these include consumer behavior, reducing waste generation, and source separation, and waste discharging based on rules.
- Partially, the inability and/or unwillingness to pay for municipal waste fees.
- Low level of awareness about SWM in general.
- Legal update is a major key of success to implement 3Rs (Reduce, Reuse, Recycle), which relates to the Legal Obstacle as mentioned above.

#### Economic Problems

The Palestinian general economic situation is deteriorating most of the times, i.e.,

- The delivery of the Palestinian tax money collected by the Israeli side is suspended sometimes, and this directly affect the economic situation (related to political arrangements).
- The indirect international trade fragments which affect all life aspects including the solid waste management sector.
- The unstable financial capability of the LGUs and the JSCs resulting from the irregular fees collection especially at the pandemic and war periods.
- The shortage in funds for renewing and supply of modern vehicles and SWM equipment- resulting in high maintenance expenses.
- Due to the underdevelopment of the recycling industry in Palestine, recyclable materials are sold cheaply to private companies abroad, resulting in economic losses.

#### Financial Problems

The SWM still do not fully recover the cost of the service, aggregate import of raw materials and goods, aggregate consumption, resulted in aggregate waste generation, very limited local industries. It’s like being a dumpsite for foreign residuals of externally produced goods. The economic deteriorated situation is resulting on the willingness and ability to accurately price the service, therefor cutting down the cost as alternative for increasing the service price could work, where cutting the cost can be achieved through,

- Efficient use of resources
- Utilization of the wasted substances from the waste
- Incentive for the prevention, implementing different tools i.e. Deposit Refunding System

### POLICY INTERVENTIONS

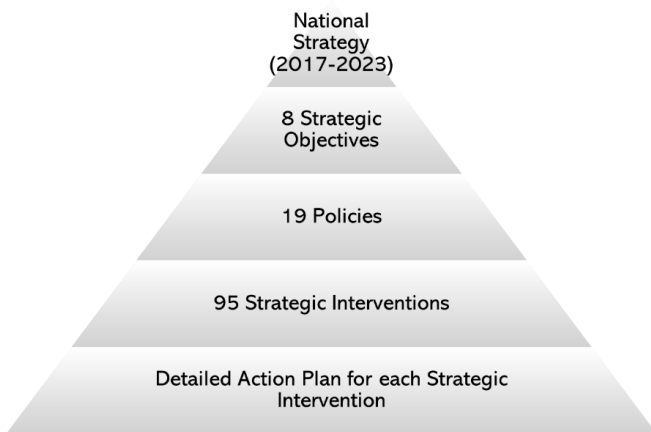
Palestine sets a national strategy for waste management approximately every five years and focuses on priority issues. The first National SWM Strategy (2010-2014) was published in 2010, the second National SWM Strategy (2017-2022) was

issued in 2017 and extended one year (2017-2023) [10], and currently, the third national strategy is in process of drafting.

The National SWM Strategy (2017–2023) is composed of eight strategic objectives, 19 policies, and 95 strategic interventions as show in the Figure 4 [15]. These outlines including institutional development, sustainable financing, and public-private partnerships. Key policies include:

- Promoting waste reduction at the source through the 3Rs
- Promoting waste minimization through the waste diversion by material recycling and energy recovery
- Enhancing recycling industries via incentives and private sector involvement
- Establishing legal frameworks and public awareness campaigns to support sustainable practices
- Promoting environmental education for raising public awareness
- Strengthening public authorities for SWM via institutional and organizational development

The detailed action plans have been developed for most policy interventions proposed by Ministry of Local Government (MoLG) and the National Committee of Solid Waste Management, Palestine [15].

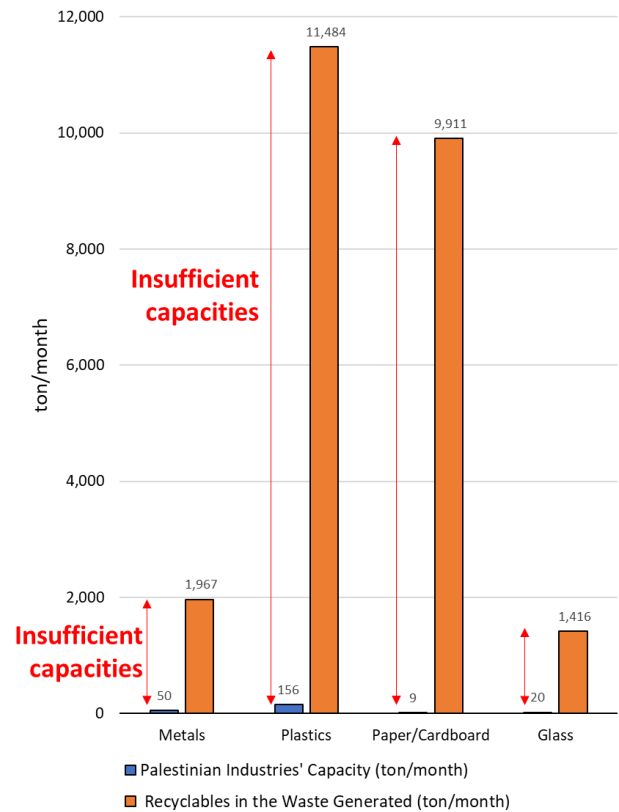


**Figure 4.** Framework of the structure of National Strategy for Solid Waste Management in Palestine (2017-2023) [10].

Based on the policies above, MoLG highlighted the year of 2019 as a “waste minimization year” and decided to work intensively on the following three issues: (i) waste reduction and minimization applying 3Rs (Reduce, Reuse, Recycle) concept, (ii) reduction of the amount of waste flowing into landfills and dumpsites, and (iii) raising public awareness on SWM issue.

In parallel with the above policy implementation by MoLG and the other public authorities, it is extremely important to promote the development of recycling industries in the private sector. This is because the private sector is the driver/investor of the recycling industry and the actor that

promotes the distribution and use of recycled goods in the market [16]. In Palestine, there are not many private industries for material recycling, and their scale/capacity is very limited. In West Bank, there are 63 small recycling industries registered that operate sorting, crushing, washing, and recycling businesses, as of 2019. They are conducting metals (such as steel, aluminum, and copper) recycling, plastics recycling, biodegradable organic waste composting, and paper/cardboard recycling. At present, the overall recycling capacity by the industries is only a few percent of the total amount of recyclable waste actually generated (Figure 5, Table 1). This shows that the actual capacity of the Palestinian recycling industry is grossly insufficient to fully develop recycling. Therefore, it is necessary to introduce 3Rs (Reduce, Reuse, Recycle) policy including public awareness raising, to make institutional reform, to promote investments to the recycling industry by the private sector, and to establish systems and policies to support the private initiative (Figure 6) [16].

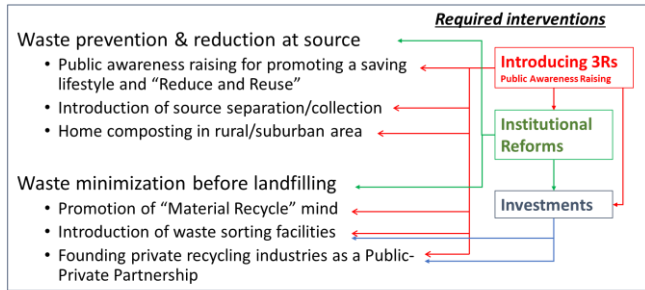


**Figure 5.** Insufficient capacity of private recycling industries in Palestine. (Data Source: MoLG-JICA Project [17])

**Table 1.** Situation of recycling in the waste management in Palestine

Type of waste	Experience	Present situation
Paper, Cardboard	Small businesses	Have little effect on total quantities of waste generated
Organic	Individuals, JSCs initiatives and NGOs activities	Some pilot projects are implementing, but not on business scale

Type of waste	Experience	Present situation
Plastic	Small business	Very small quantities only 2 successful cases in West Bank
Others (Metals)	Individuals	Recovery by informal waste pickers or unregistered small businesses



**Figure 6.** Required interventions, Introducing 3Rs, Institutional reforms, and investments, for realistic promotion of waste reduction and minimization in Palestine (Data Source MoLG-JICA Project Phase-II [7]).

### WASTE REDUCTION AND MINIMIZATION PLAN

As mentioned above, waste management and waste reduction policies have been basically established in

Palestine in its National Solid Waste Management Strategy, so it is necessary to reform the institutional system and execute policies based on the strategy. The MoLG-JICA Project conducted a multi-faceted study of basic information on waste reduction and minimization in Palestine and implemented pilot projects on individual issues [18] [19] [20] [21] [22] [23] [24] [25]. Based on the results, a plan for waste reduction and minimization under the given conditions of Palestine was developed.

The following activities in six categories (Awareness Raising, Waste Reduction at Source, Reuse and Recycle, Intermediate Treatment, Final Disposal, and Institutional Reform) are currently under planning and partly executing (see Table 2), which have been summarized in the draft National Waste Reduction Plan, Palestine [11].

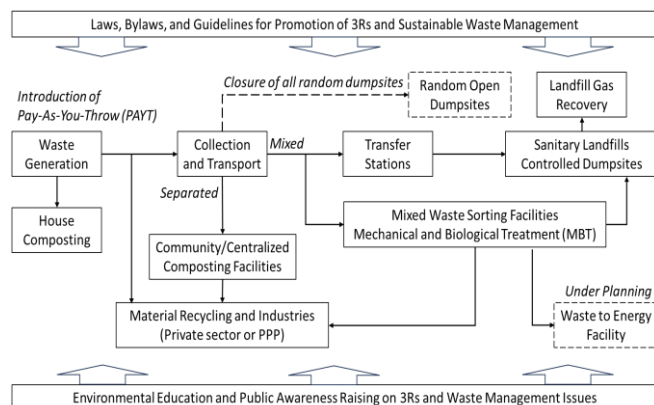
**Table 2.** Summary of proposed activities on waste reduction and minimization in Palestine.

1. Awareness Raising	2. Institutional Reform
1-1. Community level campaign 1-2. JSC/LGU level campaign 1-3. School projects 1-4. National level campaign 1-5. Media and SNS 1-6. Cooperation with NGOs/ volunteers' group 1-7. Cooperation with private sector 1-8. Commercial sector and consumers' level campaign	2-1. Law on 3Rs 2-2. 3Rs Guideline 2-3. Bylaw on Single-use Plastic Ban 2-4. Bylaw on Public-Private Partnership 2-5. By law on Construction and Demolition Waste 2-6. Guideline on Public Awareness Raising 2-7. Bylaw on Solid Waste Management
3. Waste Reduction at Source	4. Reuse and Recycle
3-1. Source separation & Home-composting with barrel/box 3-2. Source separation & House composting with rotary composters 3-3. Source separation of recyclables for centralized composting 3-4. Pay-as-you-throw (PAYT) system 3-5. Repairing and reuse	4-1. Reuse and Repair by Junkshop/mobile buyers (including web-based market) 4-2. Reuse (flea) market 4-3. Container Pay Back system. 4-4. Returnable bottles 4-5. Sorting and crushing for construction materials 4-6. Manual sorting of mixed waste & composting and recovery of recyclables
5. Intermediate Treatment	6. Final Disposal
5-1. Mechanical sorting of mixed waste and recovery of recyclables and composting (MBT) 5-2. Material recycling 5-3. Centralized composting 5-4. Waste-to-Energy (Incineration) 5-5. Waste-to-Energy (Anaerobic digestion) 5-6. Solid fuels (RDF, RPF, etc.) 5-7. Gasification	6-1. Landfill mining (excavation) 6-2. Landfill gas collection for energy recovery and mitigation of GHGs emissions

Figure 7 shows the framework of the solid waste management system proposed by the Waste Reduction/Minimization Plan described above. From the left side of the figure, at the waste generation stage, house

composting, provision of economic incentives for reducing waste generation through PAYT, and promotion of reuse and recycling are carried out. Next, at the collection and transportation stage of the solid waste generated, it is divided

into the flow of source-separated waste and the flow of mixed waste according to the local conditions, and the former is for community composting and material recycling, and the latter is aerobic decomposition for producing compost-like outputs (CLO) and material recycling after sorting by MBT (Mechanical and Biological Treatment) [26]. In addition, although it is currently in the planning stage, construction of a waste-to-energy (WtE) incineration facility is also considered by the Palestinian Authority and private sector. Eventually, at the final disposal stage, all random open dumps will be completely closed after the establishment of the SWM system, and only final rejected solid waste will flow into sanitary landfill sites. From the landfill sites, landfill gas will be collected and used for energy recovery. In order to establish and operate such a system, the legal system (Laws, Bylaws, Regulations, Standards, and Guidelines) shown at the top of the figure will be applied, and public awareness raising activities and environmental education will be implemented as shown at the bottom of the figure. These operations are basically carried out by individual JSCs or partly LGUs, but large-scale infrastructure, facilities, and equipment are provided through government funding, international development assistance funds, the Public-Private Partnership Fund for local economic development (LED), and direct investment from the private sector. It is necessary to create an institutional and social environment in which private sector investment is easy to make in order to promote the recycling industries, and the formation of public-private partnership (PPP) projects, which were implemented by two JSCs in 2019 [27], is also considered.



**Figure 7.** Outline of the waste management flow according to the proposed waste reduction and minimization plan

### Way Forward

There are still many issues to be resolved in order to make waste management sustainable in Palestine. This does not simply mean introducing new technologies and equipment, but also developing systems, institutions, public private partnership, and promoting a sound material cycle and a circular economy throughout society. The success of sustainable SWM depends mostly on the active and sustained participation of citizens [28]. It is also necessary to develop

human resources involved in waste management activities. Mentality (way of thinking) and behaviors, considering Circular Economy instead of conventional linear waste management approach is the solution. Policy makers and service providers of municipal waste management recently started thinking circularly, as most of the nations the system was developed gradually, and priorities are evolving considerably. Around 20 years ago, the priority was the public health and hygienic problem combating, by removing the solid waste from streets and residential areas, then the challenge was how to safely disposed the collected waste. Even the safe disposal was not fully achieved. still continue disposing 97% -100% of collected waste was a serious challenge, due to scarcity of lands for landfills and limited capacity of operating landfills. There is a potential of recycling and recovery to avoid contribution of natural resources depletion by continuing using virgin materials.

Waste minimization and reduction is highly recommended in Palestine, and since the system need to be treated as a circle, prevention, activating 3Rs (Reduce, Reuse, Recycle) policies and resource recovery are a crucial methodology for new thinking. Individuals as major waste generators need to be intensively targeted and to be educated, about their important role in prevention, and waste low generation ratio as a goal, while this education and awareness raising process need to be a combined with major economic and legal tools, this where the government and service providers role comes. Setting and enforcement of regulations that incentivize private sector involvement will increase the opportunity for businesses attraction to invest in recycling industries, in Palestine it is still not seen on the business scale, while on the pilot level its already started,

### ACKNOWLEDGEMENTS

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