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Waste-derived Products and Secondary Raw Materials as a Chance to Reduce MSW Management Costs in Developing Countries – Case Study for Jordan

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Abstract

The sustainable management of municipal solid waste (MSW) remains limited in developing countries due to financial constraints, precisely the high investment and operation costs, leaving significant negative impacts on the environment, the water resources, and the climate. Sustainable waste management strategies that include material recycling and energy recovery from waste can produce revenues and reduce the costs. However, a market for secondary raw materials and waste-derived products is a prerequisite for the success and permanence of these sustainable waste management strategies.

This study investigates the potential of secondary raw materials and waste-derived products to reduce MSW management costs in Jordan particularly in Greater Amman Municipality (GAM). Supported by DAAD Exceed-Swindon Program, a field study was conducted on site. During the field study, data was collected through reports, data acquisition, interviews, and field visits. A detailed review on the current waste management practice, economic activity, resources availability, and recycling sector was conducted. Accordingly, different MSW management scenarios were proposed and evaluated based on their revenue generation potential. It was found that the existing market of secondary raw materials and waste-derived products in Jordan is underdeveloped and requires further improvement. By applying certain measures, the market prospects are promising, and the expected revenues are significant. A sustainable MSW strategy has a high revenue generation potential and therefore has the potential to reduce the costs of MSW management in Jordan. In this paper, background conditions, the applied materials and methods, and obtained results are presented.

Keywords: developing countries, market research, secondary raw materials, sustainable waste management, waste-derived products, waste management costs

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1. INTRODUCTION

The sustainable management of municipal solid waste (MSW) remains limited in developing countries due to financial constraints, precisely the high investment and operation costs, leaving significant negative impacts on the environment, the water resources, and the climate. Sustainable waste management strategies that include material recycling and energy recovery from waste can produce revenues and reduce the cost. However, a market for secondary raw materials and waste-derived products is a prerequisite for the success and permanence of these sustainable waste management strategies.

Jordan is a developing country and emerging market in the Middle East with an area of about 89,000 km² and a population of about 10 million inhabitants [1], [2]. The country comprises of 12 governorates and around 100 local municipalities [1], [3], [4]. The operation of MSW management lies mainly in the responsibility of the local municipalities [5]. The current MSW management involves collection and subsequent disposal of mixed MSW at landfills. The collection rate ranges between 70% in rural and 90% in urban areas. From the existing 18 landfills, only one (Al Ghabawi) is a sanitary landfill [6]. The current practice lacks efficiency and is a subject of improvement in terms of environmental impacts and sustainability. Collected fees currently cover only 30-75% of the MSW management costs resulting in difficulties in providing proper MSW management services [6], [7].

Ideas have been discussed to improve waste management in Jordan, addressing material recycling and energy recovery from waste, e.g. in [8], [9], [10]. The Jordanian Government declared its willingness to shift to integrated MSW management and to set necessary measures to achieve it in the National MSW Strategy [11]. These measures include the set-up of separate collection systems for recyclables, preparation for reuse and recycling of MSW materials, cease of operation of uncontrolled and unlicensed disposal sites, and reduction of bio-waste ending up on landfill sites [11].

For Jordan, only a few studies provide valuable information on the markets for secondary raw materials and waste-derived products. The recycling sector is described in [12] and [13] and the compost market in [14]. Revenues from secondary raw materials from waste were calculated in [11] and [15]. Energy generation potential from waste was estimated in [16], [17], [18], [19], and [20].

On this basis, the aim of this study is to identify and analyze the market potential for secondary raw materials, waste-derived products and the energy recovery rom MSW in Jordan and to estimate the revenue generation and cost reduction potential of different MSW management strategies. Different waste management scenarios were developed based on the current collection system and a possible shift into a separate collection system in the future and then compared regarding their revenue generation potential. All calculations of possible revenues are based on the MSW generated in Greater Amman Municipality (GAM) area in terms of amount and composition. In GAM (see Figure 1), around 1.3 million tons of MSW are generated per year. The population of GAM amounts to around 3.9 million [1], [21].

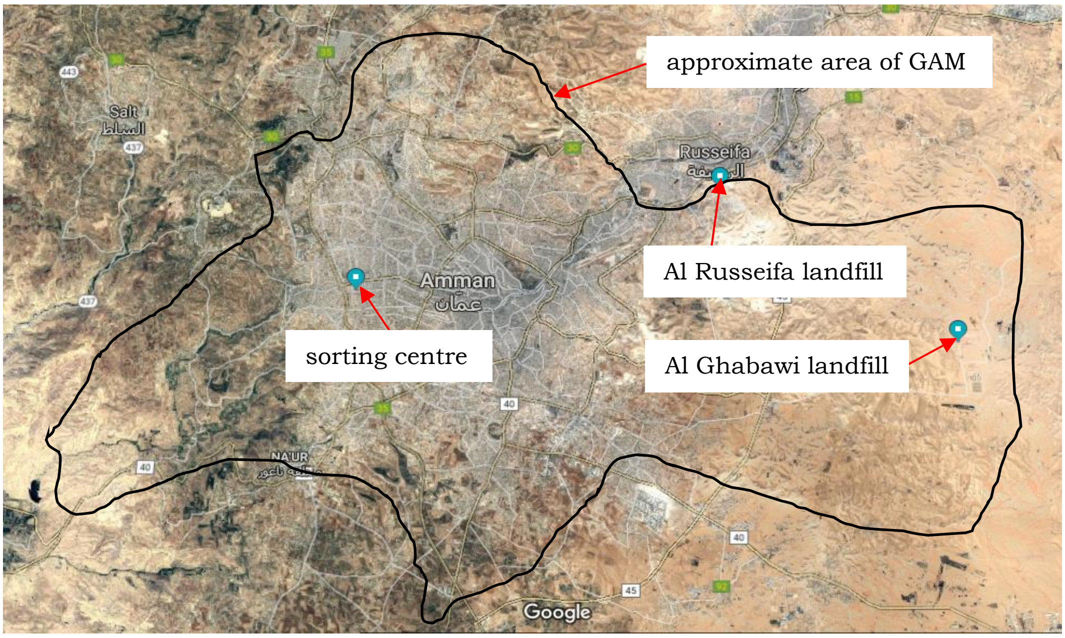


Figure 1: Approximate service area of GAM including the sites visited during the field study

2. MATERIALS AND METHODS

This study consists of three steps: (1) literature review, (2) field study and data collection, (3) followed with data analysis and calculations. In the following, the field study and the calculations will be further described.

2.1. Field Study and Data Collection

The field study lasted for three months (25th of August to 17th of November 2017) and took place in Amman. It included site visits, interviews, and further collection of literature and data.

The visited sites were (see Figure 1): a) Al Ghabawi landfill, the only sanitary landfill in Jordan, located 30 km east of Amman, which receives the MSW of Amman, Zarqa and Russeifa, b) a small composting project at the Al Ghabawi landfill site which was under construction, c) a landfill gas collection project at the Al Ghabawi landfill site under construction, d) a material recovery facility (MRF) next to Al Ghabawi landfill operated by the company "Tadweer", e) the biggest biogas plant in Jordan at the Al Russeifa landfill site operated by the "Jordan Biogas Company", and f) a small sorting center for MSW next to COZMO supermarket in Sweifieh in Amman operated by "BE environmental services".

The required information and data were obtained by the following means: a) observation of waste collection in the street and waste treatment on the sites, b) consulting the authorities (Ministry of Environment, Ministry of Agriculture, Ministry of Municipal Affairs, GAM) responsible for waste management as well as organizations and individuals active in this field, and c) interviews with managers of pilot projects, companies and organizations active in recycling, composting or waste-to-energy activities as well as with local farmers/ agricultural companies. In total, 28 key informants were consulted.

2.2. Data Analysis and Calculations

In a first step, waste amounts were calculated based on population data of the Department of Statistics [1] in combination with data from Brinkhoff [21] and the MSW generation rate for Jordan as applied in the National MSW Strategy [4]. The calculated values for the GAM area were compared and verified with data of waste amounts received at the Al Ghabawi landfill.

Waste composition was taken from the waste analysis conducted by the Royal Scientific Society (RSS) in 2011 which included determination of composition, moisture content and calorific values [22]. The values were complemented with the estimations in the National MSW Strategy [4]. **Table 1** shows the waste composition in GAM.

Table 1. Estimated MSW composition in GAM

Waste fraction	Percentage [%]
Organics/organic fraction/bio-waste*	50
Paper/cardboard	15
Plastics (PET/others)	15 (2.3/12.7)
Glass	4
Metals (ferrous metals/aluminium)	4 (2.6/1.4)
Other	12

* biodegradable waste of plant, vegetable, or animal origin

In a second step, total possible amounts of secondary raw materials, waste-derived-products and energy recovered from MSW were estimated and revenues were calculated based on the investigated market values and feed-in prices for electricity in Jordan.

Besides a total amount of Jordan Dinars (JD) per year that can be generated with different treatment options of the different waste streams, i.e. aerobic/anaerobic MBT, incineration, composting, anaerobic digestion and material recycling, a second value, namely JD/t_{input}, was determined to compare the treatment options in terms of their revenue generation potential. However, this value is not applicable to get an idea about the overall revenue generation and cost reduction potential of different waste management strategies as it solely compares the revenue generation potential of different facilities treating specific waste streams.

Therefore, in a third step, different waste management scenarios were developed depending on the collection system, i.e. mixed collection (current practice) and source-separated collection (possible future practice), and the aforementioned treatment options, and then compared in terms of their revenue generation potential as a whole waste management strategy. For this, a third value was introduced, namely JD/$t_{treated\ MSW}$.

For the mixed waste, two scenarios involving three possible treatment options were considered, see **Figure 2**:

Scenario 1, option a: aerobic mechanical biological treatment (MBT) with possible products refuse derived fuel (RDF) and compost-like output (CLO)

Scenario 1, option b: anaerobic MBT with possible products RDF, CLO, and biogas

Scenario 2: incineration

The RDF from scenario 1a and 1b can be either sold to the local industry, e.g., cement industry, or combusted in an own incineration facility to produce electricity. The first option is the standard practice and thus it will be considered in this paper. The CLO was excluded from revenue calculations, as the product must be disposed of.

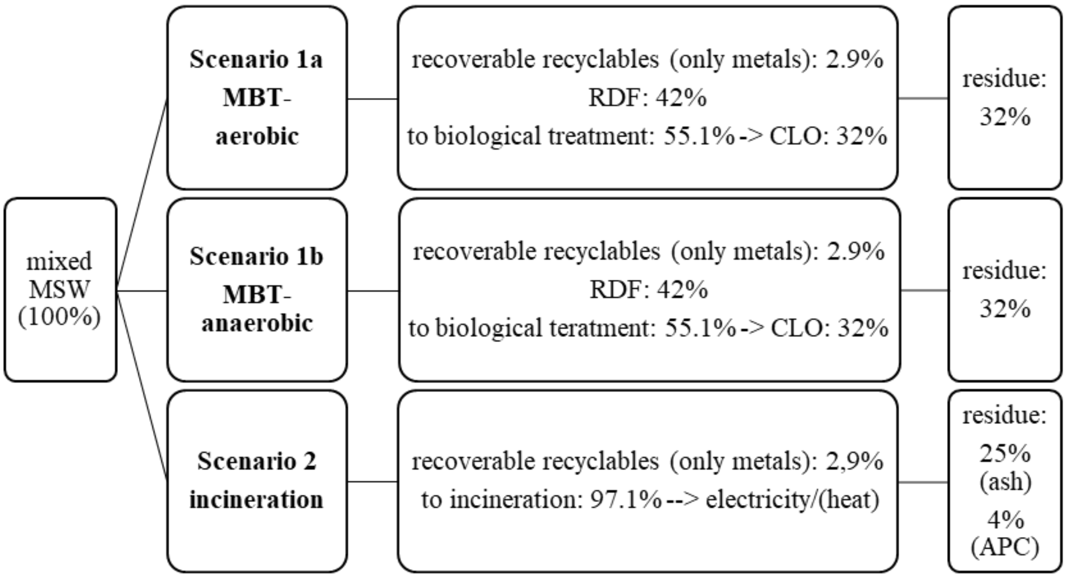


Figure 2. Overview of the scenarios based on mixed collection

In case of source separation, three waste streams (i.e., recyclables, bio-waste, and residuals) were considered. Accordingly, two treatment options were considered, see Figure 3:

Scenario 3, option a: recyclables are further treated in a material recovery facility (MRF), bio-waste in a composting plant, and residuals in an incineration plant

Scenario 3, option b: recyclables and residuals are treated analogue to 3a, bio-waste is processed in an anaerobic digestion plant

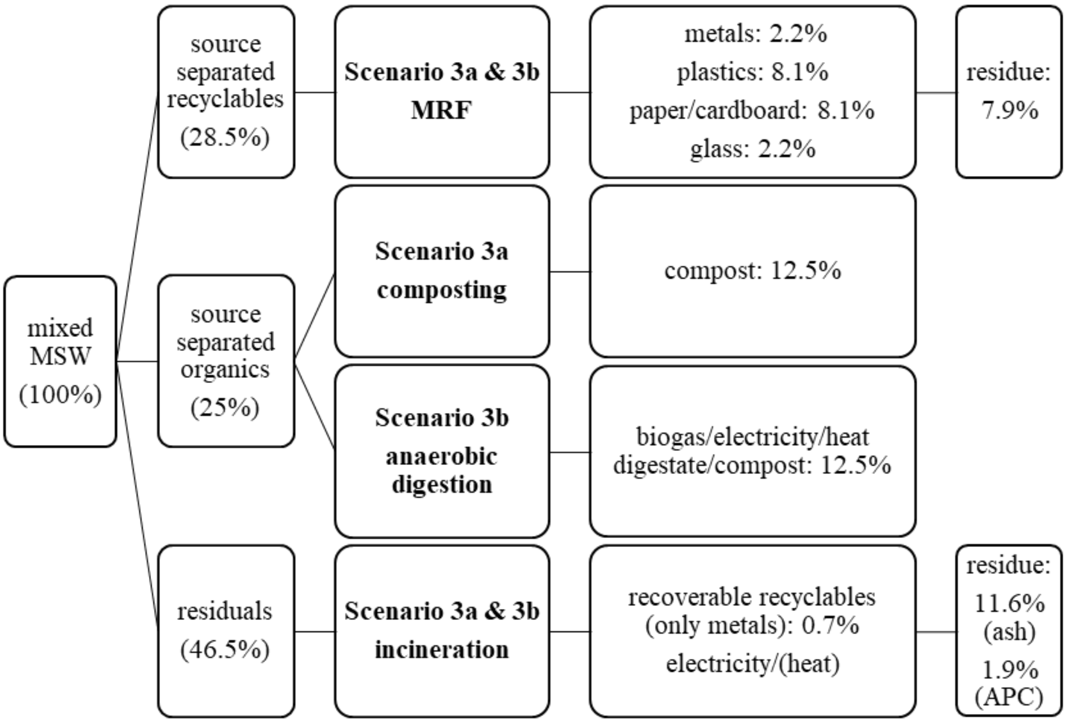


Figure 3. Overview of the scenarios based on source-separate collection

MBT for residuals was neglected since no remarkable effect on revenue generation is expected as valuable products and high calorific materials are removed beforehand. Revenues from biogas and direct waste incineration were considered in form of their electricity generation potential.

The applied efficiency of sorting at source of recyclables is 75% as estimated in the National MSW Strategy. Collected recyclables are then processed in a clean MRF with a sorting efficiency of 72%. Thus, the recovery rate of recyclables equals to 54%. In case of mixed collection, only metals are recovered at the same sorting efficiency (72%), as plastics and paper/cardboard are part of the RDF or incineration input. The applied efficiency of sorting at source of bio waste is 50% as estimated in the National MSW Strategy.

Compost and CLO amounts were calculated using average mass reduction values, which range between 45-65% for bio-waste and are around 42% for MBT input (amounts can vary greatly depending on the amount of included non-biodegradable fractions) [23].

The anaerobic digestion of the source-separated bio-waste and small-size/heavy fraction of MSW generate biogas with 60% methane content in average. According to literature [24], [25], the biogas yield of both substrates is similar and accounts to 110 $m^3/t_{digester\ input}$ as an average value within the ranges in different literatures [17], [23], [25], [26], [27], [28]. The biogas is combusted in a combined power heat plant (CHP) to produce electricity and heat with an overall efficiency up to 90% (55% heat and 35% electricity) [17], [23], [29]. 30% of the produced heat and 5% of the produced electricity are needed to run the plant [29], [26].

The bottom ash residues of incineration are 25% (20-30%) of the input waste weight, and the residues of air pollution control (APC) are 4% (2-6%) of the input waste weight [30].

The electricity generation potential was calculated for biogas incineration and direct waste incineration using formulas from literature [31]. The net efficiency of the indirect electricity generation by combustion is 20% (15-27%) [32], [33], [34], [35].

Table 2 shows the calorific values of the total MSW, RDF and the residual waste in GAM.

Table 2. Calorific value of MSW in GAM (calculated based on results in [22]*)*

Fraction	Compounds	Calorific value [MJ/kg]
Total MSW	100% of mixed MSW	8.7
RDF from MSW	42% of mixed MSW (15% paper, 15% plastics, 4.2% hygienic textile, 4.0% unclassified combustibles, 0.7% complex waste, 3.1% organics)	17.6
Residuals	46.5% of mixed MSW (25% organics*, 9.5% recyclables*, 12% others)	7.5

* based on the sorting-at-source efficiency, not captured by separate collection

3. RESULTS AND DISCUSSION

3.1. Recycling Market Characteristics

In general, the current recycling sector in Jordan can be divided into two sectors, formal and informal. The informal sector includes street collectors and waste pickers as well as several waste brokers. The number of waste pickers collecting metals, paper/ cardboard and plastics is around 5,000 [6]. The formal sector includes bigger private companies, which are officially registered as recycling companies. According to direct information from the Amman Chamber of Industry, the number of recycling facilities in 2017 amounted to 125. However, according to UNDP [12], there is a high number of unregistered entities in the recycling sector, numerous companies that ceased trading in solid waste recycling do not report this, and some of active recycling companies are not registered as such. In addition, there are few pilot programs run by national and international organizations, and few public programs. However, their contribution to the sector is comparatively low.

The main challenges of the recycling sector that were reported are volatile prices, export taxes, legislation, material quality, if collected mixed, and a low level of awareness. The export amounts of secondary raw materials from Jordan as listed in the database of the ITC Trade Map [36] indicate that remarkable amounts of recyclable waste are still rather exported than recycled locally due to limited national recycling capacity, especially for paper and metals.

Table 3 shows the market values for secondary raw materials in Jordan, which were investigated during three different interviews and then applied in this study. The obtained values are in line with literature, but a drop of prices for plastics could be recognized. Glass has currently no value in Jordan as no glass recycling is taking place since the Syrian border was closed due to civil war. Prior to this, glass was exported to Lebanon via Syria for recycling [3], [12].

Table 3. Market values of recyclables in Jordan 2017 (according to interviews)

Recyclable	Market value [JD/t]	Market value [US$*/t]
Paper/cardboard	35	49
Plastics	120	169
PET	50	71
Ferrous metals	70	99
Aluminium	450	635
Glass	0	0

* 1.00 JD = 1.41 $ at the time of the study

3.2. Compost Market

Small-scale composting is used by individuals in Jordan for farming and agricultural applications due to its simplicity. There are also a few plants producing organic fertilizers from animal manure using modest composting methods. Most of the local farmers apply fresh manure and other organic wastes as natural organic fertilizer without any pretreatment.

Interviews with four farmers showed a strong interest in composting specially to handle their own wastes like manure and field residues rather than to purchase compost. Three of them were already applying small-scale composting on site, yet they still depend on chemical fertilizer, raw manure, and in one case also composted manure. Two farmers reported lack of experience and knowledge as the reason for no or limited application of compost. It was also mentioned that purchasing compost is too expensive in comparison with raw manure. The investigations showed a compost price of about 40 JD/t (ca. 56 US $/t), which is in line with the values found in literature [11], [14]. It is around five times higher than the raw manure price (around 8-9 JD/t) [14]. According to SWEEPNET [6], the available amount of manure accounts to 4 million t/a. Recently, the local demand is satisfied by using raw manure residues as well as further chemical fertilizers and a small amount of processed manure [14]. On the other hand, Jordan has a huge fertilizer industry. The price of chemical fertilizers is around 390 JD/t (Information obtained during a Sector Roundtable and Expert Discussion on Solid Waste Management in Jordan at the University of Jordan 2017).

Determining the market size for compost requires data on the potential demand. No accurate data or information about the actual demand for organic fertilizers or about fertilizer volumes needed for one km² of cultivated land is available. It can be estimated based on the area of cultivated land (2,728 km² in 2016 [1]) and the organic fertilizer application rate of 2.5 t/ha yearly, which was reported for Jordan [14], resulting in a minimum theoretical demand for compost of 700,000 t/a.

3.3. Renewable Energy Sector

The state-owned National Electric Power Company (NEPCO) is responsible for construction, operation, and maintenance of the nationwide transmission network. NEPCO purchases the electricity from the producers as a sole buyer to sell it to the operators of the distribution networks. The company operates as national load dispatching center to coordinate the demand and the supply of power [37], [38]. To develop renewable energy capacities, several support mechanisms have been introduced with the Renewable Energy and Efficiency Law No. 13 from 2012. This law and its by-laws enable Independent Power Producers (IPP) to provide electricity from renewable sources to NEPCO with long term Power Purchase Agreements (PPA) and to ensure the purchase of energy from renewable sources [37], [39]. The Electricity Regulatory Commission (ERC) issued two regulatory directives, one for small-scale projects (< 5 MW), for which no license is required, and another for large-scale projects (> 5 MW). For small-scale projects, the reference price for electricity from other sources than solar energy and hybrid systems is 0,085 JD/kWh (ca. 0,120 US $/kWh). For large-scale projects, the reference price for electricity from biogas incineration is 0.06 JD/kWh (ca. 0,085 US $/kWh), and for electricity from biomass incineration 0.09 JD/kWh (ca. 0,127 US $/kWh). Public competitive bidding and direct proposal submissions exist for the development of large scale private renewable energy projects [39]. The tariff is considered as ceiling tariff. Developers can compete under this upper limit [40]. The feed-in prices rather encourage the construction of biomass incineration plants instead of biogas plants, and within biogas plants rather small-scale than large-scale biogas plants due to the higher reimbursement. In this study, the feed-in price for small-scale biogas incineration and large-scale waste incineration was applied.

The bulk of renewable energy projects is based on solar or wind energy. Nevertheless, the National Energy Strategy includes waste to energy with a capacity target of 20-30 MW [41]. Until now, only few waste-to-energy projects were implemented in Jordan. The biggest plant in operation is the pilot biogas project at the closed Al Russeifa landfill site. However, this plant operates currently only with landfill gas (LFG) as the digester for organic waste was switched off in 2005 after different problems like settlements and corrosion occurred. The only waste that is incinerated currently is medical waste, but according to information obtained during the interviews, without heat recovery. Two waste incineration plants for electricity generation are planned, one in Al Akaider with a capacity of 6 MW and another in Al Ghabawi with 5 MW as stated during a Sector Roundtable and Expert Discussion on Solid Waste Management in Jordan at the University of Jordan 2017.

3.4. RDF Purchasing Industries

RDF can be used as fuel for boilers in industrial or power generation facilities or for dedicated incineration plants. If it fulfils additional guideline, regulatory, and industry specifications, it can be used for kilns in manufacturing (e.g., cement, brick, lime). Other possible end-users are paper mills and iron industries [18]. In Jordan, there is a well-developed cement industry. Five factories are working in Jordan's cement sector with an annual production of more than 12 million t [42]. Two cement companies already expressed their interest in RDF but disagree with municipalities on who will pay the costs arising from production process modification and RDF preparation. The minimum calorific value required by cement kilns to secure a continuously running operation amounts to 18 MJ/kg (for secondary combustion, the value can be lower) [43]. The calculated calorific value of RDF from the MSW in GAM amounts to 17.6 MJ/kg (compare **Table 2**). As this is the minimum value, enhancing the calorific value of RDF further by drying or sorting out more fractions with low calorific value can be considered.

The price for RDF was estimated in the National MSW Strategy with 15 JD/t (ca. 21 US $/t) [11] and by A. A. M. Elnaas with 30 JD/t (ca. 42 US $/t) [44]. In this study, a price level of 20 JD/t was assumed. Burning the RDF in an own incineration plant and selling the generated electricity generates more revenues due to the high feed-in price. This option has the disadvantage of involving additional costs for plant construction and operation.

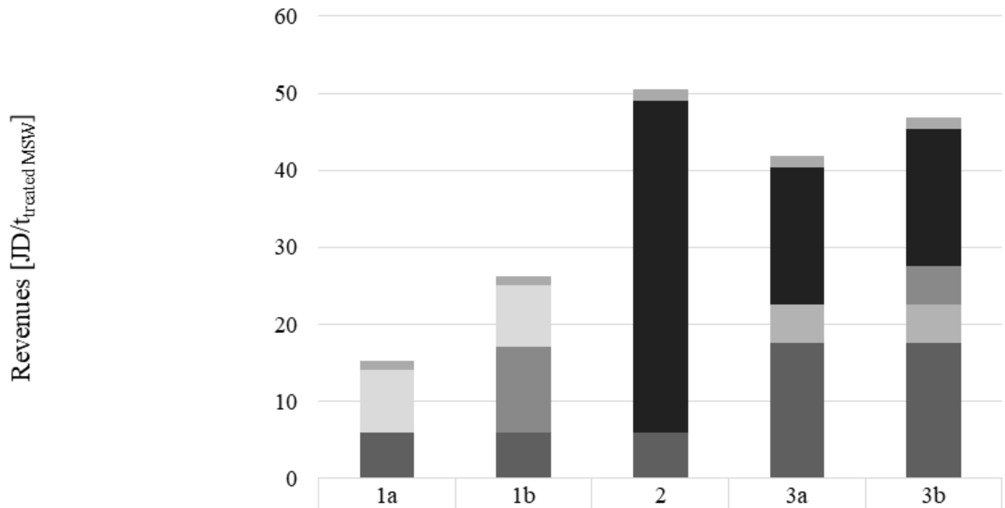
3.5. Calculated Revenues from MSW in GAM

The possible total amounts of revenues that can be generated with secondary raw materials, waste-derived products or recovered energy from MSW in GAM in the different facilities are shown in **Table** *4*.

Table 4. Possible total amounts of revenues from secondary raw materials, waste-derived products and recovered energy from MSW in GAM

Scenario	Option	Waste-derived product	Amount	Revenues JD/a (US $/a)
1 2	a b -	**Recyclables (metals)** from pre-treatment of mixed waste ferrous metals aluminium	**37,440 t/a** 24,340 t/a 13,100 t/a	7,598,800 (10,714,300)
1	b	**Electricity** from anaerobic digestion of mixed MSW in an anaerobic MBT	167,100,000 kWh/a	14,203,500 (20,026,935)
1	a b	**RDF** from MBT	546,000 t/a	10,920,000 (15,397,200)
2	-	**Electricity** from incineration of mixed MSW	628,300,000 kWh/a	56,547,000 (79,731,270)
3	a b	**Recyclables** paper/cardboard PET other plastics ferrous metals aluminium glass	**266,760 t/a** 105,300 t/a 15,950 t/a 89,350 t/a 18,050 t/a 10,030 t/a 28,080 t/a -	20,982,000 (29,584,620)
3	a	**Compost** from bio-waste	162,500 t/a	6,500,000 (9,165,000)
3	b	**Electricity and compost** from anaerobic digestion and subsequent composting of bio-waste	75,900,000 kWh/a 162,500 t/a	6,451,500 (9,096,615) 6,500,000 (9,165,000)
3	a b	**Electricity** from residual waste incineration	251,900,000 kWh/a	22,671,000 (31,966,110)
3	a	**Recyclables (metals)** from pre-treatment of residual waste ferrous metals aluminium	**9,360 t/a** 6,080 t/a 3,280 t/a	1,901,600 (2,681,260)

The total revenues were set in relation to the input amount of the different treatment facilities (JD/t_{input}), compare Figure 2 and Figure 3. These values were weighted according to the share of the total MSW amount which is treated in the facility and then summed up to calculate the potential revenues of the respective scenarios. The results are shown in **Figure 4**. Additionally, savings related to the reduction of waste amounts received at the landfill compared to the current waste management practice are included. For this, the costs of 2 JD/t as indicated for the Al Ghabawi landfill were applied [7].



	1a	1b	2	3a	3b
■ saving landfill costs	1	1	2	2	2
■ RDF sale	8	8			
■ electricity from incineration			43	18	18
■ electricity from biogas		11			5
■ compost				5	5
■ recyclables	6	6	6	18	18

Figure 4. Cumulated and weighted revenues of different MSW management scenarios in GAM

Except for the scenarios based on MBT, revenues in the range of 40-50 JD/$t_{treated\ MSW}$ could be generated. However, to compare different waste management strategies in economic terms, the costs for collection, treatment, and disposal must be considered. This includes capital investment, and operation and maintenance costs. Therefore, for a final evaluation, the costs of the different scenarios must be taken into consideration. Regarding the additional treatment facilities, MRFs and aerobic treatment facilities are generally less costly than anaerobic treatment facilities and incineration plants. Mixed waste collection (scenario 1 and 2) is in general cheaper than separate collection (scenario 3).

The current costs for solid waste collection and treatment in GAM were reported with 46 JD/t (ca. 65 US $/t). 93% of the costs (43 JD/t) go to collection and transport of the waste, and 4% (2 JD/t) to disposal. Additionally, a recovery rate of 60-75% of the costs from fee collection was indicated [7] To cover the missing 25-40%, revenues in the range of 12-18 JD/t (on average 15 JD/t) are needed. Higher revenues can be obtained by all MSW management scenarios except scenario 1a. The operation costs will increase when implementing the new MSW facilities. In the best case, the obtained revenues can cover this increase. To get an idea on the economic feasibility of each scenario, the margin for additional costs after subtracting the amount needed to cover the current costs is shown in **Table 5**. The margin is highest for scenario 2 and 3b. However, it is unlikely that this margin is enough to finance the additionally required facilities. The same applies for the other scenarios. Nevertheless, the revenues could increase the current cost recovery rate. Besides, the efficiency of the current system should be reviewed.

The final economic feasibility of the different scenarios cannot be evaluated at this point, as resilient cost assumptions for waste treatment facilities and separate collection in Jordan are not available. A conclusion can only be made with further investigation and evaluation, possibly including cost calculations for example plants. All plants except incineration ones can also be realized in low-tech variants, what reduces the costs.

Table 5. Margin for additional costs for MSW treatment in the different MSW management scenarios in GAM

Scenario	**1**		**2**	**3**	
Option	**a**	**b**	**-**	**a**	**b**
Revenues [JD/t]	15	26	51	43	48
Current deficit [JD/t]	15	15	15	15	15
Margin [JD/t]	-	11	36	28	33

4. CONCLUSION

The investigated current situation of the markets for waste-derived products and secondary raw materials in Jordan can be described as followed:

Firstly, the market for secondary raw materials still demands much development. Mainly, it is informal and faces different challenges like missing legislation, poor material quality, and limited capacity. The investigated prices for recyclables indicate the value of the materials and show the possibility to find sales markets in this sector. Secondly, two main waste-derived products have a market value – compost and refuse derived fuel (RDF). The compost market is still small in Jordan even if an enormous potential exists. The lack of interest on compost is attributed to the inferior quality and high price of currently available composts and the existing established market for raw manure, besides a strong chemical fertilizer industry in Jordan. Furthermore, RDF is of interest to the well-developed cement industry in Jordan. Thirdly, a high potential for waste-to-energy projects (especially incineration) is available due to the supportive legislative framework and the lack of local/ national energy resources.

The aforementioned comparison of the five MSW management scenarios for the example area of GAM led to the following results: It was found that revenues in the range of 10-50 JD/$t_{\text{treated MSW}}$ can be generated, with three out of five scenarios achieving revenues ranging between 40-50 JD/$t_{\text{treated MSW}}$.

Waste incineration can generate high revenues in Jordan due to the high feed-in price for electricity from incineration. The lower feed-in price for electricity from biogas incineration in comparison with direct biomass respectively waste incineration results in a competitive disadvantage for biogas technology. However, the calculated revenue potential of the scenarios based on source-separated collection is in the same range with the scenario based on mixed waste incineration. Here, the further positive impacts of sustainable MSW management on the environment, local economic activity, energy import dependency and soil quality should be emphasized.

Furthermore, the existing markets for secondary raw materials can only be developed and further utilized with source separate MSW collection. The main steps that must be taken to develop the existing markets, to provide high quality materials, and to utilize the market potential are the following: a) raising awareness amongst the population for separation at source, b) developing a supportive legislative framework, c) formalizing and structuring of the markets, d) applying standards for material and product quality, e) raising awareness amongst potential customers of recyclables and waste-derived products, f) cooperation between public and private sector, g) inclusion of the informal waste picking sector.

The study shows that a sustainable MSW strategy has a high revenue generation potential in Jordan and therefore has the potential to reduce the costs of MSW management in Jordan. However, further investigation on additional costs for MSW treatment and separate collection is required to make resilient appraisals, to which extend the revenues can reduce the costs of MSW management.

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