Action Plan for the Diversion of Organic Waste

CAZA OF TYRE - SOUTH LEBANON

ISWALEBANON.ORG | NOVEMBER 2021

November 2021

Disclaimer

This report has been prepared with financial assistance from the Climate and Clean Air Coalition (CCAC). The views expressed herein are those of the consultants and therefore in no way reflect the official opinion of CCAC nor the International Solid Waste Association.

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AD	Anaerobic Digestion
ASP	Aerated Static Piles
BAU	Business-as-usual
CAPEX	Capital Expenditure
CBO	Community-based Organizations
CC	Community Composting
CCAC	Climate and Clean Air Coalition
CCF	Central Composting Facility
CLO	Compost-like Outputs
GHG	Greenhouse Gases
IC	Individual Composting
ISWA	International Solid Waste Association
LCF	Local Composting Facility

MBT	Mechanical and Biological Treatment
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
OMSAR	Office of the Minister of State for Administrative Reform
OPEX	Operational Expenditure
RDF	Refuse-derived fuel
SLCP	Short-lived Climate Pollutants
SOER	State of the Environment Report
SWEET	Solid Waste Emissions Estimation Tool
SWM	Solid Waste Management
US EPA	U.S. Environmental Protection Agency

EXECUTIVE SUMMARY

In September 2020, the International Solid Waste Association (ISWA) in collaboration with the Climate and Clean Air Coalition (CCAC) published the report "Estimation of waste sector greenhouse gas emissions in Tyre Caza, Lebanon, using the Solid Waste Emissions Estimation Tool (SWEET)". Following the onset of the financial crisis in Lebanon as well as the closure of the Tyre waste treatment facility, a sub-project was developed that builds on the findings of the mentioned report and adapts it to the current situation. The current report therefore aims to: 1) Estimate the impact of the closure of the waste treatment facility in Tyre on greenhouse gases (GHG) and short-lived climate pollutants (SLCP) emissions in the region, 2) Set up an action plan to treat and divert major sources of organic waste from being openly dumped, and 3) Assess the potential impact of this action plan on the reduction of these emissions.

In addition to a desk review of the existing literature and studies such as the Regional Master Plan for Tyre Caza prepared by OMSAR, data was collected through two main approaches. First, data estimates for solid waste quantities accepted by major Lebanese facilities were gathered from the Council for Development and Reconstruction (CDR) reports and the Office of the Minister of State for Administrative Reform (OMSAR) reports. These included data on urban as well as rural areas, the latter being more relevant to the study area. Second, data was collected through phone surveys with the municipalities of the Tyre region. This included information on waste quantities and types, municipality capabilities, current disposal schemes, etc.

Considering that Lebanon passed through several major events including an ongoing economic crisis, the onset of the COVID-19 pandemic, and the Beirut blast, which are expected to have had significant impacts on waste generation rates and possibly waste characteristics, data analysis was performed to determine changes between pre-crises and post-crises waste generation and characteristics. This assessment showed a significant decrease of around 24.43% in waste generation rates (until end of data availability) with the organic waste percentage mostly unchanged at 54.22%. This drop in waste generation rates is expected to have increased due to the persistent economic crisis.

Several interventions were studied as options to treat sources of organic waste in the area. Advanced methods that require high investment and operational costs were discarded due to the massive drop in financial capabilities of the government as well as the municipalities. Instead, this study focused on composting at the individual, community, local, and central levels. Three composting scenarios were selected, a central composting facility in Abbassiyyeh, a local composting facility in Aalma Ech Chaab and community composting in Bmaryamine.

To assess the impact of these scenarios on emissions, the Solid Waste Emissions Estimation Tool (SWEET v 4.0) tool was used. The adjusted business as usual (new BAU) scenario (post-crises) showed a decrease in these emissions correlated with the overall waste generation drop. Results also showed that the central facility processing about 17 tons/day was the only scenario that would provide the significant emission reduction with around 6.4% decrease from the new BAU by the year 2050. However, greater emission reduction can be achieved by combining the implementation of the centralized composting facility with additional measures at disposal sites namely ending open burning, rehabilitation of dumpsites, landfill construction with methane combustion. With this scenario emissions reductions can reach as high as 53.9% from the BAU by 2050.

Finally, the financial modelling tool OrganEcs, developed by the US EPA, was used to perform an initial assessment of the financial details for three options related to the central composting facility pilot scenario in Abbassiyyeh. The options included different variations for who would cover investment costs (equipment, infrastructure, etc.) and transportation of waste to the facility. It was shown that the composting facility may present a profitable model if the waste received is properly sorted and transported to the site free of charge.

1. INTRODUCTION

1.1. Project Background

ISWA Task Force on Closing Dumpsites and the CCAC

ISWA's Task Force on Closing Dumpsites was established in 2018 with the aim of closing dumpsites throughout the world by conducting studies and research and providing capacity building and technical support to affected communities through ISWA's extensive network of international experts in the field. This initiative specifically focuses on addressing the urgent need of closing dumpsites to improve local, regional, and global health and environment. Uncontrolled dumpsites often suffer catastrophic structural failures that have killed hundreds of people around the world, as well as being detrimental sources of ground and surface water contamination and sources of disease. Additionally, dumpsites are also one of the largest sources of global anthropogenic methane from the decomposition of organic waste, and black carbon emissions from open burning of wastes are the second largest source of short-lived climate pollutant (SLCP) emissions at dumpsites after methane.

The CCAC Municipal Solid Waste Initiative (Waste Initiative) provides support to cities and national governments to reduce emissions across the waste sector including closing open dumpsites, capturing, and utilizing landfill gas, proper waste handling, and managing organic waste.

OMSAR

The Lebanese Office of the Minister of Administrative Reform (OMSAR), in 2018 developed an Integrated Regional Solid Waste Management Plan for the District of Tyre that provided a detailed baseline assessment of the sector in the region and proposed an integrated system for sustainable waste management through enhanced collection, treatment and disposal as well as addressing governance and institutional aspects. OMSAR also acted as the Contracting Authority for the operation and maintenance of the Ain Baal mechanical biological treatment plant that aimed to serve most of the municipalities in the District through a subsidized fund from the national government.

Tyre Emissions Estimation Study

In 2019, a collaborated effort between ISWA and CCAC sought to work towards the closure and rehabilitation of the Ras El Ain dumpsite that used to accept waste from all over the District of Tyre. This project was developed through the Task Force on Closing Dumpsites that sought to select a site that can successfully demonstrate a plan to close an open dumpsite by moving to alternative solutions to manage the waste being openly dumped.

The result would be a roadmap to close the open dumpsite and a move to integrated waste management solutions that could be replicated and scaled up to allow for inter-city and inter-country learning to enhance waste management practices while reducing methane and black carbon emissions. Furthermore, the activities covered by this project would help Coalition partners fulfil the CCAC High Level Assembly (HLA) commitments of the Bonn Communiqué on waste through the proposed activities that will provide the best practices to shape policies, plans, and programs on diversion of organic waste from landfills, collection and use of landfill gas and prevention of open burning of waste.

The District of Tyre was selected from 3 nominated candidate cities from around the world, since it met several necessary criteria that included:

- Nominated site is a CCAC Waste Initiative city or part of the CCAC network
- Existence of baseline study and data for the site
- Being a small to medium sized site

- Strong local interest, political will, and government support to work on the site
- Approvals to begin work at the site
- Potential for scalability and replicability of the project results on a national and global scale.

Having satisfied this criterion, the CCAC and ISWA conducted a study and published a report that utilized the Solid Waste Emissions Estimation Tool (SWEET) that allows cities or regions to benchmark waste sector greenhouse gases (GHG) and short-lived climate pollutants (SLCP) emissions and estimate the amount of emissions reduction achievable through alternative waste management and diversion scenarios based on the Regional Waste Master Plan developed by OMSAR.

The baseline scenario in the study considered that the mechanical biological treatment facility at Ain Baal was still operational, providing some stabilization of the organic fraction of waste that is generated in the District, and thereby minimizing the potential for GHG emissions to be generated from the decomposition of organic waste at open dumpsites.

However, in March 2020 the Ain Baal MBT ceased operation due to contractual issues and conflict between the Union of Tyre Municipalities and the contracted operator of the facility. Therefore, during this time, without the minimum biological stabilization of the organic fraction at Ain Baal, there has been a significant increase in the amount of untreated organic waste being disposed of at open dumps, thereby significantly increasing the potential for methane generation in various dumpsites around the Caza.

ISWA Lebanon and the Organics Management Sub-Project

In light of the current situation with untreated waste going to open dumps, the CCAC and ISWA developed a sub-project to the primary emissions estimation study that focuses on piloting the management and control of organic waste in order to divert organics from dumpsites and thereby avoid the generation of methane from disposed waste. For this, ISWA Lebanon, the National Member of ISWA for Lebanon that was established in 2019, offered its assistance to prepare an Action Plan for the diversion of organic waste in the District of Tyre.

1.2. Objective

The objective of this study is to estimate the impact that the closure of the treatment facility has had on the GHG and SLCP emissions generation in the region, to set up an action plan that can divert major sources of organic waste from ending up in dumpsites through source segregation and subsequently treating the organics, and to ultimately assess the impact of the action plan's implementation on reducing emission generation.

1.3. Methodology

In order to achieve the project's objective, the execution of the project was divided into three main activities:

Activity 1: Baseline assessment and study

The baseline assessment process was initiated with a desk review of existing literature and studies such as the Regional Master Plan for Tyre Caza prepared by OMSAR, especially the baseline study report. This information was quality assessed and, considering the economic and social changes that have occurred since their preparation, primary data needed to be collected that provided information on crucial parameters such as waste generation and composition and assessment of the sources of waste in the region.

Data was therefore collected through two main approaches: Solid Waste facilities that measure the flow of waste, and Municipalities through phone surveys. The data from the waste facilities was gathered from two main categories: BML, referring to Beirut and Mount Lebanon, which are mostly urban, and OMSAR (i.e., Zahle, Bar Elias, and Baalbek facilities) which are mostly rural. As for the data from the municipalities, their waste generation data was collected verbally through a direct contact with representatives from each municipality.

In some cases, it was extremely difficult to either contact or collect data from a number of municipalities. This was due to one or a combination of the following reasons:

- Inability to contact the municipality (i.e., inability to get contact information, wrong contact information)
- No cooperation from the municipality (i.e., lack of willingness to participate in the survey, delays in answering)
- Unanticipated reasons (e.g., the spread of COVID-19 in one case led to the Mayor being hospitalized and no alternative was proposed to answer the questions)
- Fuel shortage problems within the country making it extremely difficult to perform on the ground surveys
- Overall political, economic, and social events and problems which made logistic and contact procedures more complicated

For such cases, if partial information was given and was considered relevant, then this was included in the survey data sheets. Otherwise, the whole entry for the municipality was discarded.

The collected data was analyzed to get the waste generation, method of disposal, and insights on key commercial generators.

With this updated data, the impact of the closure of Ain Baal Facility and the changes that waste generation and composition has on the emissions generation was estimated using the Solid Waste Emissions Estimation Tool (SWEET).

Activity 2: Establishing targets

Based on the findings of the baseline study, targets for organic waste diversion could be developed by reviewing existing practices and assessing various types and levels of composting techniques as well as potential suitable target locations for implementation. This set specific diversion targets for alternative scenarios and subsequently allowed the comparison of emissions reductions for each scenario using SWEET.

Activity 3: Action Plan development

By identifying success factors and drivers, these scenarios were developed by assessing the technology required for each and the various types of collection systems put in place that are necessary for the implementation of an Action Plan for an integrated approach to organic waste management.

The financial implications of the scenarios presented in the action plan were also assessed using the US EPA's OrganEcs tool which can help identify investment costs and estimate returns on investment to propose final recommendations for potential future interventions as well as a set of actions and next steps that should be taken in order to implement an organics diversion project.

2. Baseline Assessment

2.1. General Background Information

Tyr (Sour) as a District is part of South Lebanon Governorate which comprises two other districts (Jezzine & Saida). The administrative center of Tyr District is within the Municipality of the historic city of Tyr, the oldest coastal cities of the Mediterranean Basin. It is bounded on the north by Saida District, on the east by Bint Jbeil District and on the South by the international border.

Tyr covers a surface area of 418 km^2 with a coastal strip that extends from the Litani River north to the international border in the South. The coastal strip includes a fertile agricultural plain where spreads of banana plantations and citrus fruits form a significant part of the production of these fruits at the national level.

As for the number of municipalities within the Tyr district, there is some inconsistency, the Data center on local development in Lebanon reports a total of 62 Municipalities. However, a total of 60 and 64 Municipalities are reported by the UNHabitat and the Mayor of Tyr of Municipalities/Head of Tyr Union of Municipalities, respectively. The reason behind this might be associated with some villages/localities which do not have a municipal council.

The population of Tyre Caza varies by season, and was estimated to include 244,505 Lebanese citizens in the winter season and 314,200 Lebanese in the summer season in 2016. Another 55,000 Syrian refugees, 66,600 Palestinian refugees, and 10,500 United Nations Interim Force in Lebanon (UNIFIL) personnel also produce waste managed in Tyre Caza, which results in a total of about 394,000 persons in 2016 (annual average population) receiving waste collection services.

2.2. Existing waste Infrastructure

The general waste management system currently in place consists of collection of mixed municipal waste from curbside bins and steel drums by each individual municipality and either taken for treatment to the central mechanical biological treatment plant in Ain Baal or directly to open dumps for disposal. Collection equipment usually consists of small 5m^3 pickup trucks, tractors and trailers, and compactors in larger municipalities. No sanitary landfill exists in the region and despite there being plans for the construction of one, this has never materialized yet. In 2019, the Union of Municipalities stated that there were about 33 active open dumpsites throughout the district with open burning taking place at about 22 of those. During its operation, the Ain Baal MBT facility only served at most about 20-25 of the municipalities in the Union of Tyre Municipalities after having undergone a capacity upgrade from 150 to 250 tons per day that was completed in 2018. However, due to operational problems and contractual issues between the contractor and the Union of Municipalities in charge of the facility, operation was ceased and an alternative contractor was never allocated to continue the works. A more detailed account of the facility's history is presented in Section 3.1 of this report. The closure of the treatment facility has thus led to untreated waste being directly disposed of in open dumps, which have since likely increased in number.

The Integrated Waste Management Plan prepared by OMSAR in 2018 conducted a detailed baseline assessment of the overall existing waste management system in the District. Overall the assessment indicated that:

- Despite collection coverage being very high at around 100%, covering the whole population, it is still inefficient and not well organized.
- Uncontrolled disposal rate is very high at around 81.5% demonstrating that there are serious public health and environmental risks in the region.
- The rate of diversion away from open dumps is thus 18.5% (including moisture losses) but more than half of this is due to activity of the informal sector.
- Material recovery rate is only about 11.5% and yet again 83% of this is done by the informal sector. The informal sector thus manages about 10% of the total waste generated.

- Institutional development is also weak, with problems with overall cooperation between municipalities and their planning efforts.
- Cost recovery rate is very low. Waste treatment was covered by OMSAR but the financial stability of the system in place is questionable.

2.3. Overall Waste Generation and Composition Trends

2.3.1. Pre-crisis Waste Generation

The third quarter of 2019 saw the beginning of the economic crisis that hit the country's financial banking system and has led to a rapid devaluation of the Lebanese currency. In turn, inflation increased sharply and has had severe repercussions on the population's real income and purchasing power, plunging the people into poverty. This phenomenon would have significant impacts on waste generation and composition, given the correlation of these parameters with economic conditions. Moreover, the emergence of the COVID-19 pandemic and subsequent lockdown measures put in place during most of 2020 further exacerbated the situation. For this reason, this report provides a comparison of waste generation prior to the crisis (i.e., pre-October 2019) and post-crisis which is still ongoing today.

The Master Plan of 2018 provided the latest published information on waste generation, recycling, and material flows to treatment and disposal facilities within the District prior to the onset of the crisis. It estimated a total generation rate of 100,000 per year of municipal solid waste (MSW), excluding construction, demolition, and institutional waste, of which approximately 9.5 percent is diverted from disposal by the informal recycling sector. Regular waste collection services collect all generated waste remaining after informal sector diversion and deliver it to the Ain Baal for processing, or directly to dumpsites for disposal. In 2018, approximately 82 percent of generated MSW, including processing rejects and unused compost from the Ain Baal MBT plant, was disposed of in dumpsites operating in Tyre Caza.

In regards to waste composition, previous reports have indicated that the organic waste fraction is between 50-55% of total municipal solid waste. This range considers the difference between urban and rural areas. Urban areas tend to have a value closer to 50% whereas more rural ones tend to be closer to 55%. This has been reported in the 'State of the Environment Report (SOER)' published in 2011 (MOE/UNDP/ECODIT, 2011).

2.3.2. Post-crisis Impact on Generation

2.3.2.1. Changes in Waste Quantities

Data from Facilities:

From the data collected from the waste facilities (BML and OMSAR) a sharp decrease was observed for many of the months after the economic crisis in Lebanon. The main events taken into consideration were 1) The economic crisis and the uprising (October 2019), 2) Onset of the COVID-19 pandemic (around Feb-Mar 2020), and 3) the Beirut blast (when data was available).

Using the latest available data for facilities that cover mostly rural areas (i.e., OMSAR data), the following changes in waste quantities were obtained (latest available data: March 2021):

Table 1 Facilities waste percentage drop

Facility	Waste Percentage Drop
Baalbeck	20.7%

Bar Elias	27.02%
Zahle	25.56%

In order to estimate a drop factor for the changes in waste generation rates, the above three drops were averaged to get **24.43%** as the average drop factor, which was used in this project. Note that this rate is subject to change, and that it is likely to increase even further considering that since March 2021, there has been no significant alleviation of the economic crisis, and that political tensions and overall quality of life has gotten worse. In addition, immigration is still strong, and this might have a strong impact on the quantities of waste reported.

Data from Surveys:

The map shown in figure 1 below shows the tonnage of municipal solid waste generation per day of the villages. These results were obtained from the municipality surveys (A detailed list can be found in Annex 9.3).

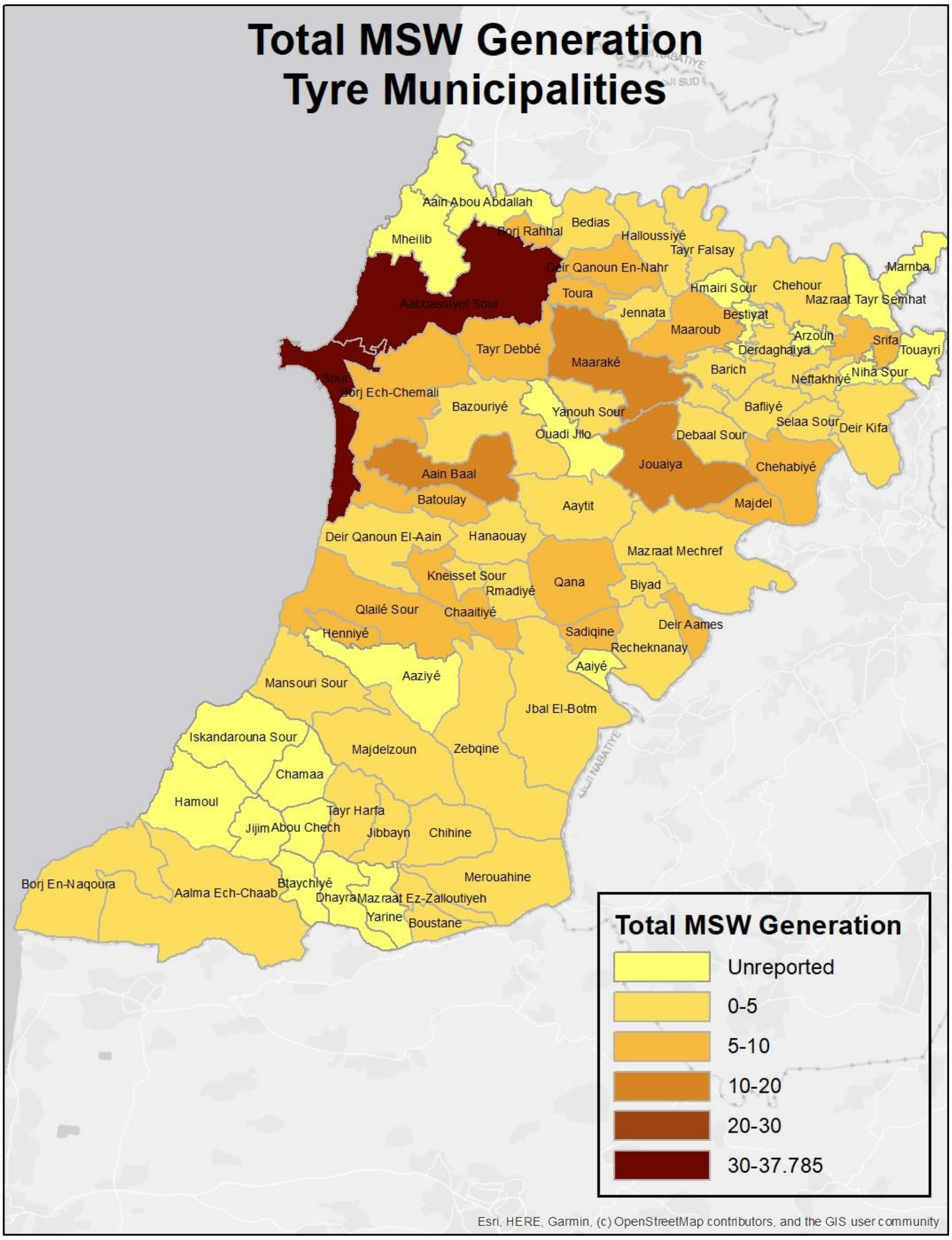

Figure 1 Total MSW generation of Tyre municipalities

The map shows the estimated waste generation rate per municipality. In order to calculate this rate, it was important to divide the municipalities into two sets: 1) Set 1: that declared that its data was quite recent (i.e., after the economic crisis and onset of COVID-19 pandemic and only a few months old as a maximum (no more than 6 months), and 2) Set 2: that declared that its data was based on old estimates that were mostly before the events stated previously.

For Set 1, there was no need to estimate waste generation rate as this was taken as is. On the other hand, the old values presented by Set 2 were taken and multiplied by the drop factor stated previously (calculated after estimating BML and OMSAR waste generation drops). This allowed the rough estimate of current waste generation rates for all surveyed municipalities and to estimate the total waste generation in the study area.

It is clear that Aabbasiyyeh and Tyr have the highest MSW generation rate per day (at around 37 tons per day).

The total reported waste generation (Cumulative of all the municipalities surveyed) was found to be around 119,363 tons per year (calculating this number took into consideration that the municipalities declared that their data was not recent (i.e., at least 6 months old) by applying the drop factor above.

Considering that this number is still very close to that present in the original study, even though it excluded some municipalities, and that many municipalities said that they estimated their waste production based on number of trucks, either the values presented in the previous study may have been underestimated or that the values provided this time may still be based on old estimates and that they may not be representative of the new situation. The latter option may be true given the huge changes the country has been passing through. Hence, the general drop factor was used on the existing waste quantities (these were used in the SWEET's previous iteration found in the previous CCAC report) in order to estimate emission generation.

2.3.2.2. Changes in Waste Composition

Organic Waste Composition Change:

The change in organic waste percentage was determined by comparing the 2-year drops in total waste and compost production change (which was used as reference for organic waste change) for the two facilities: Baalbeck and Bar Elias:

Table 2 Total waste change and compost production change of Baalbeck and Bar Elias facilities

Facility	Total Waste Change (%)	Compost Production Change (%)
Baalbeck	-27.54	-25.09
Bar Elias	-23.49	-28.04
Average	**-25.515**	**-26.565**

Considering that the pre-crisis percentage of organics was determined to be around 55% in rural areas, how the above changes will affect this percentage will be determined.

Table 3 Initial and new organic waste quantities

Initial Quantities (tons)		New Quantities (tons)	
Total	Organics	Total	Organics
100	55	74.485	40.389

The new percentage of organics becomes 40.389/74.485 = 54.22%

Considering that the change is not significant, the initial approximation of 55% organics in the total waste stream was maintained.

Other Data:

To account for the portion of waste being burned, a 14% burn rate was considered based on the blend of combustible materials in the waste stream. This was taken as is from the previous study.

2.4. Assessment of sources of organic waste

2.4.1. Household

Figure 2 shows the reported waste generation rates per person (as calculated by dividing the total reported waste generation rate of the municipality by its reported population):

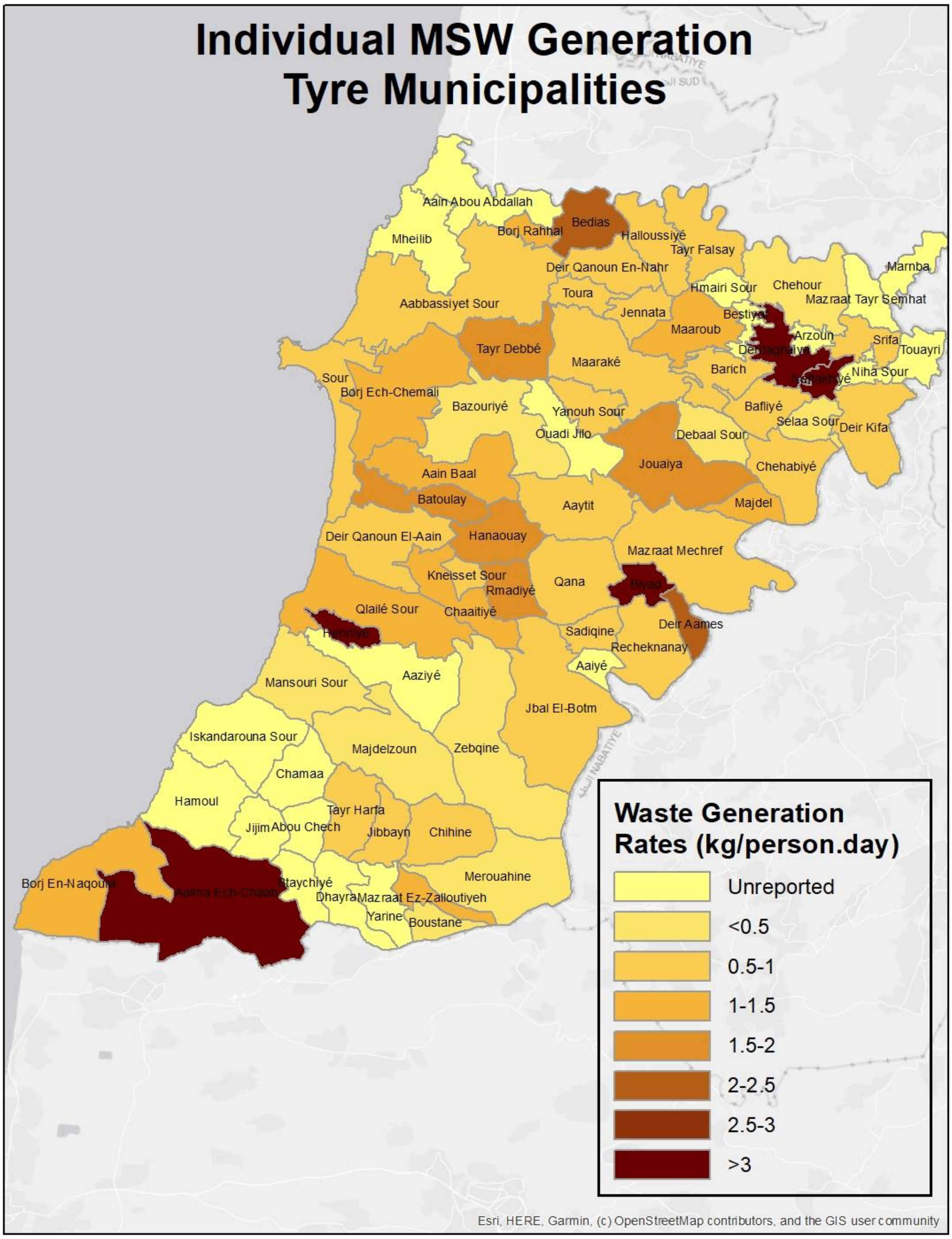

Figure 2 Individual MSW generation of Tyre municipalities

The reported values are divided into the below histogram. Most values were between 0.6 and 0.8 kg/person/day. The second category reported was between 0.8 and 1 kg/person/day. Other values were mostly distributed around these ranges. However, there are some outliers and municipalities that have higher than average per person waste generation rates.

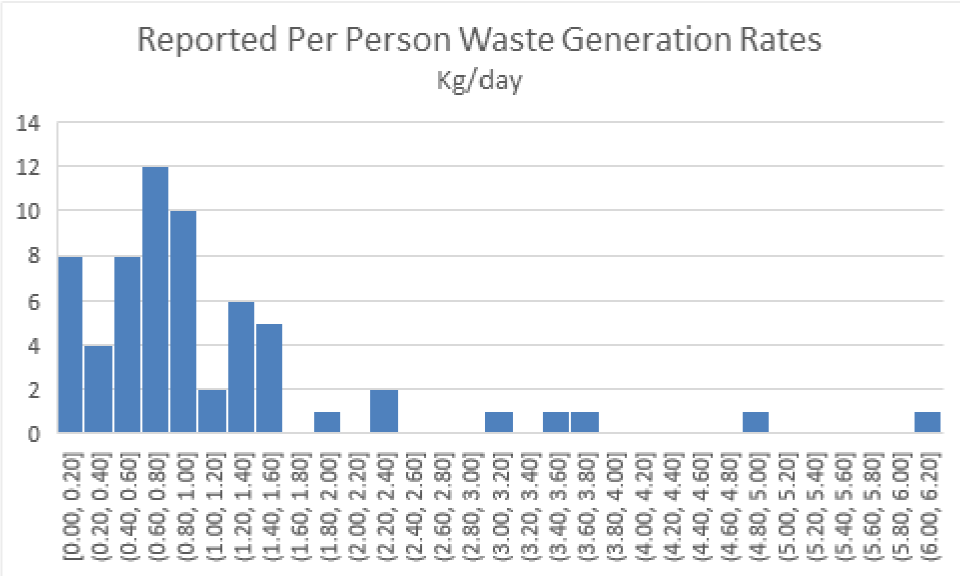

Figure 3 Reported waste generation rates per person

In order to calculate the commercial waste generation rates, an attempt was made to extrapolate that value by comparing the reported waste generation rates to the expected waste generation rate. The latter was determined by multiplying the population by the average waste generation rate in rural areas, the value of which was determined from the 'State of the Environment Report (SOER)' published in 2021. SOER states the following: "The average unit generation rate is estimated at 0.95 – 1.2 kg/cap.d in urban areas and 0.8 kg/cap.d in rural areas, with a country weighted average of 1.05 kg/cap.d3 (MoE/EU/GFA, 2017, SWEEP-net, 2014). To note that the aforementioned SW generated rates may not apply beyond year 2019"

However, when viewing the difference between these two values, highly variable and unusual numbers were observed, indicating the possibility that the reported waste generation rates may be under or overestimated in some instances. Such a method would yield problematic results when comparing it with the number of reported establishments, with high discrepancies. In addition, municipalities with small populations would typically exhibit higher reported per person waste generation rates when dividing the waste generation by the population, which would not allow the comparison with the average rural waste generation rate per person. Hence, this method was eliminated.

2.4.2. Commercial

The different commercial establishments for the surveyed municipalities were also assessed. The categories to which they belong are the following:

- Education establishments including: schools, universities, and teaching institutes
- Farming establishments including: poultry farms, livestock farms, butchers, and slaughterhouses
- Touristic establishments including: restaurants and hotels
- Agricultural establishments such as retail vegetable markets, wholesale vegetable markets, agricultural coops, agricultural mills, and factories

The map below in figure 4 shows the total number of commercial establishments per municipality. Note that this map disregards retail vegetable markets and butchers, since any variation in the reported number of these two factors can contribute to the total number of commercial establishments in a way that makes the comparison between municipalities inaccurate. For instance, if one large municipality underestimated the total number of butchers due to its large area and inability to accurately assess all butchers on its lands, this will drive it closer to a municipality with much less commercial activity but which has reported all available butchers. The same holds true for retail vegetable markets.

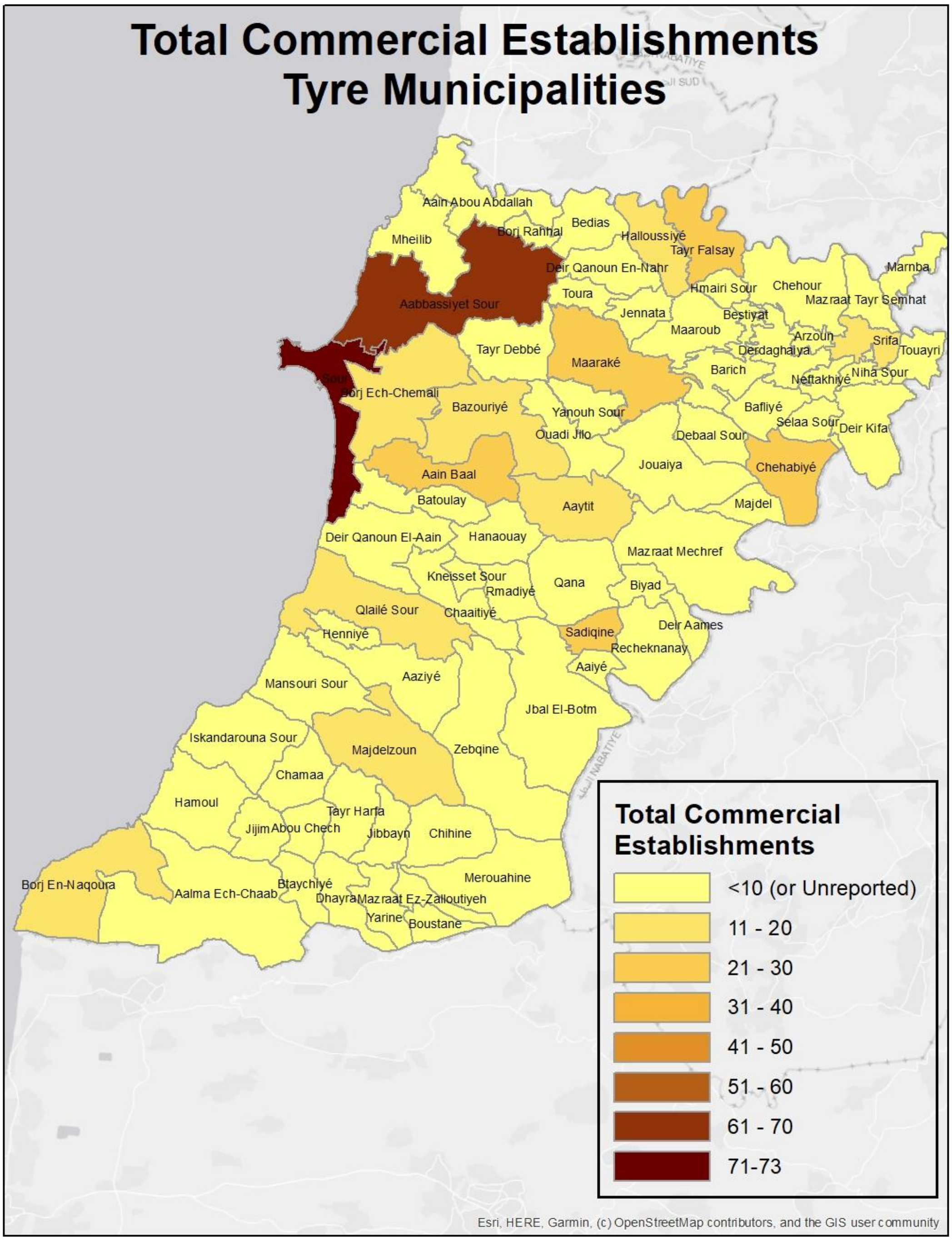

Figure 4 Total commercial establishments

The map shows that the municipalities that host the largest number of commercial establishments are Tyre and Abbassiyyeh. Most other municipalities hold similar, less significant, values. For Tyre, this is reasonable considering its touristic nature. Tyre is host to a number of hotels, resorts, restaurants, and other service facilities and receives a number of local and international tourists every year, especially in the summer season. A number of these establishments are localized near the Tyre beach whereas the remaining are more spread out. Abbassiyyeh has more spread out establishments in comparison.

When looking at educational establishments, Tyre and Abbassiyyeh also have the highest number. In addition, nearby municipalities such as Berj El Shmali also have a high number of educational establishments compared to farther ones. This is expected when considering that usually the number of educational establishments increases when approaching the big cities in Lebanon.

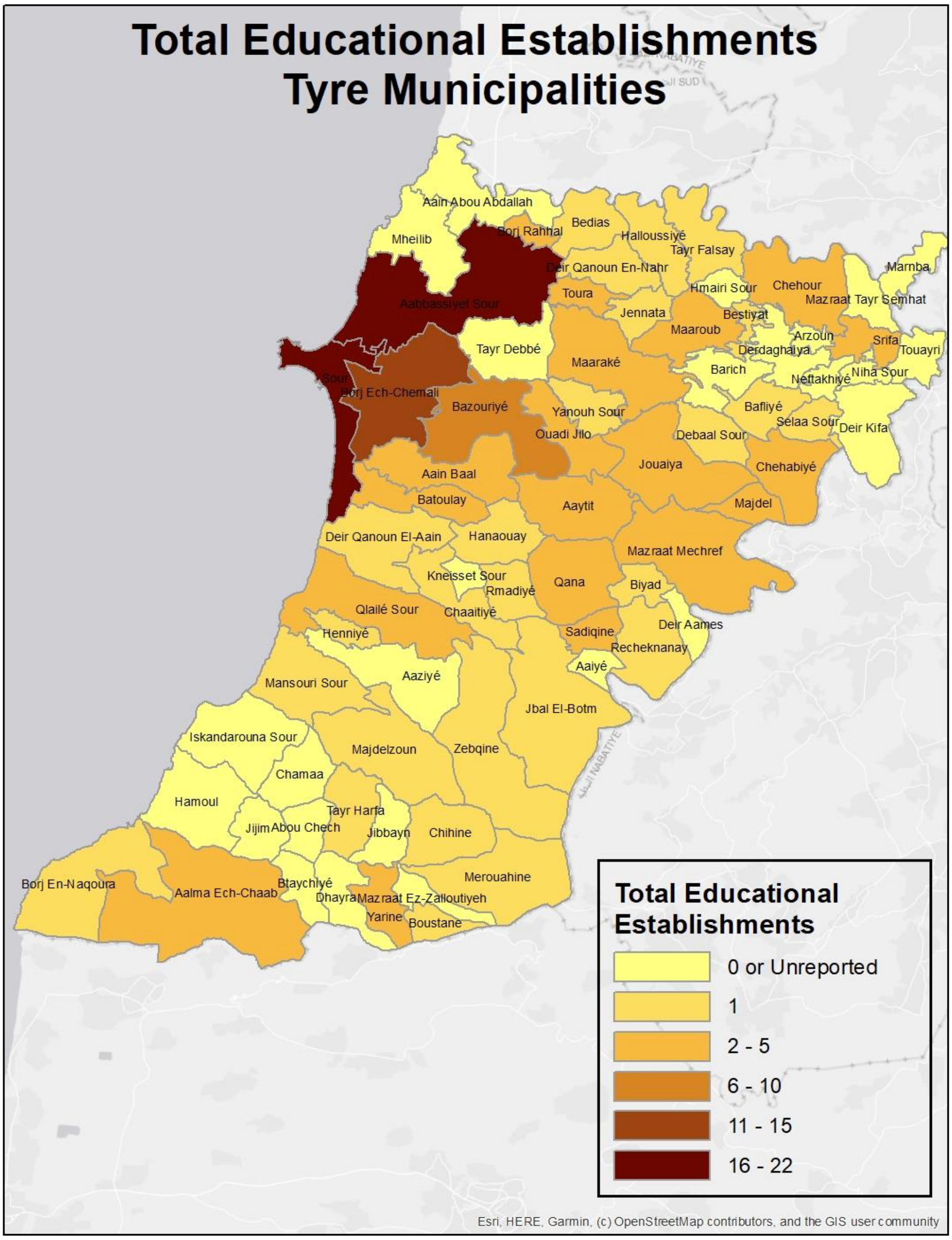

Figure 5 Total Educational Establishments

The total number of agricultural establishments show more of a clustering pattern, in which a number of close municipalities have more agricultural establishments than the adjacent ones.

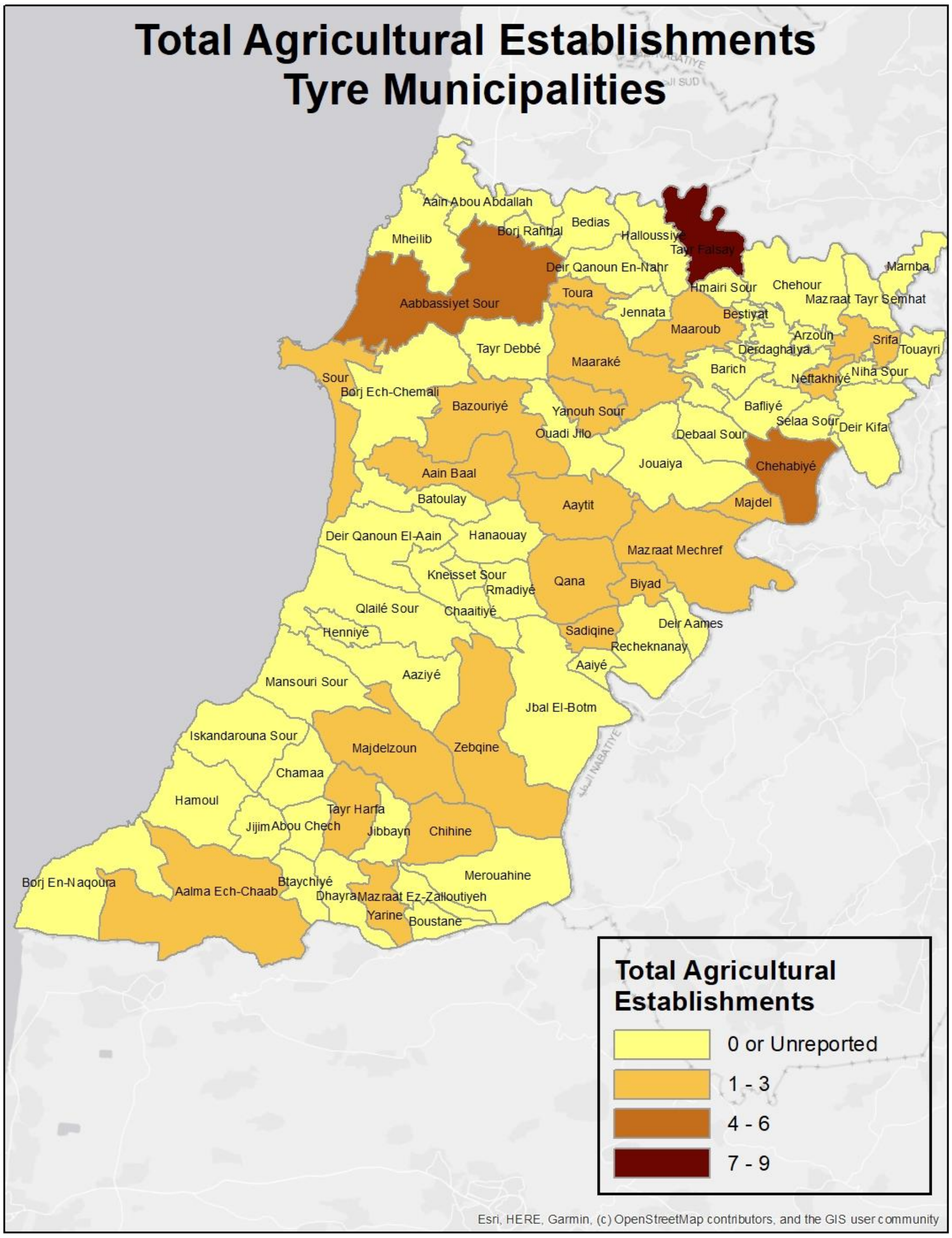

Figure 6 Total Agricultural Establishments

2.4.3. Agricultural

The agricultural map of Tyr (shown in figure 7) was obtained by intersecting the land use and cover map (shown in the annex 9.5) and the map of Tyr to know the categories of crops and the area they cover in each village, in hectares. Then a series of calculations were performed to get the tonnage of biomass per village (shown in annex 9.5)

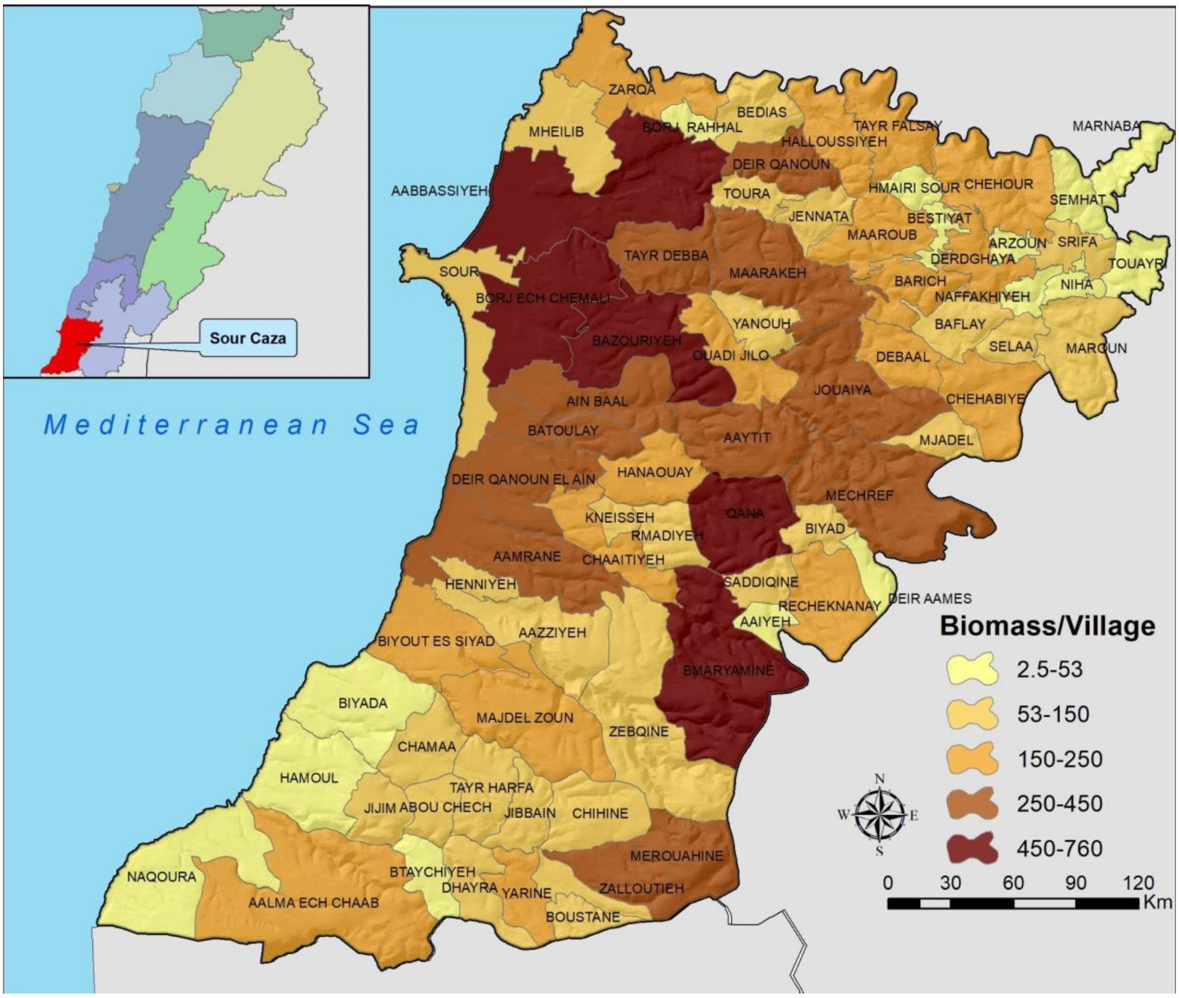

Figure 7 Agricultural Biomass per Village

In this map, banana trees were not taken into consideration even though they produce high amounts of residual biomass. This is because they have a high moisture content, and are rich in nitrogen thus they cannot be used as carbon material. In addition to that, oak trees were also not considered even though they cover a large area of the Caza, they are assumed to be mainly forests that are not subjected to maintenance and frequent pruning.

2.5. Emission Estimation Using SWEET

2.5.1. SWEET

In order to assess the impact that the closure of the Ain Baal MBT and the onset of the economic crisis and the COVID-19 pandemic on GHG and SLCP emissions, the Solid Waste Emissions Estimation Tool (SWEET) was applied to quantify this effect in addition to any potential future emissions reductions that may arise as a result of adopting various waste management scenarios. SWEET was developed by the U.S. EPA, under the auspices of the Global Methane Initiative and in support of the CCAC, the latest published version of which (v. 3.1) was applied to the previous emissions estimate study for Tyre in 2019. An updated version (v. 4.0) has been developed and was applied to this present study as a pilot.

SWEET provides estimates for the full suite of SLCPs and other GHG emissions in the waste sector, including methane, black carbon, carbon-dioxide, nitrogen oxides, sulfur oxides, particulates, and organic carbon.

Emissions sources covered include: (1) waste collection and transportation; (2) open burning of waste; (3) landfills and open dumps; (4) organic waste management facilities (composting and anaerobic digesters); (5) waste-to-energy facilities; and (6) waste handling equipment.

SWEET can analyze multiple waste management scenarios while incorporating disposal site data and an accounting of collected wastes over a 100-year period. LFG generation and recovery are calculated using default model assumptions derived from U.S. EPA's Colombia Landfill Gas Model, which includes adjustments to account for the effects of site conditions including climate. SWEET provides annual SLCP emissions estimates which can be used to evaluate the effects of waste management planning decisions over the short- and medium-term horizon.

Version 3.1 of SWEET used in the 2019 report had added value over previous versions in that it had the ability to evaluate the effects of dumpsite closure and remediation on emissions and allowing user flexibility in assigning various rates of open burning over time in alternative scenarios, which yields more realistic estimates of black carbon emissions. Some of the major changes from SWEET v 3.1 to v 4.0 included revisions to emissions calculations for organics management facilities were made by applying emissions factors listed in US EPA's Waste Reduction Model (WARM), including:

- Revised methane emissions factors for anaerobic digestion (AD) and composting facilities.
- Nitrous oxide (N_2O) emissions from AD and composting facilities were added to SWEET using WARM emissions factors and a GWP of 298.
- SWEET now includes emissions reduction from increased carbon storage that occurs when compost or AD digestate is applied to soils, which is calculated as net emissions reduction after accounting for transportation emissions and compost volume losses.

The results of the 2019 study for Tyre District were therefore rerun using SWEET (v4.0), illustrating the effect of implementing various waste management scenarios can have on emissions reduction as opposed to the business-as-usual model.

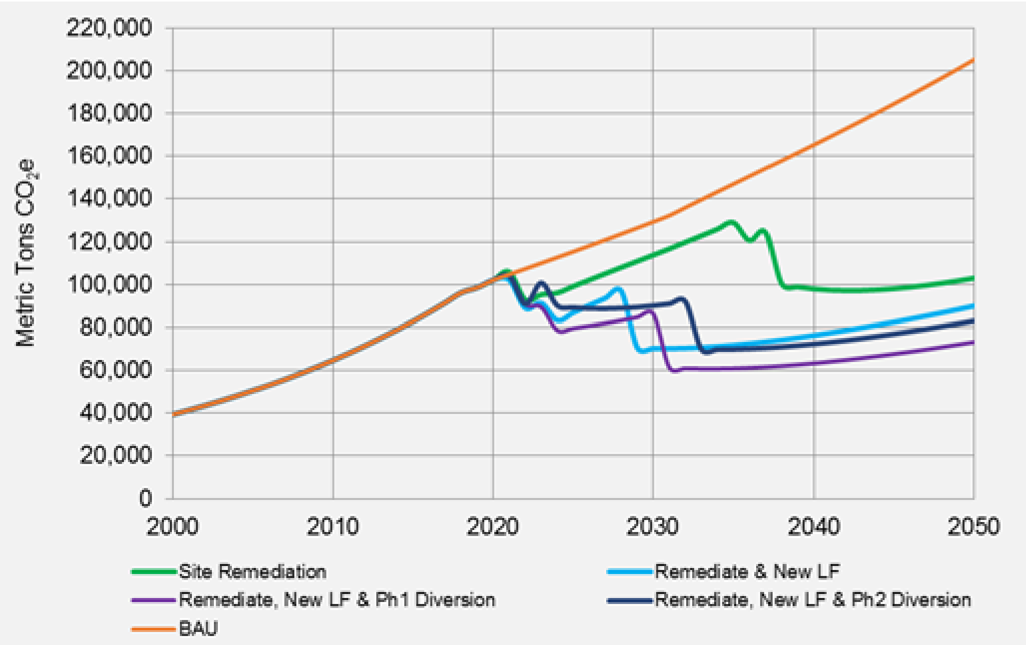

Figure 8 Effect of various waste management scenarios on emissions

For the purpose of this study, the SLCP emissions under business-as-usual were initially compared to illustrate the difference in between pre- and post- crisis scenarios (2019-2020). Due to the significant drop factor in the overall waste generation (24.43%) a dip in the new BAU can be seen in the graph below.

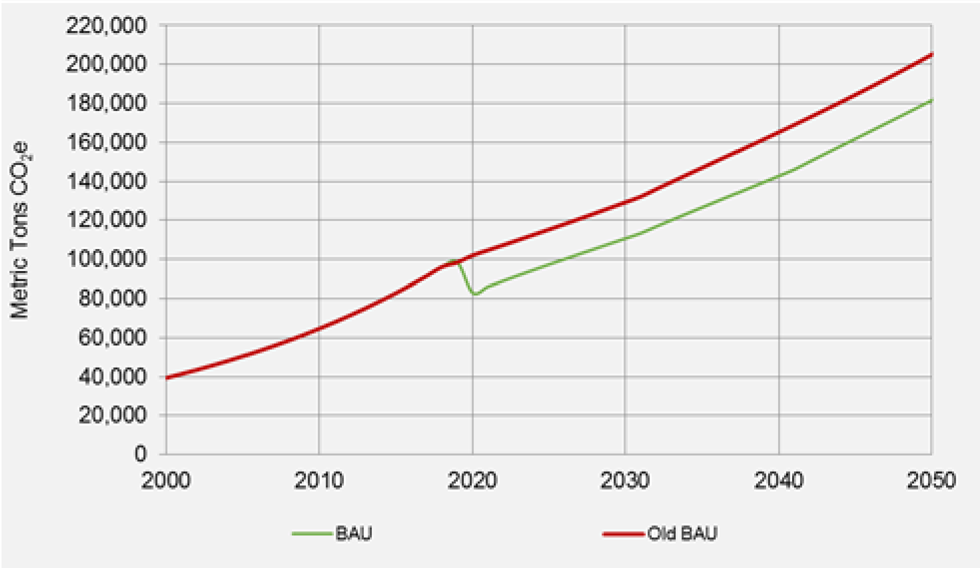

Figure 9 Comparison Graph of old and new BAU

2.5.2. Calculation of Transportation Parameters

The following information was collected to calculate the values of the transportation parameters, namely:

- Distance to disposal site
- Number of heavy and light trucks
- Total weekly distance traveled

The distance to the disposal site (dumps in most municipalities) was retrieved from phone surveys with the municipalities. These values were used as received.

The next step was to determine the number of heavy and light trucks. In some cases, these were given directly by the municipality representatives, however, in other cases, these needed to be extrapolated. For instance, some heads of municipalities referred to their trucks using descriptive words such as ‘truck’, ‘pick-up’, ‘big truck’, etc. These were converted into either ‘heavy’ or ‘light’. Refer to annex. 9.2 for the conversions.

Others gave general information about the number of trucks they had. In such cases, it was necessary to determine what category these trucks fell into. This was done by analyzing the number of trips that the trucks performed in a certain time period and comparing it with the waste generation rate. Such analysis enabled the determination of the capacity of these trucks and thus to categorize them. Most trucks were determined to be light trucks, and this is expected considering the size of the municipalities that were studied.

For instance, the municipality of ‘Berj Rahhal’ declared that they had 3 trucks for waste collection. They also stated that their total waste production is around 9 tons per day. Assuming a waste density between 300-400 kg/m^3, 9 tons per day would give around 25 m^3 of waste daily, meaning that around 8.5 m^3 per truck. These were considered to be light trucks.

Annex 9.2 summarizes the assessment for the remaining municipalities.

Finally, in order to determine the total weekly distance traveled, the weekly number of truck trips to the disposal site (from survey) was multiplied by the distance to that site.

3. SET TARGETS FOR ORGANIC WASTE DIVERSION

3.1. Lessons Learned from Past Successes, Barriers and Opportunities

Ain Baal Facility

The Ain Baal mechanical biological treatment (MBT) facility, located about 8 km east of the city of the Tyre, was originally constructed in 2009 by OMSAR with a fund from the European Union as a centralized facility designed to treat approximately 150 tons/day of mixed waste and a processing capacity of about 90 tons/day of organic waste at the composting facility. Due to design limitations and operational challenges at the facility, and the desire to accept more waste from more municipalities in the District, the MBT was upgraded in 2018. This included a capacity increase up to 200-250 ton/day (depending on number of shifts) as well as other improvement to the sorting lines and equipment, addition of a compost maturation hangar, an odor control system, and a leachate collection system.

The original composting system at the facility relied on tunnel composting technology, consisting of 10 windrows separated by concrete walls, each 50m in length, 2m in width, and 2.3m in height. Air is introduced in the windrows by mechanical turning equipment that mixes the organic material in addition to forced aeration by blowers that pump air through a network of embedded pipelines underneath each windrow. It also has a drainage system for the stone bed to collect and remove leachate. When the facility was upgraded, no modifications were made to this component, but instead a second phase for composting was introduced that consisted of a new hangar that would allow maturation in windrows, refinement, and storage of compost. The dimensions of the hangar are 90m length and 25m width.

However, based on the evaluation of the upgraded MBT facility conducted by OMSAR prior to commissioning the upgraded facility, the lack of modification of the first phase of the composting system (the most important stage) could seriously impact the entire process. The bottom of the windrows was completely compacted, thereby not allowing for drainage nor for proper aeration. Additionally, the blowers appeared to be too small and even non-operational.

Despite the improvements to the plant, operations at the facility inevitably suffered from frequent complaints of odor and mismanagement. During the operation, the turning equipment that was never replaced would frequently break down and the cost of maintenance and spare parts were so high that the contractor could not afford them. Without adequate turning, organic material is not able to aerobically decompose properly and releases greater amounts of foul odors. Moreover, the newly installed biofilter was not operated properly, with the media inadequately irrigated rendering the equipment essentially ineffective.

Although the incoming capacity of the waste was significantly reduced as a way to mitigate the odor issue, it could not be properly controlled. In addition to various other contractual issues, the Union of Tyre Municipalities ultimately decided to cease operation of the facility and resorted to simply dumping of waste in various different locations throughout the District.

Regional Master Plan

The Regional Master Plan developed by OMSAR in 2018 applied an integrated approach to waste management and proposed reorganizing the collection system that prioritized segregated collection of 4 different waste streams: organics, recyclables, special waste and residuals. The plan set out targets for resource recovery targets over a 15-year period:

- Recyclables: To capture 60% of the recyclables in the waste stream by 2025 and 66% by 2032 through proper source separation programs and some additional recovery by the existing facility.

- Organic fraction: To capture 15% of the organic fraction by 2025 and 35% by 2032 through source separation programs

- Green Points: Divert 5% of the waste generated through Green Points. This will be roughly 40% bulky recyclables and 60% special waste streams (e-waste, white goods, furniture, mattresses, etc.), based on similar experiences.

Based on the District's land use classification, the Plan divided the region into a system of clusters using various criteria, including physical planning, environmental, techno-economic, and social criteria. A system of transfer stations was proposed to link the waste collection system together. The transfer stations (including Ain Baal) would not only potentially serve as collection points for waste but can also serve as collection points for specific waste streams such as organics or special waste that can then be taken directly to their respective treatment facilities once established.

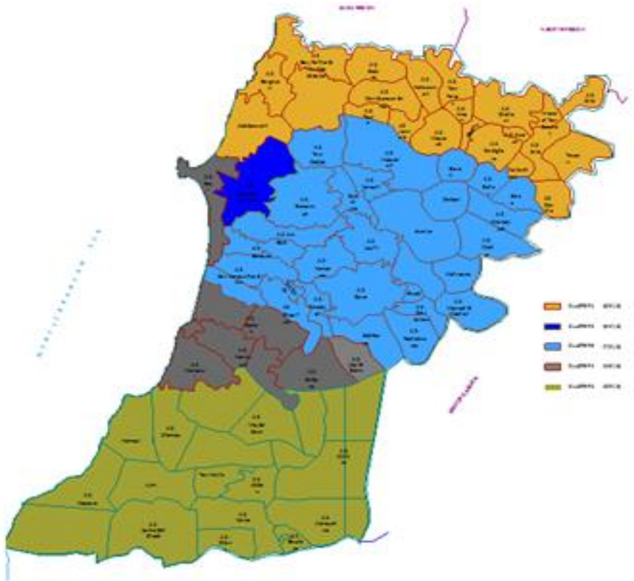

Figure 10 Indicative waste collection clusters of municipalities and zoning

The Ain Baal facility would act as the central location where residual waste is treated prior to final disposal. Once the segregated collection system for non-organic and organic waste is implemented and enforced, the frequency of residual collection could be decreased. According to the waste flow model, the implementation of the master plan would result in a gradual reduction in the treatment capacity required.

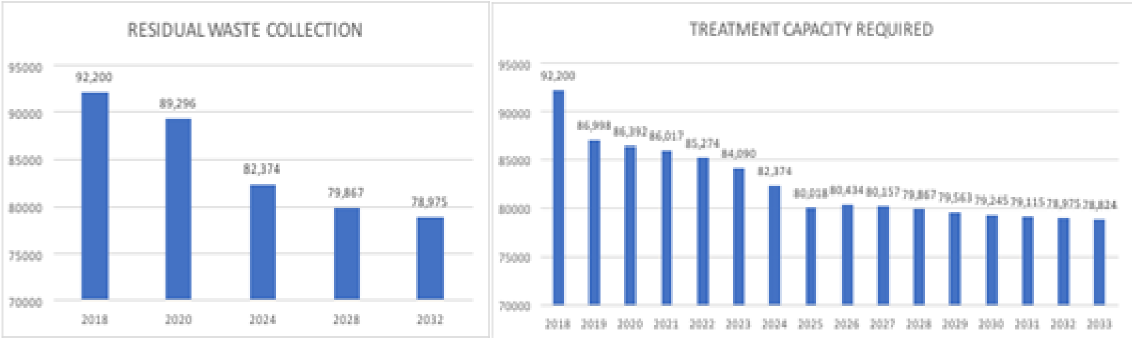

Figure 11 Residual waste collection and treatment capacity required

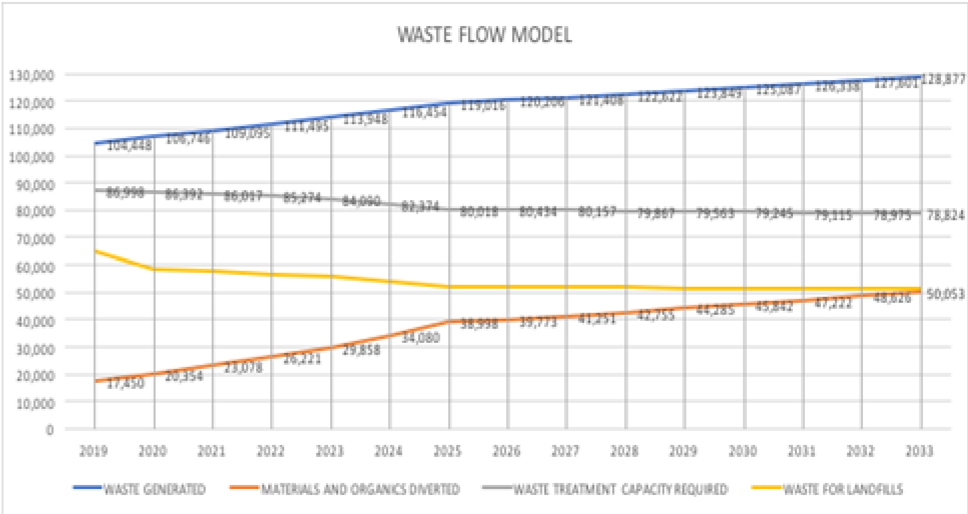

Figure 12 Waste flow model

Due to high recycling targets, less recoverable materials will be found in the input waste stream, and they will be characterized by poorer quality. Therefore, it would be expected that no more than 25% of the incoming materials will be subject to sorting and recovery. This means that the main purpose of the treatment plant will not be to sort materials, as this would be implemented by the source separation programs, but to manage – stabilize the organic fraction and prepare useful products like RDF and Compost Like Output.

Success Stories

In 2018, Kawkaba municipality took major steps to achieve sustainability in waste management. They followed a three stages plan which consists of raising awareness on source separation, installing a waste recovery facility for recyclable waste, and installing a composting facility for organic waste management. The municipality, the community and other relevant stakeholders (i.e., community-based organizations, local farmers, local agro-food industries) were all involved in the implementation of the proposed pilot. They led an awareness campaign which included brochures, door-to-door communication and meetings and conferences on the importance of sorting at source. Their SWM system depends on a collection process founded on household primary sorting, in which bags of different types of waste are collected daily by a municipal truck. In addition to that, NGOs fund the facility's capital expenditure, and all operational costs are financed by the municipality. As a result, Kawkaba now operates a Clean MRF and a successful composting facility which processes a total of 0.5 Ton per day of organic waste.

3.2. Strategy

At the country level, several factors have led to the increase in the solid waste burden in Lebanon according to the SWEEP-Net Lebanon country report on the solid waste management published in 2014. The factors included are the following:

- Population growth
- Rapid growth of the urban areas and the big cities
- Absence of legal framework and poor enforcement of the law
- Contradiction in environmental policies
- Social habits that do not encourage waste minimization
- Social keenness to use new materials rather than used ones
- Increased number of Syrian refugees

Also, a very important challenge that is usually faced is the citizens' opposition to any waste management operations in their neighborhoods which is a common phenomenon called Not in My BackYard (or NIMBY effect). Particularly in Lebanon, where most of the waste management operations have been failing due to one or more of the above-mentioned reasons, this phenomenon must be well addressed to assure the best composting practices that ensures the success of captivating or suppressing any undesirable outcomes such as air, soil, and sound pollutions.

In a case study related to small community-based composting plants, 11 small community-based composting plants were built in selected municipalities throughout Lebanon, particularly in the south. The project was funded by USAID and other NGOs including YMCA, PM, and CAII. Some of these plants suffered considerable operational problems which are due to technical failure in the systems, or to financial, institutional and/or legislative barriers. Moreover, the absence of sorting at the source and proper sorting and refining units at the plant is a major obstacle for the production of good quality compost and hence its marketability. Also, the scale of the plants would not allow to develop economies of scale that would reduce overall costs and would also focus available technical expertise on fewer facilities for which higher levels of performance would be feasible.

Thus, the technical lessons learned were focusing on the importance of the adaptability of the technology selected to Lebanon, specifically to each region, and on the technical tolerance of the technology that should be of low maintenance and of low operation failures.

Also, since 2019 the country has been through a rough socio-economic crisis starting with a currency depreciation followed by the COVID-19 pandemic that affected the government and all its entities financially. The SWM plan is not considered a priority to municipalities anymore with most of them being reactive to the successive crises they are facing, neglecting important matters that do not seem urgent at the moment.

The project seeks to address the challenges of organic waste diversion from landfills by proposing alternative measures relying on a multi-level decentralization model composed of three main keys.

- A balanced input of materials that ensure a proper composting process can take place
- A suitable location for the composting process to be conducted at, which has to be adapted to the area's specific needs and context.
- The design and implementation of an effective monitoring system to ensure the success of the process, by identifying and solving issues that arise throughout the implementation phase.

It is important to note that advanced organic treatment techniques such as anaerobic digestion have been eliminated as possible interventions considering the recent economic collapse and overall instability of the country. These techniques have high capex and opex requirements compared to basic composting techniques. In addition, precise operational conditions need to be maintained throughout their functioning, and this is extremely difficult when basic infrastructure such as water, electricity, and fuel are currently limited in availability.

The composting process

A good composting process relies on a mix of carbon material, such as garden waste, and nitrogen material, such as food scraps. As kitchen waste makes up the majority of waste in households, restaurants and hotels, it is a material which everybody can access easily.

Knowing that in the targeted area, many households and homestead owners in that area have one or more pieces of land that some agricultural activities take place. However not all of them do, and the project should not expect all the residents to have access to home composters. This is why it is important to communicate with citizens and find the best solution to manage leftover pruning and agricultural waste that is deemed important to any composting intervention. One of the solutions can be a roaming chipper/shredder that processes the agro waste on the go, or a community drop zone for agro waste. This carbon material is then distributed to residents throughout the region or transformed to the nearby composting facilities.

The composting options

Four composting options are to be offered to the region’s inhabitants based on the population density as a priority, then the distance between the targeted area and the nearest existing composting infrastructure.

A. Individual composting (IC)

This consists of home composters *(Such as the Meshbox or 250L HDPE Composting Bin)* for households with enough space to host them. They are distributed to households in scattered areas with a small population size that generates less than 250 kg of organic waste per day.

A strong communication strategy should be targeting these inhabitants so they could correctly manage their own waste. It should include all the needed management procedures such as turning, watering, troubleshooting methods. This would minimize the reliance on any superior entity or personnel and would engage the people in composting.

B. Community composting (CC)

These are made of composting boxes and a community will have access to either 3, 5, 6 or 10 composting boxes together in one location, depending on the community’s size, to ensure sufficient space for a proper composting process to take place. Community composting sites are set up in densely populated areas generating organic waste between 250kg and 1.5 tons per day.

Similarly, a communication strategy should take place to increase the inhabitants’ awareness on waste management practices. However, in this case trained personnel (Master Composter) should be regularly following up on the process and record all the parameters (i.e., temperature, humidity, odor intensity) so the municipality or any superior entity would keep track of the process and could diagnose any occurring problem to take the right corrective measures. This person should be in close contact with a community representative so he can be the go-to person when any problems arise.

C. Local composting facility (LCF)

For semi-urban areas with a population with organic waste generation ranging between 1.5 and 6 tons per day where home composting or community composting is not an option, small scale composting plants must be established to treat the generated biowaste.

This option dictates the need for a waste transportation method connecting the source of waste production to the LCF. Many options are available including a public collection service door to door or depending on large bins. It is important to focus on the quality of waste segregation to ensure an acceptable compost with minimal errors that usually result in putrid odors. Also, manual segregation at the facility would be a good option.

D. Central composting facility (CCF)

For urban areas with a large population generating more than 6 tons of organic waste per day, central composting facilities must be established for treatment of the organic waste. Those facilities must be able to process the municipal waste in addition to any agro-industrial waste from large producers. Those plants should be designed to treat all waste produced within a 6.5 km radius in addition to any large amount of commercial waste in the region.

This option also dictates the need for a waste transportation method connecting the source of waste production to the CCF. It is important to focus on the quality of waste segregation to ensure an acceptable compost, but given the large quantities it is understandable to face challenges in sorting quality. This is why more automated solutions for segregation at the facility should be adopted given the large amount of waste received periodically.

Note that waste segregation from source should always be the key aspect for a successful intervention in the region. Collection schemes and communication strategies should be further developed in accordance to a time plan that gradually integrates the population in the program.

The following map in figure 13 shows the amount of organic waste generated per village in tons per day. As shown, the highest generation is found in Tyr, Aabbasiyyeh, Ain Baal, and Jouaiya which produce more than 6 tpd.

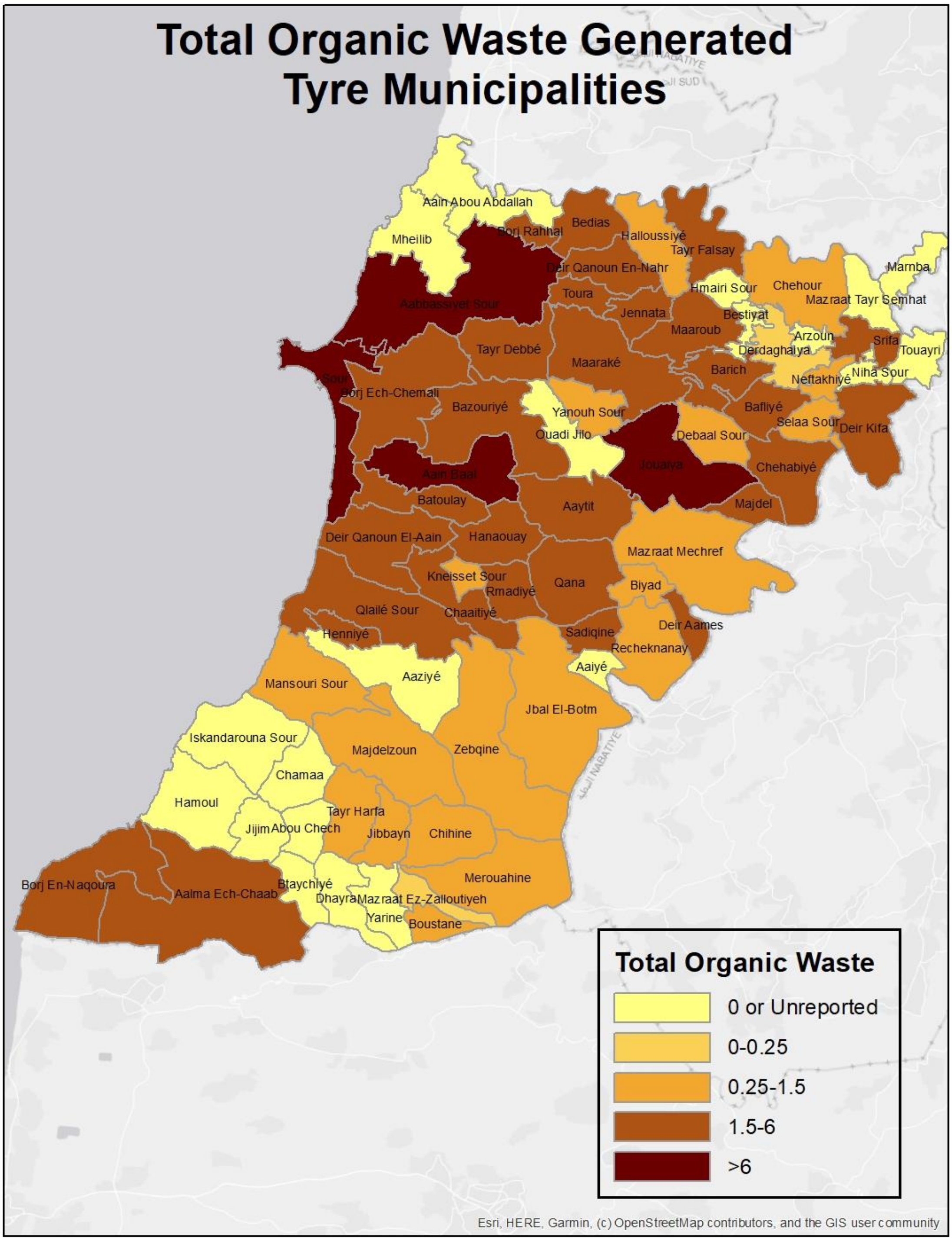

Figure 13 Total organic waste generated

3.3. Analysis of results

According to the organic waste generated map shown above in figure 13, since the highest generation rate is found in Aabbasiyyeh, Ain Baal, Tyre, and Jouaiya, and according to the composting options stated above, these villages were chosen to have Central Composting Facilities (denoted by a red star in the map below figure 14). The other villages are color coded to show which central facility they send their organic waste to, or to show which composting option they apply. These were decided based on the four composting options stated in section 3.2.

- If the location is in an urban setting where the generation of organic waste is more than 6 tpd, opt for the central composting facility (CCF). This facility should encompass any small village within 6.5 km radius (driving distance to be determined, ideally less than 12km).
- If the organic waste generation is between 1.5 and 6tpd, opt for the local composting facility option (LCF).
- If the organic waste generation is less than between 0.25kg and 1.5tpd, opt for the community composting method (CC).
- If the organic waste generation is even less than 250 kg per day, opt for the Individual composting option.

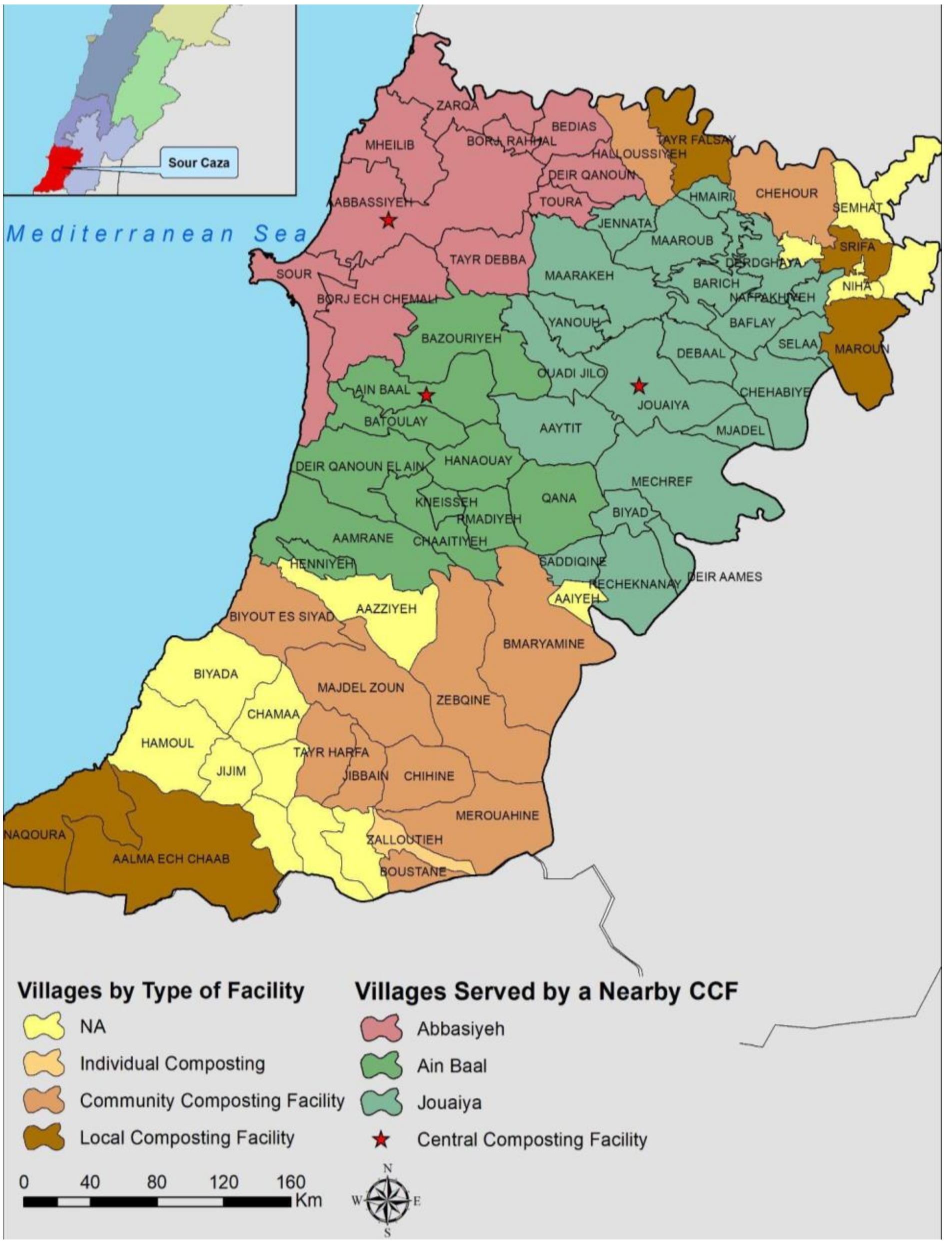

Figure 14 Types of facilities across different villages

This table shows the organic waste generated and the optimal disposal plan decided on for each village.

Table 4 Organic waste generated and optimal disposal plan of the villages

Village	OWG	Optimal Disposal Plan	Village	OWG	Optimal Disposal Plan
Abbassiyyeh (Sour)	**20.35**	**Abbassiyyeh CCF**	Jennata	1.65	Jouaiya CCF
Aalma Ech Chaab	**2.73**	**LCF**	Jibbain	1.10	CC
Aamrane	5.23	Ain Baal CCF	Jijim	0.00	NA
Aaytit	1.93	Jouaiya CCF	Jouaiya	7.70	Jouaiya CCF
Aazziyeh	0.00	NA	Khreibeh (Qana)	4.13	Ain Baal CCF
Abou Chech	0.00	NA	Kneisseh (Sour)	0.28	Ain Baal CCF
Ain Baal	7.70	Ain Baal CCF	Maarakeh	5.78	Jouaiya CCF
Arzoun	0.00	NA	Maaroub	5.50	Jouaiya CCF
Baflay	2.20	Jouaiya CCF	Majdel Zoun	0.62	CC
Barich	1.65	Jouaiya CCF	Marnaba	0.00	NA
Batoulay	5.50	Ain Baal CCF	Mazraat Aaiyeh	0.00	NA
Bazouriyeh	2.20	Ain Baal CCF	Mazraat Ain Ez Zarqa	0.00	Abbassiyyeh CCF
Bedias	2.75	Abbassiyyeh CCF	Mazraat El Mechref	0.61	Jouaiya CCF
Bestiyat	0.00	Jouaiya CCF	Mazraat Ez Zalloutieh	0.24	IC
Biyad	0.44	Jouaiya CCF	Mazraat Tayr Semhat	0.00	NA
Biyada (Sour)	0.00	NA	Merouahine	0.55	CC
Biyout Es Siyad	1.10	CC	Mheilib	0.00	Abbassiyyeh CCF
Bmaryamine	**0.83**	**CC**	Mjadel	4.68	Jouaiya CCF
Borj Rahhal	4.95	Abbassiyyeh	Naffakhiyeh	1.24	Jouaiya CCF

		CCF			
Borj Ech Chemali	3.54	Abbassiyyeh CCF	Naqoura	2.48	LCF
Boustane (Sour)	0.62	CC	Niha (Sour)	0.00	NA
Btaychiyeh	0.00	NA	Ouadi Jilo	0.00	Jouaiya CCF
Chaaitiyeh	3.30	Ain Baal CCF	Qalaat Maroun	1.65	LCF
Chamaa	0.00	NA	Recheknanay	0.41	Jouaiya CCF
Chehabiyeh (Tayr Zebna)	5.50	Jouaiya CCF	Rmadiyeh	1.65	Ain Baal CCF
Chehour	0.96	CC	Saddiqine	4.68	Jouaiya CCF
Chihine	0.28	CC	Selaa	0.41	Jouaiya CCF
Debaal	1.10	Jouaiya CCF	Sour	20.63	Abbassiyyeh CCF
Deir Aames	4.95	Jouaiya CCF	Srifa	5.50	LCF
Deir Qanoun El Ain	1.65	Ain Baal	Tayr Debba	5.29	Abbassiyyeh CCF
Deir Qanoun En Nahr	5.50	Abbassiyyeh CCF	Tayr Falsay	1.93	LCF
Derdghaya	0.22	Jouaiya CCF	Tayr Harfa	0.47	CC
Dhayra	0.00	NA	Touayri	0.00	NA
Halloussiyeh	1.10	CC	Toura	3.58	Abbassiyyeh CCF
Hamoul	0.00	NA	Yanouh (Sour)	0.55	Jouaiya CCF
Hanaouay	2.06	Ain Baal CCF	Yarine	0.00	NA
Henniyeh	5.50	Ain Baal CCF	Zebqine	0.55	CC
Hmairi Sour	0.00	Jouaiya CCF			

3.4. Approach for Selecting Initial Pilot Location

In order to start a successful pilot that can be built on, it is essential to showcase a successful model by targeting commercial establishments as a starting point and eventually increasing the fraction on a voluntary basis to include households that are willing to contribute and participate in the project. Selecting an initial pilot location is highly dependent on where there is feedstock security as it is least likely to fail.

3 Scenarios for the initial pilot locations are being considered

A. A Central Composting Facility (CCF) in Aabbasiyyeh: since the organic waste generation is more than 6tpd. Also, it is in a partnership with Tyr, meaning it encompasses the organic waste generated from Tyr and its neighboring villages.
B. A Local Composting Facility (LCF) in Aalma Ech Chaab: since the organic waste generation is between 1.5 and 6 tpd.
C. Community composting (CC) in Bmaryamine: since the organic waste generation is between 0.25 kg and 1.5 tpd and it also has high biomass.

Note that for the first scenario, originally, Aabbasiyyeh was selected as the initial pilot location since it has the highest portion of organic MSW and biomass according to the map shown in figure 15. This map is a combined map of the MSW generated and biomass of each village, and the villages shown contain high portions of both. In addition to that, the data surveyed from the municipalities showed that Aabbasiyyeh has high commercial waste generators. After a field visit to the village, it was noticed that most commercial waste generators were small scale restaurants that have insignificant waste generation, thus this pilot location was deemed unsuitable on its own. As a result, different options were discussed and it was decided that Tyr is the other priority location focusing on commercial waste generation. However, a visit to the area showed that Tyr does not have available land, thus a decision was made to create a partnership between Aabbasiyyeh (since it has available land and biomass) and Tyr (since it has high commercial waste generation), highlighted in the map of figure 16.

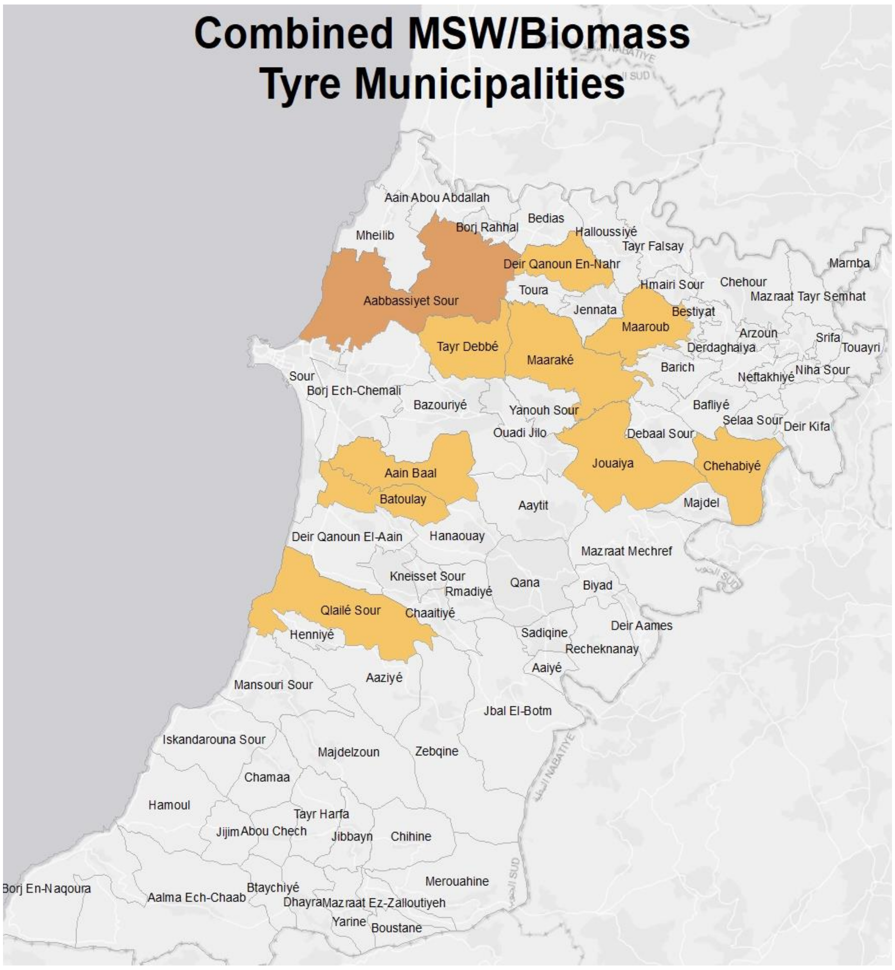

Figure 15 Combined MSW and Biomass map

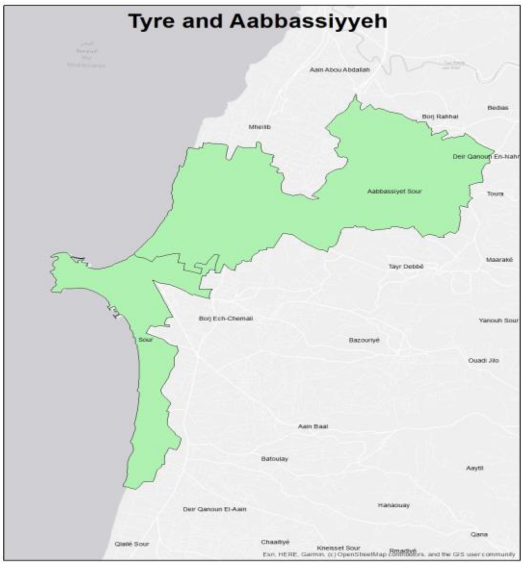

Figure 16 Tyre and Aabbassiyyeh municipalities partnership

For the second scenario, Aalma Ech Chaab was chosen because out of all the villages that require an LCF, it is the second highest organic waste generator that also has high biomass.

As for the third scenario, Bmaryamine was chosen because out of all the villages that need community composting, it has the highest biomass

3.5. Validation Through Ground Truthing

A field visit to Abbassiyyeh and Tyr took place to fill in gaps in the information and to validate the original data. This section summarizes the results, and based on them the first scenario mentioned above in section 3.4 was chosen

3.5.1. Abbassiyyeh

- Most of the village's waste comes from households. The houses around the municipality sort at source, but are not very efficient because the process is not monitored and some people do not sort. So, 7-8 tpd of organic waste comes from these houses.
- Commercial waste sources are:
    - 2 tpd from 3 major restaurants
    - 1 tpd organic waste from 2 hospitals (80 beds, 120 beds)
    - 1 tpd organic waste from 3 hotels (they have 4 hotels but one of them gives waste to chickens)
    - The village has 3 cow farms which have around 50 heads total
    - The village has 3 chicken farms which have 5000 chickens
    - There is a military base, but their organic waste is fed to a chicken farm next to them
    - Vegetable retail markets feed their organic waste to chickens also
    - There are no agro processors
    - There are 2 olive mills but the residual material is used to make soap

The rest of the waste is from households and other small restaurants or snacks and are mixed MSW. In addition to that, after the crisis, waste generation decreased, and most organics are being fed to animals since animal feed became expensive. It was noticed that there are no clusters of restaurants or hotels in the same place, they are spread all around the village, and most also closed due to the crisis.

As for site locations, the head of municipality suggested the facility could be built on the land that is near the dumpsite as it is for the municipality and is about 2000 to 3000 m2. It is far from the locals and has road access.

3.5.2. Tyr

- Commercial waste sources are:
  - Two whole-sale vegetable markets: the large one produces 5 ton waste every two days and the other smaller produces 1 ton every two days. The larger vegetable market visited is a hangar with about 15 rows of vegetable and fruit stands

Figure 17 Wholesale vegetable market in Tyre

  - Three large restaurants that produce 3 tpd of waste in total
  - 47 restaurants and 6 hotels
    - 10 – 12 restaurants, hotels, and cafés located at Nabih Berri street along the beach that produce around 2 tpd
    - 18 – 20 restaurants, café's, bars, and guesthouses located to the north that produce around 3 tpd
    - The rest are scattered all around and produce around 1 tpd

Figure 18 Cluster of restaurants in Tyre

- There are no have farms, agro processors, or mills.
- The military bases dispose of their waste elsewhere.
- They have 1 hospital in the informal settlement and the people living there take their organic waste

Concerning potential site locations, there is no land available.

3.6. Pilot Organic Waste Diversion Approach and Targets

The plan is to target the community by implementing a gradual integration process. This process solicits the community to contribute to the source separation of organics programs on a voluntary basis.

The reason behind gradual integration is to guarantee that all material collected is sorted at source and is free of contaminants, this is crucial to ensure that the end product is commercially sellable and residual and contaminated waste does not pile up on site. Hence, the model must set some initial community targets such as:

- For villages that do not sort, or sort minimally: beginning with 13% of the population and building the facility for 35% of the organic waste generation in the village and then expanding to this level within one year.
- For villages that sort some of the recyclables: beginning with 25% of the community and building the infrastructure for 50% of the organic waste generation, to reach within one year.
- For villages that already sort organic waste: beginning with 50% of the population and building infrastructure for 75% of the organic waste generation to reach within 1 year.
- For the small villages that do not sort at source, targeting higher than 13% because the community is easier to reach and communicate with, thus beginning with 40% to 50% of the population is acceptable.
- To ensure inclusivity during year one, bins will be set up to form drop off zones for community members who are willing to participate but are not included in the collection program.
- Dividing operations among the regions will result in economically efficient collection, however it might compromise the ability to rely strictly on voluntary participation.
- During the next year, the station can be expanded based on the performance of different projects, and their operation can evolve. This can be designed to leverage private investment.

As for the targeted quantity to pilot, according to the set gradual integration plan, the total quantity of organics that can be diverted from the waste mix can be estimated in the following tables for the 3 scenarios stated above:

Scenario 1: Aabbasiyyeh CCF

The targeted quantity to be piloted for the Aabbasiyyeh CCF is 17 tpd

Table 5 Quantity to be piloted for the Abbassiyyeh CCF

Village	Organic Waste Generated (tpd)	Partial Integration Rate	Targeted Quantity (tpd)
Abbassiyyeh (Sour)	20.4	25%	5.1
Bedias	2.8	40%	1.1
Borj Rahhal	5	40%	2
Deir Qanoun En Nahr	5.5	40%	2.2
Mazraat Ain Ez Zarqa	0	40%	0
Mheilib	0	40%	0
Sour	20.6	13%	2.7
Tayr Debba	5.3	40%	2.1
Toura	3.6	40%	1.4
		Total	**17**

Scenario 2: **Aalma Ech Chaab LCF** and **Scenario 3: Bmaryamine CC**

Table 6 Quantities to be piloted for the LCF and CC

Village	Organic Waste Generated (tpd)	Partial Integration Rate	Targeted Quantity (tpd)
Aalma Ech Chaab	2.732	45%	**1.25**
Bmaryamine	0.825	40%	**0.33**

Building on what was achieved in the proposed scenarios, there must be a gradual upscaling and expansion plan to target more areas and increase the capacity of the existing pilots. Starting with the first scenario, Abbassiyyeh facility will process 17 tpd of organic waste in the project's first year of implementation. This would cater for 27% of the total organic waste generated in the target area. The plan would be to expand the facility each year. Since the composting bunkers are planned to be installed, then each year a new bunker may be added in a modular way. Also, it is important to implement another facility to target a new area. In this plan, Jouaiya will be the second facility to be up and running. However, this replication could not be done until after two years after the success of the Abbassiyyeh pilot. Hence the following table forecasting 5 years into the project with including the capacities and the coverage rate in each year:

Table 7 CCF 5-year forecast

Location:	Abbassiyyeh			Jouaiya		
Type of Facility:	CCF			CCF		
OWG:	63.2			51.1775		
	Qty of Bunkers*	Capacity (tpd)	Coverage rate	Qty of Bunkers*	Capacity (tpd)	Coverage rate
year 1	3	17	27%			
year 2	4	26	41%			
year 3	5	33	52%	3	20	40%
year 4	6	40	63%	4	25	48%
year 5	8	51	80%	5	33	65%

** The quantity of bunkers needed excluding the buffer unit. Mainly the design must include an additional bunker.*

The same logic will be applied with the second and third scenarios if implemented adopting the following plans respectively:

Table 8 LCF 5-year forecast

Location:		Aalma al Chaab		Naqoura		
Type of Facility:		LCF		LCF		
OWG:		2.732		2.48		
	Qty of Containers*	Capacity (tpd)	Coverage rate	Qty of Containers*	Capacity (tpd)	Coverage rate
year 1	1	1.25	45%			
year 2	2	1.5	55%			
year 3	2	1.77	65%	1	1.25	50%
year 4	2	2	75%	2	1.6	65%

** The quantity of containers needed excluding the buffer unit. Mainly the design must include an additional bunker.*

Table 9 CC 5-year forecast

Location:		Bmaryamine		Merouahine		
Type of facility		CC		CC		
OWG:		0.825		0.55		
	Qty of CC bins*	Capacity (tpd)	Coverage rate	Qty of CC bins*	Capacity (tpd)	Coverage rate
year 1	19	0.33	40%			
year 2	24	0.43	52%			
year 3	29	0.52	63%	13	0.22	40%
year 4	34	0.61	74%	18	0.32	58%
year 5	39	0.7	85%	23	0.41	75%

** The quantity of community composting bins needed excluding the buffer unit. Mainly the design must include an additional bin.*

3.7. SWEET Based on Pilot Target

SWEET was used to estimate the impact that implementation of the three alternative scenarios for composting programs (starting in 2023) presented above (central, local and community) would have on SLCP emissions. The results demonstrated that the composting programs will have minimal impact on emissions generation, with the exception of Scenario 3, centralized composting facility, that would have a noticeable lower level compared with the usual scenario with a 6.4% decrease in total emissions by 2050.

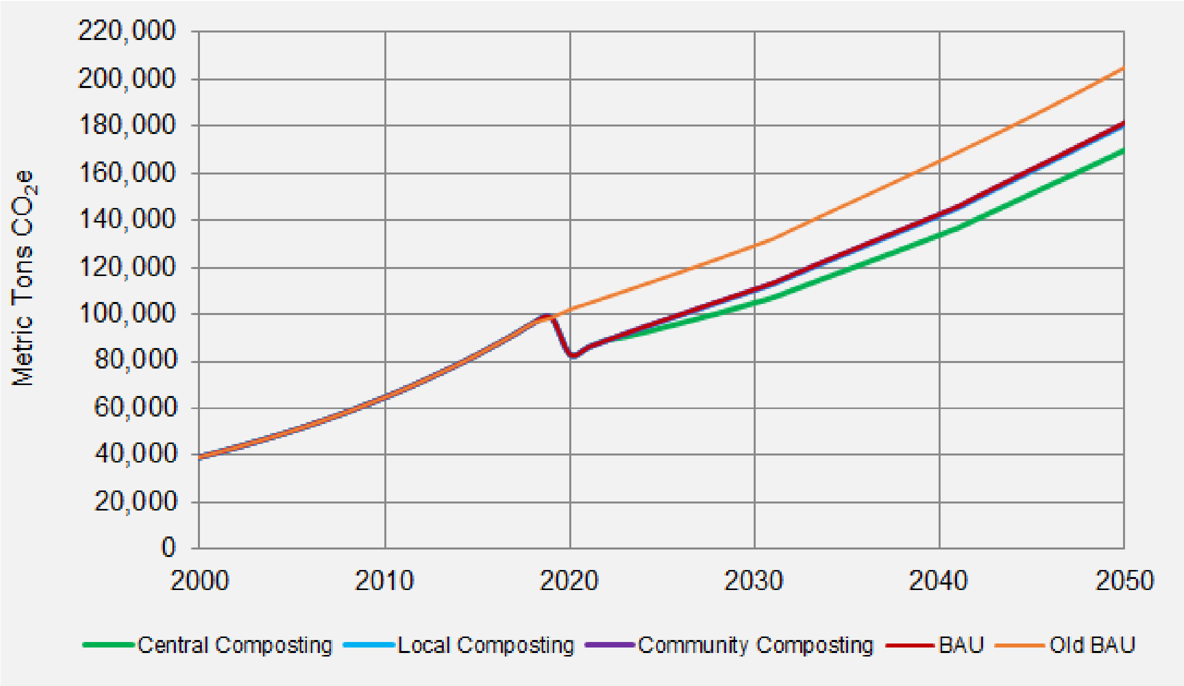

Figure 19 Composting scenarios emissions estimation results

4. Action Plan

4.1. Success Plan Drivers

With a goal of establishing a sound and integrated solution, the success of the intervention must build on previous success stories in the region and in the country, understand the limitations and challenges that caused the previous actions to fail, and work closely to answer the local context and cater to its needs. Core to addressing the target region's waste management challenge is understanding the key economic, social and environmental challenges they face and the existing opportunities.

Working closely and directly with local farmers in the area is one of the main pillars to the success of the intervention since they are the ones that consume the fertilizers and soil amendments and they also produce large quantities of pruning waste that must be processed and used in the composting pilots as carbon material and bulking agents. The plan must take into consideration the farmers' locations, road accessibility, type of crops cultivated, and the amount of crops spoilage annually.

Financing a SWM treatment facility in general is challenging given that many uncertainties may arise especially with the condition of the waste received and the quality of sorting differs which can pose a lot of risks vis a vis the uniformity of the end product. Therefore to attract a private sector investment through clear and innovative business models, there must be a guarantee in raw material quality (i.e., sorting status). Hence the need for clean waste flow that has a limited amount of rejects within the tolerable range. This can be established through working closely with agro-industrial entities that produce a relatively clean source separated organic waste resulting from spoilage and/or leftovers from their relative process (including potato peels, unwanted seeds, olive pomace, etc.). In addition, to selective households that are voluntarily willing to sort their waste in the correct manner.

Additionally, the profitability of the composting facility depends on receiving a clean stream of organic waste free of charge. The problem with transporting the waste is not only the cost that is associated with the fuel and the vehicles, it is also due to the high moisture content of the material that exceeds 90%. A large portion of the material transported would be water that is not really useful and will be mostly lost in seepage (in the form of leachate) and evaporation during composting.

Another key element in the success of the project is the cooperation with the local authority represented by the municipality and the union of municipalities. This would help in overcoming lots of challenges related to social objections and permitting disputes. The municipality by law has the final authority in any permitting process that happens inside its political border. Moreover, investing in community engagement and awareness for proper sorting must be done in line with the local people's needs and in close cooperation with the municipality for logistics and legal backup.

4.2. Scenarios for Intervention Based on the Targets Set and the Sources Discussed

The four composting options mentioned above are illustrated and explained in the diagrams below.

A. Individual composting

Households and commercial establishments provide organic waste that is sorted at source, and the tree pruning is provided by farmers and urban landscape. It is then collected by the municipality and turned into wood chips, and the organic waste and carbon material are taken to the composting sites for fermentation. The final compost product is then used for urban landscape and potter plants.

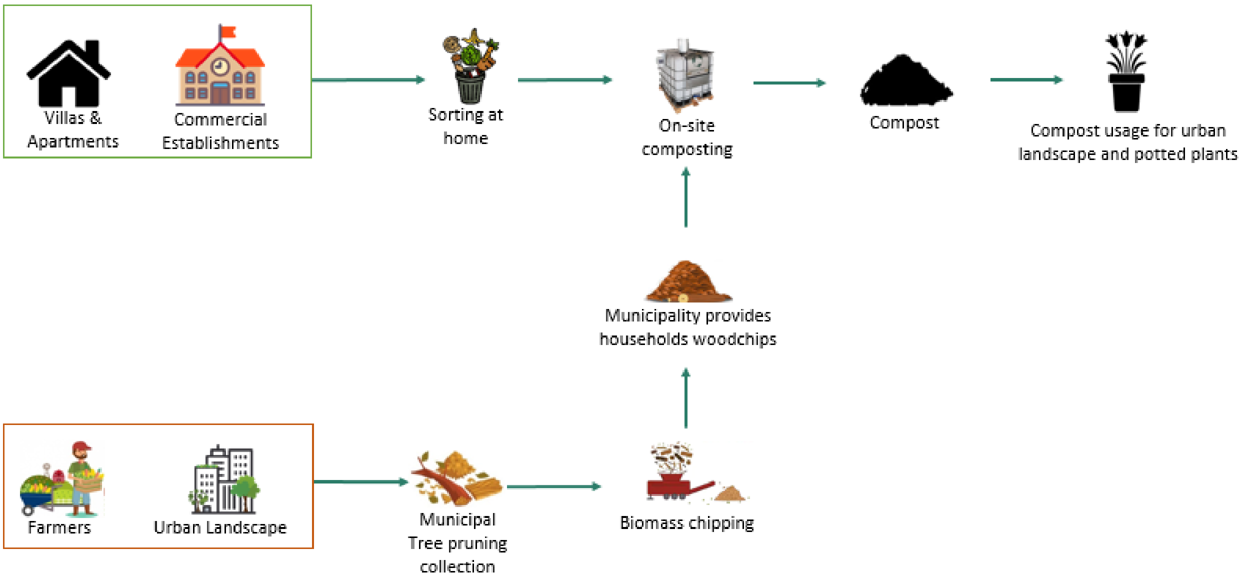

Figure 20 Individual composting process flow chart

B. Community composting

Households, restaurants, and commercial establishments sort their organic waste at source, and they either voluntarily drop it off at the composting site, or they are provided with collection services. The municipality collects tree pruning from farmers and urban landscapes and provides wood chips to the composting sites, and the final compost product is taken by the program operator and is packaged and sold.

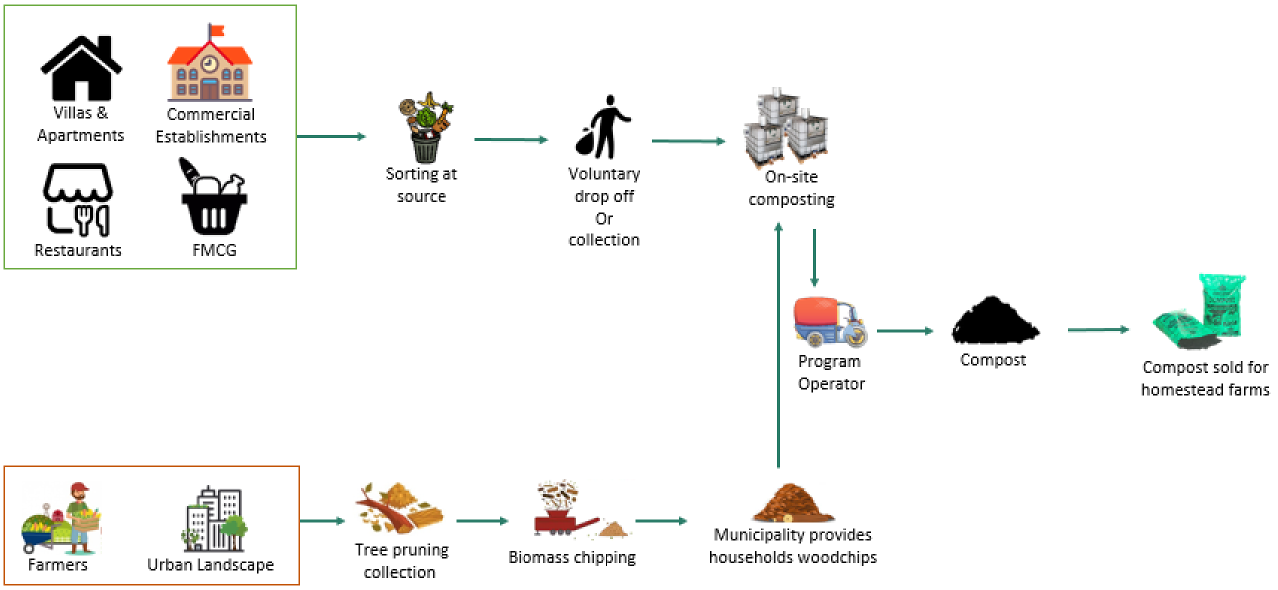

Figure 21 Community composting process flow chart

C. Local composting

For the local composting facility, the bio-waste from restaurants, agro-industries, households, academic establishments, and supermarkets is collected by the municipality and sent to the in-vessel composting facility. Tree pruning is provided by farmers, urban landscapes and forests, and a mobile wood chipper reduces wood to small chips to be collected by the municipality and sent to the facility, and the final compost product is sold in bulk to farmers.

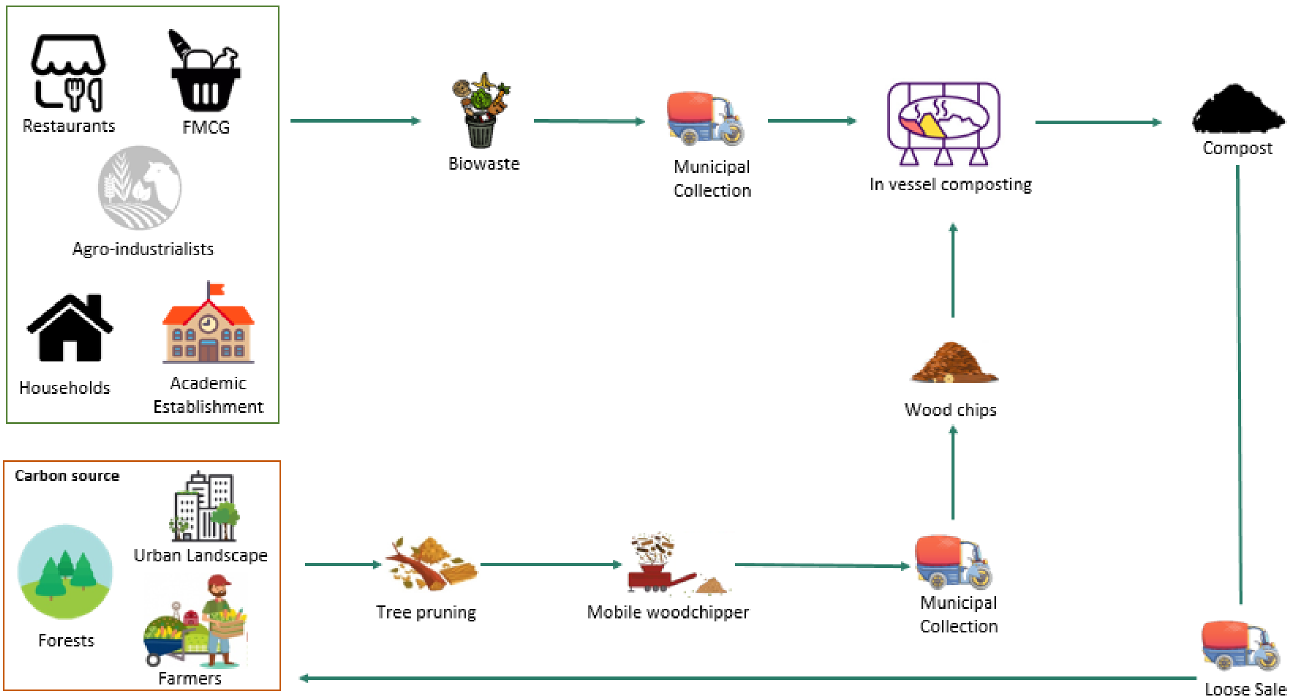

Figure 22 Local composting process flow chart

D. Central composting

A subcontractor collects bio-waste from households and the different establishments and sends them to the facility. Farmers provide tree pruning that are turned into wood chips via mobile wood-chipper, and a subcontractor collects the carbon material and sends them to the facility which is operated by a contractor. The final compost product is either packaged and sold commercially, or sold in bulk to farmers.

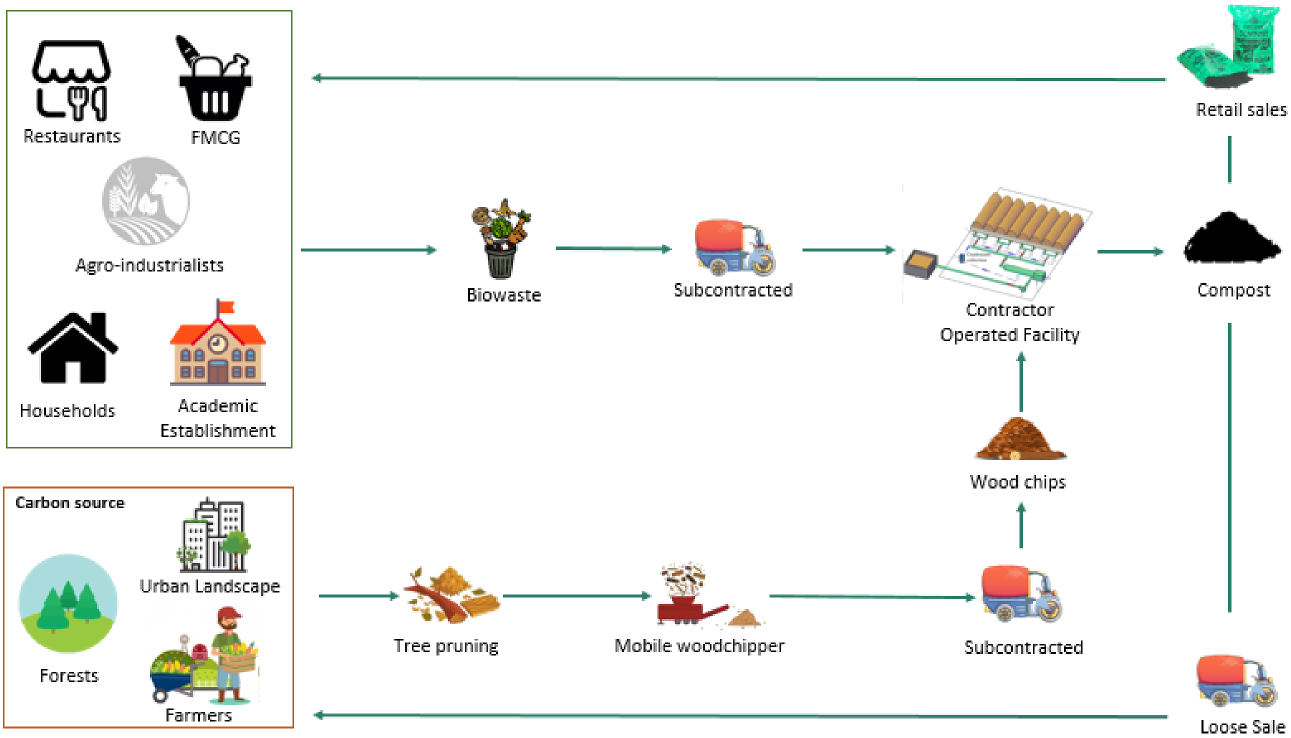

Figure 23 Central composting process flow chart

4.3. Type of Technology Required

Composting is defined as the aerobic decomposition and stabilization of organic material by microorganisms under controlled conditions. During composting, microorganisms require oxygen, and active composting generates heat, carbon dioxide, and water vapor. Rapid composting occurs when the right conditions are met. These conditions include: properly mixed organic material and a balanced carbon to nitrogen ratio between 20:1 and 30:1, adequate oxygen and moisture levels that support aerobic microbial activity, and temperature that encourage thermophilic microorganisms.

Composting occurs in two phases; the mesophilic phase (10-40°C) and thermophilic phase (40°C – 65°C) where the biodegradable waste is pasteurized and pathogens, weed seeds and fly larvae are destroyed. When the active composting phase is over, the material enters the curing phase where microbial activity and temperature of the pile decreases and becomes stable resulting in a matured compost ready for use.

Since the most important parameter for a successful composting process is oxygen, all composting systems are just different methods of providing the required oxygen needed by the microorganisms. Even though composting is a natural and biological process, it might have some negative outcomes such as bad odors and leachate generation which are often problems that should be well managed to limit any chance of pollution.

Composting can be done either in closed volumes or outdoors, and the following list encompasses a number of composting techniques and a brief explanation to better understand them.

- Windrow composting: consists of forming long windrows (in a prism shape) of feedstock outdoors that need to be agitated or turned mechanically in a determined frequency. This method requires low infrastructure needs but high land footprint and operating cost.
- Passive aerated static piles: similar to the windrow composting in terms of pile formation and space conditions. However, the mechanical agitation is no longer needed and replaced by passive pipes underneath it to create a chimney effect for aeration.
- Active aerated static piles: the piles of feedstock are formed above aeration pipes that are actively pushing air either positively or negatively (vacuum suction).
- In vessel ASP: Similar to active aerated static piles however the feedstock and the pipes are contained inside a closed volume (e.g., steel containers, concrete bunkers). This offers more control over weather conditions.
- In Vessel Drum (tumbler): This technology combines windrow composting and in vessel ASP. The feedstock is added to a rotating cylindrical drum. Active aeration may be added to the process.

For the 3 pilot scenarios, the in-vessel aerated static piles method will be used since it offers the necessary balance between the time needed for treatment, capital cost, and operation complexity. This ASP technique will be enhanced by adding more layers of control onto the pile. The approach will be to implement low-tech Aerated Static Pile with increasing containment to provide protection from external weather conditions which would increase the time efficiency, quality of the product, and require less leachate management. Thus, the feedstock will be contained inside a well determined volume such as concrete bunkers, large containers, or small containers (depending on the scale of the pilots). In addition to the layers of control for the factors affecting the composting process, receiving more waste in a smaller land footprint is possible because the material will be stacked vertically and can be piled up to a higher elevation.

This technique requires the composting piles to be built on a network of perforated aeration pipes linked to a blower that pumps air into the pile to aerate it. Turning or agitation of the materials is not needed once the pile is formed. Also, if the air supply is sufficient and distributed uniformly, the active composting period will be completed in approximately three to five weeks.

The quality of compost is highly affected by the purity of the feedstock mix, meaning MSW must be adequately sorted to remove any contaminants, and the organic waste is dropped off on site on a concrete pad (called reception area), then carbon material obtained from agricultural waste and pruning is mixed into it. The feedstock mix is inserted into the ASP system for fermentation where active biodegradation occurs for a period of 21 days. After that, the material is removed and left to cure for 45 days. Subsequently, the material is introduced into a vibrating sieve to segregate finished compost product from other material that still needs further processing.

This ASP method will be implemented on 3 different scales:

A. ASP Bunkers for the Central Composting Facility to treat 17 tpd of organic waste
B. Large ASP containers for the Local Central Facility to treat 1.25 tpd of organic waste
C. Small ASP containers for Community Composting to treat 0.33 tpd of organic waste

A. ASP Bunkers

Composting inside ASP Bunkers is one of the proposed solutions for large quantities of organic waste received frequently. The bunker structure is mainly composed of 3 wall-rooms that may be further enclosed by adding an elevated roof and a possible door if needed.

The bunker's floor must include an aeration medium that must not interfere with the handling loader. This method enables the operator to use the most out of the available space. That is due to the walls that allow the material to be stacked in a more compact manner unlike open space windrows that require side slopes for stability.

It is recommended to cover the bunkers with a metallic cladding or corrugated roofing sheets to shield the feedstock from weather conditions and to limit the generated leachate resulting from the over-humidified feedstock.

The Aeration system can be implemented either in a positive or negative method. Positive is when the fan blows the air into the composting feedstock; negative is when the fan sucks the air from the atmosphere through the feedstock. The latter may be used if there is a need for further treatment of the air particles since it would be easier to channel it into a bio filter.

Generally, four to five large bunkers are needed to accommodate the quantities to be treated at the central composting facility pilot scenario. The active composting time required for the fermentation of the raw material is around 21 days. The facility must accommodate a curing space which should be designed to store the composted material for at least 60 days. Moreover, a storage space is needed to safekeep the final end product prior to selling it to the farmers.

B. Large ASP containers

The large ASP container is an in-vessel solution, meaning the composting process is done inside an enclosed controlled environment in order to prevent air pollution and soil contamination, and to protect the environment from gas emissions and leachate.

Aeration is achieved through a blower fan supplying the airflow through plastic pipes inside of the container. Since the system is fully enclosed and airtight, the oxygen needed in the composting process enters only through the main inlet using an air blower and air can only exit from the main exhaust outlet that is connected to a condenser and the bio-filter at the top of the container which controls the emission of foul odors; before discharging the exhaust air into the atmosphere.

In order to manage the moisture of the pile, a leachate drainage and percolation system is installed. The leachate produced from the feedstock drains to the back of the container where it is captured and pumped out into a holding tank where it is stored. In the center of the roof, a sprinkler system is installed to allow the recirculation of leachate back onto the feedstock. Humidification of the composting pile is needed when the moisture content decreases significantly during the active composting process.

For the local composting facility pilot scenario, two containers will be needed for fermentation, and the spacing between them will be used for curing/storage. Corrugated roofing will also be installed, and the beams and girders under the roofs are designed based on the weather conditions of the site. The roofing is elevated above the container's roof level for ventilation purposes, and a longitudinal slope is required for rainwater runoff.

After the curing period, the final compost is ready for screening and may be packaged or sold in bulk as per the market demand.

C. Small ASP containers

The scale considered as community composting corresponds to modular units (or modules) with a volume of approximately one cubic meter. Community composting is carried out by different generators (mainly families) in the same shared and nearby area.

For this pilot, small ASP containers will be considered. Since it is an in-vessel composting system, it is completely enclosed thus allowing the treatment of organic waste without the risk of pest attraction and infestation. The container is an automated unit with a small footprint that effectively eliminates the need for heavy labor and garden space.
An aeration system is required as the lack of oxygen will cause anaerobic conditions so each container is independently connected to a blower that forces the aeration in the medium through a drilled pipeline. A bio-filter is also installed to ensure that any air leaving the unit is odorless.
No leachate or liquids can enter or escape the system in an uncontrolled manner meaning it can be placed almost anywhere. Liquid leachate flows out of these systems into a main container, preferably below the level of the station, where a separate treatment process will take place in order to end up with a good quality liquid that can be reused. This collection could be very beneficial to hydrate landscapes since it is rich in nutrients.
The small container can treat up to 20 kg of feedstock per day, 8 to 12 kg of organic waste and 10 to 12 kg of carbon material, so to treat 0.33 tpd of organic waste, approximately 20 containers are needed. The material is expected to ferment for 21 to 30 days if the temperature is maintained at 55 to 60 degrees Celsius and the recommended curing time after discharge is 1 month.

4.4. Collection System Needed

As part of the waste management plan, the collection system plays an important role in the success of any intervention. While source separation has been proved that it is the key to establish high efficiency of waste treatment. In this model, the municipality will be in charge of the waste collection and will assign proper staff to be responsible for the collection and the monitoring of the collection scheme.

Many ways are suggested to establish a collection system. Four main models are discussed below and compared with each other: door to door, outdoor bins placed near the housing units, curbside bins located in the streets, and communal drop-off zones.

Door to Door

Sorting waste fractions at home for a door-to-door collection system proves to positively affect the environmental impacts of waste management strategies both by reducing the amounts of the waste landfilled and by originating new circular economies. In this scenario, the collection personnel assigned by the municipality will pick up the organic waste to throw it inside a collection vehicle that must be properly designed based on the quantity of waste collected, and the waste collection route. One of the main roles of the assigned staff is to visually and manually inspect the material before accepting the collection.

Generally, organic waste has a high density since it has a high moisture content. This will entitle heavy waste bags in a relatively small volume. So, the staff will first perform a manual and a visual check on the bags to estimate the weight versus the volume. In the case of clear contamination, warnings shall be issued and more severe actions should be followed if the inhabitants did not comply with the sorting plan followed in the target region.

The monitoring agent will have a checklist to ensure all of the set targets for the collection are covered. In addition, he will be the focal point between the residents, the treatment site operator and the municipality.

While this method is considered one of the most efficient ways in terms of monitoring and quality of sorted material, it still has its limitations when it comes to human resources and operational costs. More workers are needed to cover all the residents, hence the need for more financial resources to cover the payroll expenses. Nevertheless, the need for bins and special trucks is reduced from the capital needs.

Outdoor Bins

Another collection method may rely on outdoor two or more bins installed near the buildings or multiple housing units. The type of the bins will rely on the collection frequency and the type of truck that will be used for collection. The volume of these bins is either 120 or 240L made from plastic.

In this case the monitoring will be done on neighborhoods levels instead of taking individual houses one by one like it is the case in the door-to-door method.

Less workers are needed to cover the collection route since they are no longer going to collect from each household by itself. However, a greater investment is needed to distribute the bins in an even way across all the target areas.

Curbside Bins

This method depends on the installation of large-scale bins at the roadsides and in public places. The user would need to travel a relatively long distance to throw the household waste. These bins are placed efficiently to decrease the travel distances crossed by the collection vehicle. Generally, more than one bin is placed at the side of the pavement. In most cases the bins are made from steel and can carry a volume ranging from 1000 to 2000L.

In terms of monitoring, this is considered the weakest method since it is extremely difficult to restrict the access to the bins, which leads to the mix of sorted waste with unsorted waste. This would complicate the treatment and recovery after collection.

Regarding the financial feasibility, this method requires larger collection vehicles and steel bins that are relatively expensive. Although the labor force is limited compared with the other methods, the fuel and maintenance costs associated with the collection vehicle are not to be underestimated.

Communal drop off zone

In many waste collection models adopted worldwide and specially when a more than one method is used, the communal drop off sites are recommended to keep a safe haven for the citizens to throw their sorted waste in specifically when they missed the collection schedule or if they are seasonal or occasional residents in the village. Usually this site is easily monitored and offers more options for the sorting method. It can easily accommodate special waste drop offs like electronics and textiles in addition to specific types of plastic.

This method can almost guarantee the sorting quality of the waste while having the least maintenance and operating cost associated with the activities. Nevertheless, it has the largest space footprint with medium investment requirements.

Comparison between the collection methods

To be able to distinguish between the collection methods, all the special needs of each target area must be considered. There is no single method that fits all applications regarding waste collection. The following table may assist the waste management strategy designer to decide which method to recommend in each region

Table 10 Comparison between different collection methods

	CAPEX*	***OPEX*****	***User Contribution***	***Labor intensity***	***Quality of sorting***

Door to Door	Low	Medium to High	Low	High	High
Outdoor bin	Medium	Medium	Low to Medium	Medium	Medium to High
Curbside Bin	High	Medium to High	High	Low	Low
Communal Drop off zone	Medium	Low to Medium	High	Low	High

*CAPEX: Capital expenditures
**OPEX: Operating expenditures

Supply of carbon material to composting sites

The collection of carbon material is a seasonal process related to the time of the year when the farmers perform their pruning. During the high season, instructions will be provided to the farmers by the monitoring agent to place the carbon waste on the curbside during a specific week. Then, the composting operator will be collecting the residues using his machines. The operator will then chip and shred the wood waste to smaller pieces in order to be more efficient in the composting process. Note that special requests can be placed for only large quantities of carbon material to be collected out of season. Also, it will be very important for the operator to note the type of carbon material collected, its quantity and time to process for work efficiency reasons. The volume can also be noted once the material is received in the composting site based on a preset ratio.

4.5. Sorting at Source

For households to understand why they should recycle, an implemented awareness work will make this new reality visible and will popularize these new behavior patterns. This is why awareness campaigns and education on the importance of recycling and how waste should be separated; are the way to raise awareness among consumers. Above all, these campaigns help households and citizens to change their habits; they need to be convinced of the potential and importance of recycling, something that is only achieved when communicating with them about it.

The objectives of these awareness campaigns will be as follow:

- Rethink the approach to municipal waste, including decisions on consumption (refuse), production (reduce), reuse and recycling;
- Change the mindset of citizens towards considering waste as a valuable resource
- Organize events and activities targeting all community members to encourage continuous action and sharing of success stories on solid waste management
- Encourage day-to-day action in households and schools, at the workplace and community level to improve solid waste management

The below are awareness strategies that can be implemented in the community:

A. General Door to Door Education, from Municipal and Community Based organizations volunteers.
    - Explain the components of a Solid Waste Management system through brochure distribution
    - Elaborate on the health impacts of solid waste
    - Setting personal goals and activation: Motivate people by setting a clear goal for their own behaviors to help them aspire to that behavior. A volunteer goes door to door to set personal

waste management goals with residents and presents them with a sticker/checklist that serves in reminding them of the goals they set for themselves.

B. Experimental Door to Door education, from Municipal and Community Based organizations volunteers.

- Enable critical thinking on a household level: Local CBO volunteers in collaboration with the Municipality teach the parents and kids on how to sort their waste and recycle.

C. Advertising Methods:

- Television Awareness campaign: Advantage of reaching a wide audience and could cover broad awareness issues and broad state-wide messages
- Radio awareness campaign: A wide and varied audience could be obtained with different community groups being targeted by different radio stations.
  Using radio advertising is particularly useful for targeting rural and poor neighborhoods with limited access to Television
- Newspaper Awareness campaign: Daily newspaper includes on a weekly basis importance of recycling, how to sort and what are the current undergoing initiatives in the country
- Free Call Line & Messaging: This provides people with waste reduction, reuse and recycling information, pertinent to the municipality that they reside within. The municipality could call the homes and interview them on their waste sorting and suggest ideas for improvement. The Municipality can also send a message to the registered mobile numbers as a reminder of sorting and recycling.

D. Develop Learning Model

- Engage waste management training and classes targeting public schools, educational centers and religious institutions.
- Class participation using a model of bonus points for every true answer.
- Initiating essay competitions for primary and secondary school titled “How can I keep my area clean”, where gifts can be awarded.
- School activities: Students sorting school waste as an educational elective. The better engaged the student is, the higher will be their grades and the higher will be their yearly grades.

E. Conduct community and livelihood trainings / workshops

- Municipalities with the support of organizations, organize free thematic waste management workshops every week targeting the population at large. Families join to participate.

F. Community engagement into waste management

- Educational waste sorting games for youth and adults in the neighborhood square
- Recycling Campaign Focused on Jobs creation: A group of recycling industry folks, government agencies and women volunteers join to drive a campaign around waste recycling with an economic development strategy
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- Smart Bins provided by the municipality fitted with technology, informational content and instructions: Reward consumers with discounts, deals and social connections.
- Raffle games: For every 5 items recycled, a possibility to win games, prizes or awards
- Giving Back: Families can donate clothes and furniture no longer needed that will be sent directly to charity homes that need help. Recyclable items will be sold: The amount received from the sale is used to fulfill the wish list of the charity homes and school projects.

- Composting locally at the community-level yields exposes community members to the concept of source-separation of food scraps, educates vulnerable families and the general public about composting and creates green jobs.

4.6. The Role of Ain Baal Facility

Despite several design flaws and operational problems, the MBT at Ain Baal should still have a role in the treatment of waste within any future management plan, specifically in the treatment of residual waste. During its operation, the facility specifically struggled with processing higher quantities of waste and the operator was not capable of meeting the treatment requirements of less than half of the municipalities in the entire District, even though it was designed to do so. Nevertheless, the facility is fully equipped to adequately treat mixed residual waste but perhaps not at the initially expected capacity if desired targets for quantity and quality of recyclables and compost-like outputs (CLO) need to be achieved.

In this regard, the facility can have a future role in further extending the circular principles of waste management by preparing the outputs of the system for energy recovery. The 2018 Integrated Waste Management Plan (IWMP) for Tyre recognized the high quantity of residuals coming out at the end of the MBT process as well as the poor-quality CLO which was not fit for purpose as a compost material, but both of which exhibit high calorific properties that could be capitalized on. As such, the Plan proposed the possibility of adapting the facility to produce refuse-derived fuels (RDF) that can be used as a petcoke substitute in cement kilns. Bio drying was also proposed as a means of preparing the organic fraction along with other residual materials to produce a useful product provided specific economic, environmental and technical parameters are met. But until such advanced technologies can be feasibly incorporated into the facility's operations, the MBT can still serve its purpose of managing residuals, recovery of recyclables, and stabilization of organics prior to final disposal.

With the establishment of schemes for the diversion of recyclables and the organic fraction away from the MBT, the treatment capacity for residuals may reduce to a manageable level to allow for better operational practices to be realized. That being said, however, this still does not negate the necessity for a safe final disposal site to be executed as a means to divert waste from open dumps and to reduce open burning of waste throughout the District of Tyre.

As part of the vision proposed to the region, it is always important to have a safe place to go to at the end of the waste chain. Among all the possible solutions, and even after applying all kinds of circular economy models that shall reduce the quantity of wasted material. The existence of a well-constructed sanitary landfill is the safest refuge to all the residual unrecovered municipal waste.

The proposed vision is to implement waste diversion techniques by first relying on responsible energy consumption, home composting, and sales of products that are no longer needed in a second-hand marketplace. Furthermore, sorting at source should be gradually implemented across the targeted villages with the implementation of some local and/or central composting procedures that can divert up to 55% of the daily produced municipal waste in addition to landscape and pruning waste from farmers that are used as a carbon material supplements to the composting mix. After the successful implementation of the composting pilots, material recovery facilities (MRF) should be built to further valorize the recyclable portion of the waste. Approximately, this portion of the waste constitutes about a third of the total municipal waste. Although it is not easy to recover the whole quantity of recyclables, nevertheless, when source separation is executed properly the recoverability rate increases significantly.

Having said all the above, the unsegregated waste coming from the households during the gradual integration of the plan has to go to the landfill which shall also receive all the residual unrecovered waste coming from the composting and the material recovery facilities. This explains the importance of the Ain Baal landfill that is already existing and shall incorporate some modifications in order to play the role suggested in this plan.

4.7. Value Chain

Mismanagement of waste is not a problem affecting one entity rather it is a societal problem affecting the whole community. This is why it is important to engage the community in any intervention related to solid waste management and let them be aware of the risks associated with the subject. Moreover, in a soundly planned waste management intervention, all the stakeholders must play a role that incentivizes them to be committed to the ultimate solution.

Starting with the most affected stakeholder that is the community members, the proposed project offers a cost saving opportunity from waste reduction and possible discounts on readily available compost. Also, they will regain a sense of pride and civic duty being a progressive citizen with minimal environmental impact.

Regarding the municipalities, they will have the opportunity to play their rightful role serving their community and promoting sustainable development in the target area. They will also reduce the liabilities associated with open dumping and burning not to mention the media recognition and awards to be received.

Through the value chain proposed in this project many other stakeholders are included that fall in the heart of the process. SWM contractors will emerge that the municipalities would recruit to do the job in exchange for the revenues coming from the treatment and valorization process. And after recovering the recyclables from the waste, recycling industries would access more material in higher quality than the one offered by other recyclers working in unsorted waste. Also, farmers in the area will benefit from locally produced compost which is becoming a rare commodity given that it is usually imported and the economic crisis has affected this market. Social enterprises will emerge building innovative business models around accessing new markets and linking the treatment facilities to the recycling communities.

5. FINANCIAL OVERVIEW

The OrganEcs is a tool for estimating the costs associated with an organic waste management project. It provides planning-level assistance to local governments, waste professionals, policymakers, facility operators, and project developers to help them make financial decisions about their potential organic waste management projects. The tool offers details in economics and finances where investors can check the revenue streams, the business model, all the costs associated with the operations and the profitability. This tool was developed by the U.S. Environmental Protection Agency , under the auspices of the Global Methane Initiative and in support of the Climate and Clean Air Coalition . Note that the tool requires a minimum waste throughput of 2000 tons per year which is applicable in the pilot's scenario 1 but could not be applicable for scenario 2 and 3.

In scenario 1, the daily organic waste input is 17tpd and it is expected to increase until it reaches 51tpd in about 5 years. The OrganEcs tool was used in 3 simulations that include the following:

Case 1: The facility's investment related costs for equipment and infrastructure are covered by a grant. The organic waste is transported by the relevant municipalities in the target area at their own expense. Hence their related costs are not reflected in the model.

Case 2: The facility's investment related costs for equipment and infrastructure are covered by a loan. The organic waste is transported by the relevant municipalities in the target area at their own expense similarly to case 1.

Case 3: The facility's investment related costs for equipment and infrastructure are covered by a grant. The organic waste is transported by the facility's operator in the target area at their own expense. Hence their related costs are reflected in the model

The facility's inputs and assumptions taken are listed as follows:

- The facility labor needs are: 1 manager in addition to 3 operator workers
- Electricity retail price 0.25$/kWh which is an average cost between private generator and EDL power supply
- Land owned by a public entity and is used for the pilot without any rental or leasing costs
- Capital investment needs are $ 200,000 for infrastructure and $ 100,000 for equipment.
- No gate fees are charged on the waste generators since they are supposed to be source sorted with minimal rejects percentage
- Market price for compost sold in bulk (unpackaged) is $ 50.00 per ton
- Inflation rate is 2%
- Compost production rate is 50% from organic waste with 95% of the produced compost is sold
- Revenues are generated from compost sales solely

Outputs of Case 1:

Table 11 Financial output of OrganEcs model for case 1

Composting with Forced Aeration		USD
Initial Capital Investment ($)	*Covered by the grant*	$0
Total Annual Expenses in YR 1 Operations ($/year)		85,000
O&M/ton in YR 1 Operations ($/ton of waste processed)		14
Total Land Required (ha)		4
Total Organic Waste Available in YR 1 (tons/year)		5,270
Total Bulking Agent Required in YR 1 (tons/year)		1,000
Total Waste Composted in YR 1 (tons/year)		6,270
Compost Produced in YR 1 (tons/year)		2,822
Revenues from compost Sales in YR 1		$136,702

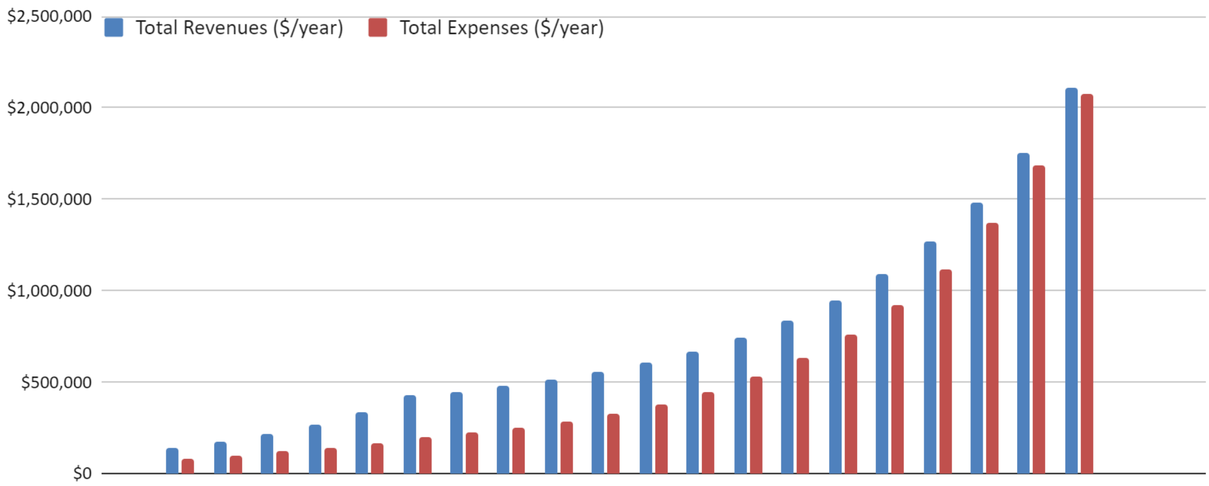

Figure 24 Case 1 revenues and expenses

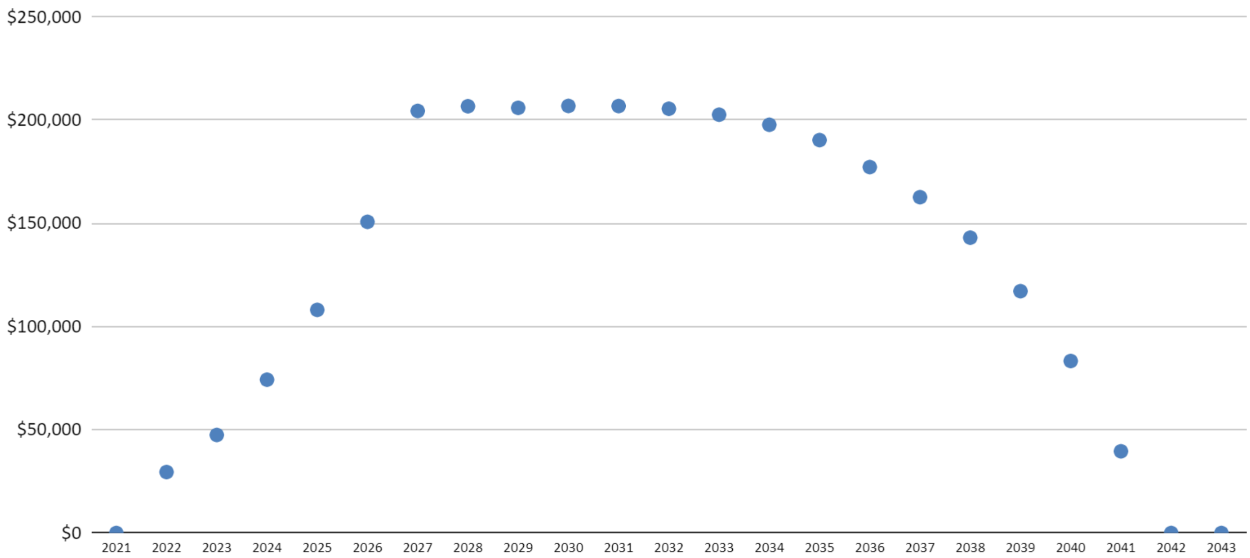

Figure 25 Case 1 Gross profit

Outputs of Case 2:

Table 12 Financial output of OrganEcs model for case 2

Composting with Forced Aeration	USD
Initial Capital Investment ($)	$321,300
Total Annual Expenses in YR 1 Operations ($/year)	169,000
O&M/ton in YR 1 Operations ($/ton of waste processed)	27

Total Land Required (ha)	4
Total Organic Waste Available in YR 1 (tons/year)	5,270
Total Bulking Agent Required in YR 1 (tons/year)	1,000
Total Waste Composted in YR 1 (tons/year)	6,270
Compost Produced in YR 1 (tons/year)	2,822
Revenues from compost Sales in YR 1	$136,702

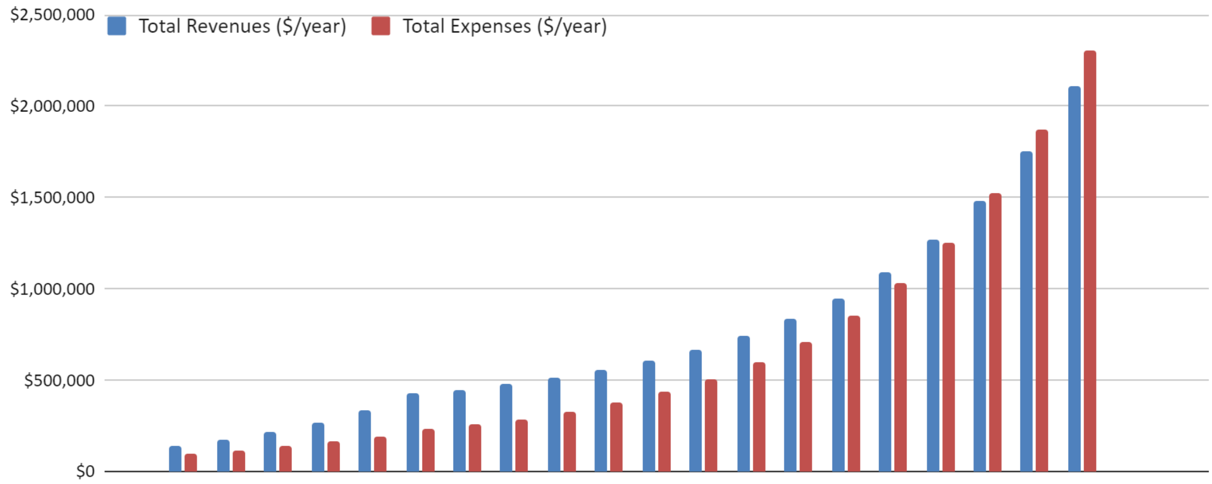

Figure 26 Case 2 revenues vs expenses

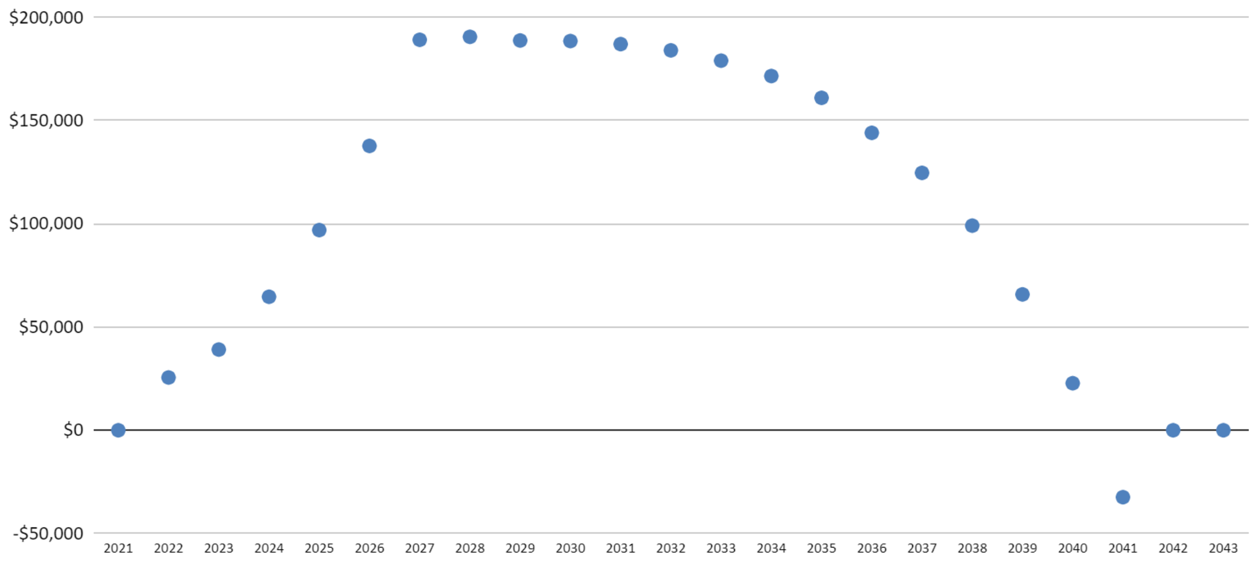

Figure 27 Case 2 Gross profit

Outputs of Case 3:

Table 13 Financial output of OrganEcs model for case 3

Composting with Forced Aeration	USD
Initial Capital Investment ($) *Covered by the grant*	$0
Total Annual Expenses in YR 1 Operations ($/year)	176,400
O&M/ton in YR 1 Operations ($/ton of waste processed)	$29
Total Land Required (ha)	4
Total Organic Waste Available in YR 1 (tons/year)	5,270
Total Bulking Agent Required in YR 1 (tons/year)	1,000
Total Waste Composted in YR 1 (tons/year)	6,270
Compost Produced in YR 1 (tons/year)	2,822
Revenues from compost Sales in YR 1	$136,702

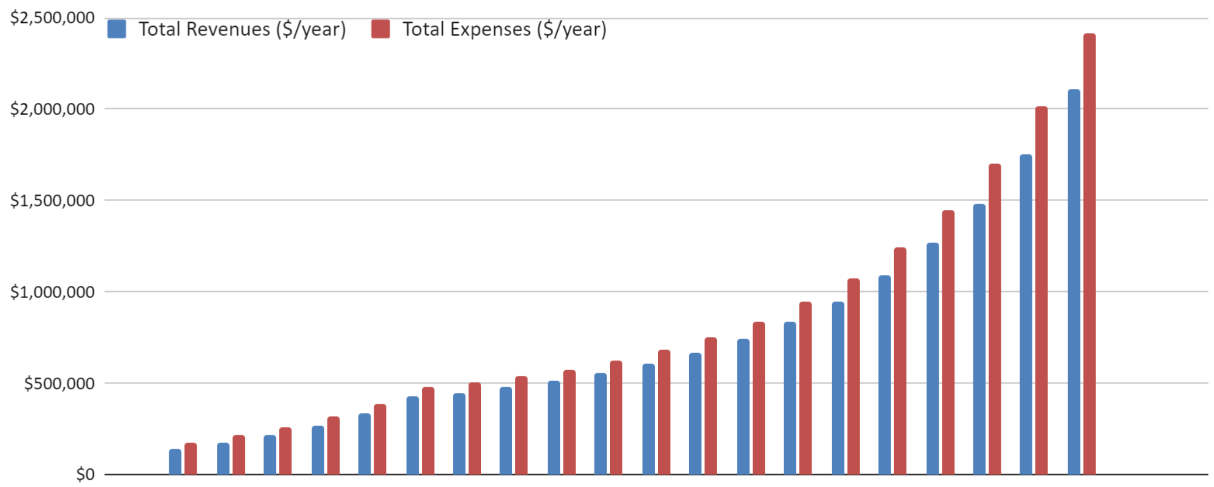

Figure 28 Case 3 revenues vs expenses

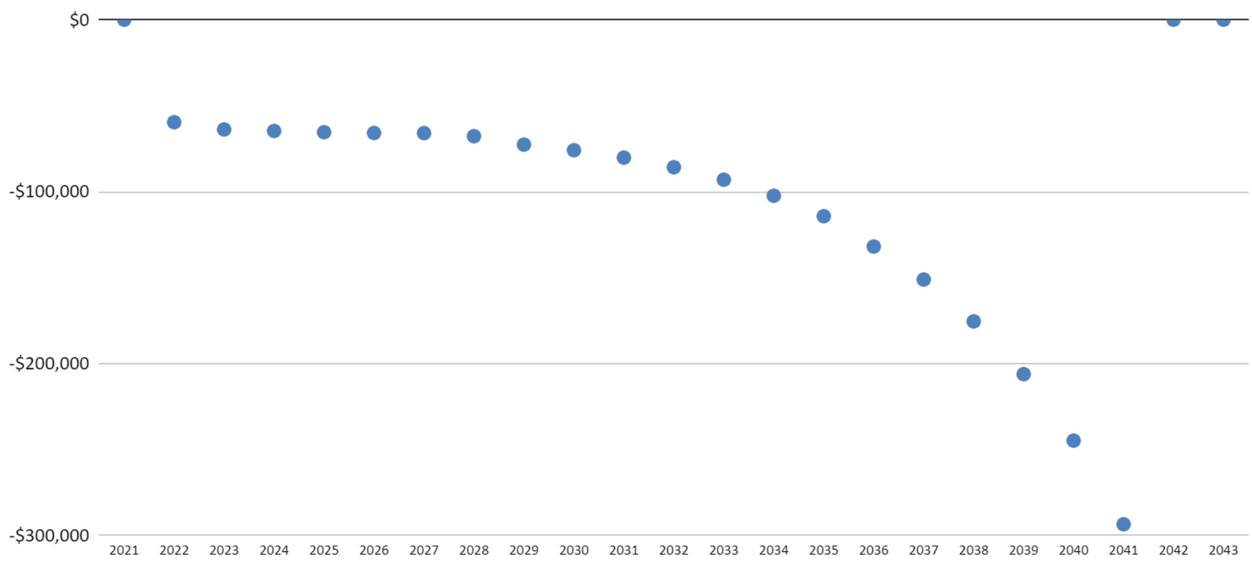

Figure 29 Case 3 Gross profit

Analysis

The simulations presented above showed that a composting facility may be profitable and economically sustainable if the following cases apply: (1) organic waste is delivered without any transportation expenses, and (2) the waste is source separated with a limited amount of rejects remaining (less than 10%).

The first two simulations proved that it would still be possible to achieve a profitable financial model even if the facility was financed via a 5 years loan with 5% interest. Nevertheless, case 2 reached a net loss of around $ 40,000 only in the last year of operation which is due to the inflation in bulking agent and energy cost. This can be easily mitigated by imposing a small gate fee or cutting some costs in this specific year.

Moreover, case 3 could still be acceptable if the operator receives a fee of $29 per ton of organic waste received to cover the annual expenses. The operator would still be incentivized to produce high quality compost because the revenue from compost sales would be the sole source of pure profit.

In scenario 2, the daily organic waste input is 1.25 tpd and it is expected to increase until it reaches 2 tpd in about 5 years. The financial model of the Local Composting facility includes: The Capital Expenditures and the operational expenditures

The CAPEX consists of: the civil works such as soil leveling, excavation and land preparation, in situ pouring of concrete for the receiving area and under the trommel screen, 200 mm concrete masonry unit walls installed on the backside of the feedstock piles, corrugated steel roofing to shelter from rain and sun, 40 Ft modified shipping containers into in-vessel composters with integrated aeration, Bio-Filter, and Leachate management. These include a blower to provide aeration, and 4-inch diameter PVC or HDPE pipes with staggered holes, a leachate tank and pump to collect the leachate. Also, a trommel screen and a mechanical bagger to screen and package the finished compost, a skid steer loader for waste removal and easy short distance transportation. It also includes electrical equipment such as a board panel, timers, contactors and breakers, and assorted equipment such as fork, shovel and a wheelbarrow, and estimated mechanical and electrical installation and transportation costs.

As for the OPEX, they include: equipment maintenance which are expenses attributed to the maintenance of machinery, depreciation costs, and operational costs such as monthly fees and Costs for insurance and NSSF subscriptions for the individuals working at the facility, and electricity and water bills.

Table 14 CAPEX and OPEX of the LCF

CAPEX	**Capital Expenditures**	**$90,000**
OPEX	**Operational Expenditure**	**$20,000**

As for the third scenario, the daily organic waste input is 0.33 tpd and it is expected to increase until it reaches 0.7 tpd in about 5 years. The financial model of the Local Composting facility includes: community composting, the CAPEX includes 40 small containers used for food & garden waste management, Delivery & installation followed by a training to the project personnel, Equipment Kit containing Compost Thermometer, Hay Fork, Shovel, Metallic Compost Screen, Plastic cover, Bags of carbon material, and Quality control visits to do a recap training, monitor the composting practices & evolution of the composting process during the first 2 month of the project implementation, on a 2 weeks basis. As for the operational costs, they include electricity bills and the salary of a part time employee.

Table 15 Cost summary of the CC

Cost Summary	**Total**	**$ 52,000**

Financing Opportunities

The Action Plan requires necessary financial resources for effective implementation mainly for conducting necessary design of infrastructure and executing further associated studies such as detailed feasibility studies or Environmental Impact Assessments in addition to capital costs for construction and most importantly securing operational costs that will determine the sustainability of any activity taking place.

Early identification of costs and securing necessary project financing is therefore crucial to the success of the Plan and is one of the first activities to be targeted during implementation.

While CAPEX is often easily secured through multilateral donors and other international organizations (e.g., European Union or USAID), accounting for OPEX for the entire lifetime of the project is frequently more difficult to secure. For this reason, a proper cost recovery mechanism is necessary for the implementation of any solution and ensuring its long-term sustainability. At this time, given the current economic conditions, it’s not likely that the private sector will be willing to invest in pilot projects that are not guaranteed to provide an attractive return on investment, however they can be the key to the long-term vision.

Funds to cover OPEX for SWM operations are usually collected by imposing municipal tariffs/taxes for service users or putting gate fees at treatment and disposal facilities. However, these cost recovery mechanisms are sometimes difficult to implement since municipalities often struggle to collect enough funds from residents especially when economic conditions in the country are becoming increasingly worse. Gate fees can also drive illegal dumping of wastes. Local authorities typically rely on national government subsidies to conduct works as a result, yet with the economic situation being in a dire state this is also difficult. As such, options for generating revenue from the treatment and end-use of compost must be prioritized and worked towards, and thus requires organizing the collection process of organics and ensuring quality end-products are generated. Marketing a locally produced quality product may be more attractive to farmers given the dramatic hike in imported fertilizer products over the course of this economic crisis.

Development of such products does require trial and error in order to streamline the organics management system and can take time. If the business model can be demonstrated to be lucrative, this may in turn attract private sector investment. Private sector organizations are revenue driven and can play a crucial role in operating treatment and disposal technologies without the need for national subsidies. Additionally, assistance from international organizations such as the International Finance Corporation (IFC) can be sought so that private companies can have access to financial resources in the form of loans that can support investment in such projects.

Ultimately, it is essential that the Action Plan should progress towards revenue generating solutions in order to ensure long-term financial sustainability and that the private sector must be engaged to facilitate this.

6. MAXIMIZING ACTION PLAN IMPACT

It was demonstrated through running the SWEET model that the implementation of the Action Plan has the potential to reduce GHG and SLCP emissions by way of composting, with marginable benefits with a centralized composting facility. However, in combination with the composting programs, major emissions reductions can be further achieved by implementing additional measures mainly pertaining to final disposal sites. In this regard, additional scenarios were developed that can illustrate this added benefit. These included:

A. Implementing composting programs and ending waste burning at dumpsites – this would diminish in 2022 and end in 2024
B. Implementing composting programs, ending waste burning, remediating dumpsites and developing a new sanitary landfill by 2031.
C. Implementing a composting program in 2023, end waste burning, remediate dumpsites, develop a new sanitary landfill by 2031 and collect landfill gas starting 2035.

As a result, Scenario 4 showed the greatest emissions reduction that can come from collection and combustion of methane. This scenario in conjunction with the centralized composting can achieve an emissions reduction of about 53.9% from the BAU. This implies that despite the benefits and necessity of establishing the composting program, it is essential that additional efforts for eradicating open burning, dumpsite rehabilitation, and sanitary landfill construction (with gas collection) are also given necessary importance and must be driven for implementation as well.

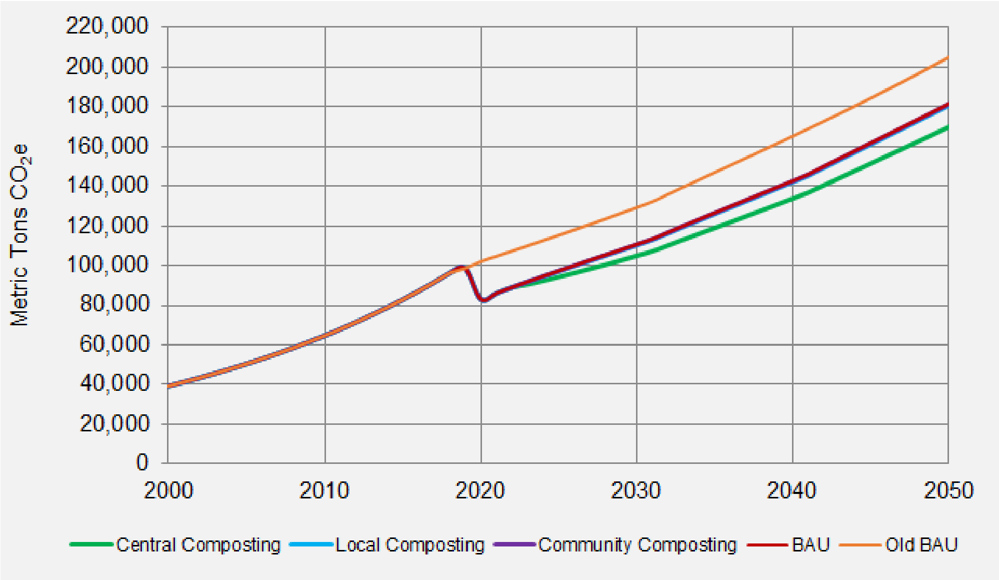

Figure 30 Scenario 1 - Total Emissions: Composting Programs only

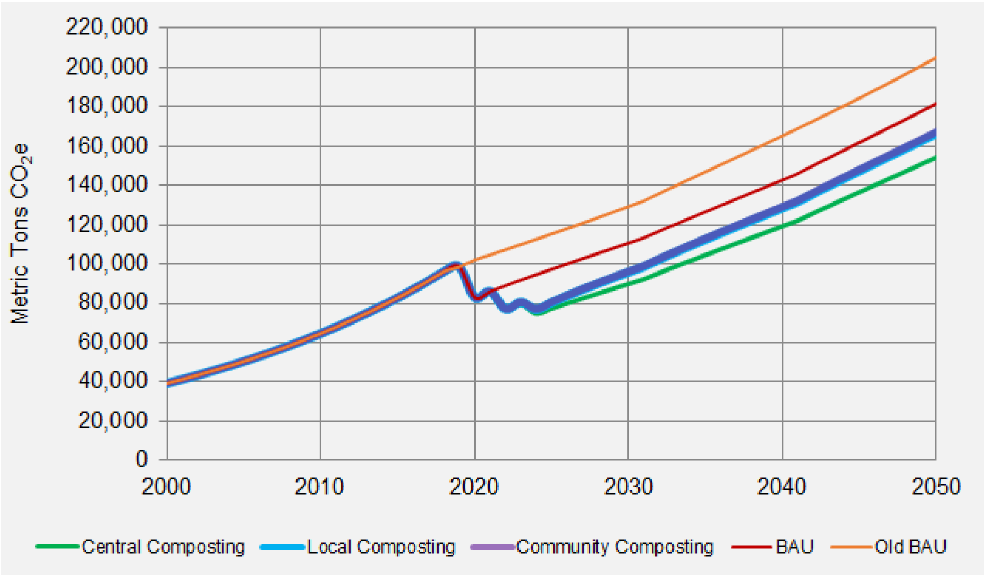

Figure 31 Scenario 2 - Total Emissions: Composting Programs & End Waste Burning

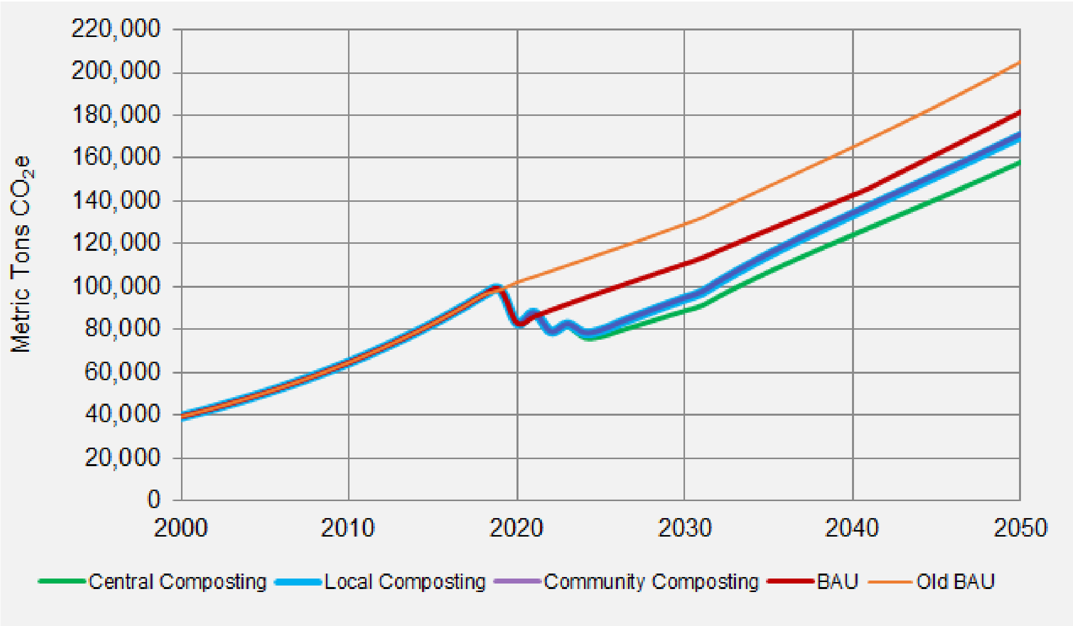

Figure 32 Scenario 3 - Total Emissions: Composting Programs, End Waste Burning, Remediate Dumpsites, New Landfill in 2031

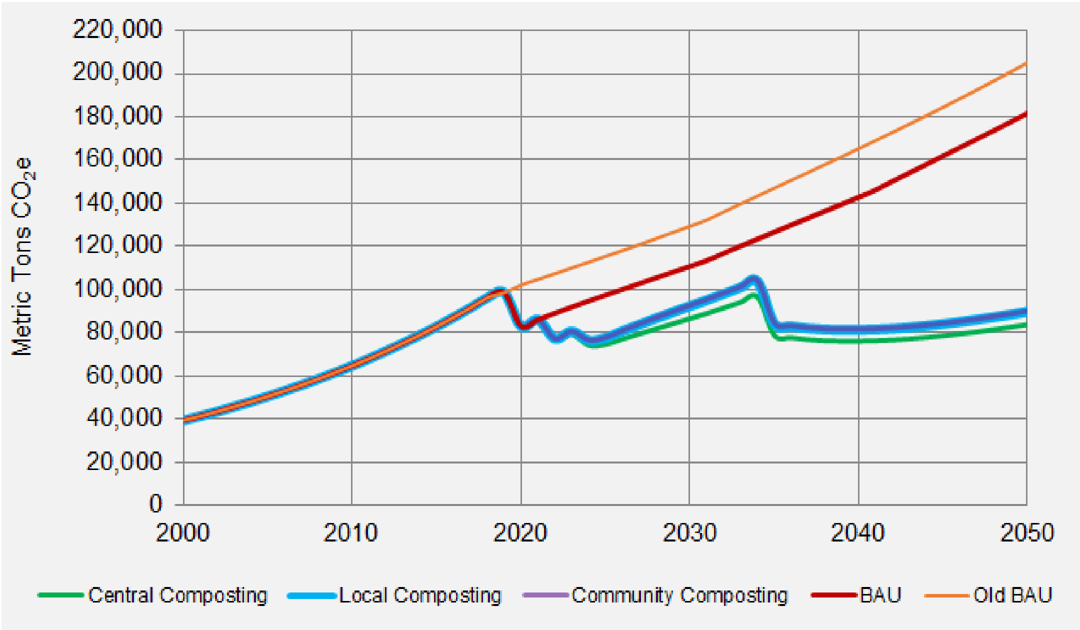

Figure 33 Scenario 4 - Total Emissions: Composting Programs, End Waste Burning, Remediate Dumpsites, New Landfill (2031) with LFG Collection (2035)

7. Conclusions and Recommendations

Data was collected from two main sources: 1) Waste Facilities that record information on the quantities and composition of waste, and 2) A Survey conducted with the municipalities that retrieved information on waste management, population data, and the presence of establishments in their judiciary areas. This data was used to estimate how much waste generation and composition changed after the recent events that occurred in Lebanon: the economic collapse, the onset of COVID-19 pandemic, and the Beirut blast.

After understanding these changes, the new levels of greenhouse gas emissions were estimated and compared with the baseline presented in an earlier study conducted in 2019, using the SWEET. The study also assessed the effect of the closure of the MBT facility at Ain Baal. SWEET was used to estimate emissions of the old business-as-usual in comparison with the new one that was estimated based on observed waste generation and composition trends in regions with similar semi-rural characteristics. Given the notable reduction in waste generation of about 24.43%, a dip in the total emissions was seen. This rate is expected to have increased from the latest data availability and to keep increasing with the continuous and worsening economic situation, especially when taking into consideration the decrease in purchasing power and the huge immigration of the Lebanese population. The percentage of organic waste in rural areas was mostly unchanged though

Composting as an intervention to reduce organic waste disposal at dumpsites was looked into, and the impacts of this intervention on GHG emissions and potential diversion rates was observed and assessed. Three composting scenarios were selected, a Central Composting Facility in Abbassiyyeh, a Local Composting Facility in Aalma Ech Chaab, and community composting in Bmaryamine. SWEET was run to estimate total emissions from the three composting scenarios, and the results showed that the central facility processing about 17 tons/day was the only scenario that would provide the most emissions reduction with about a 6.4% decrease from the new BAU by the year 2050. However, greater emissions reductions can be achieved by combining the implementation of the centralized composting facility with additional measures at disposal sites namely ending open burning, rehabilitation of dumpsites, landfill construction with methane combustion. With this scenario emissions reductions can reach as high as 53.9% from the BAU by 2050.

Finally, the OrganEcs tool was used to get an idea about the financial details of three options related to the central composting facility pilot scenario in Abbassiyyeh. It has been shown that the composting facility may present a profitable model if the waste received is properly sorted and transported to the site free of charge.

In addition to that, it is important to mention the recommended actions and next steps to be taken

A. **Prepare a detailed feasibility study for the implementation of a centralized composting facility** – this would provide more specific details on: a) the technical components of the composting facility (i.e., land requirements, detailed assessment of the sources, collection and transportation plan, treatment targets and quality parameters of the compost), and b) the financial costs for CAPEX and OPEX, with project phasing and marketing strategy for the compost, plus the cost of additional required studies (e.g., environmental impact assessments or initial environmental examinations).

B. **Site allocation of composting facility and assessment** – this should identify the ideal location for the facility giving due consideration to proximity to sources and potential receptors and sensitive locations.

C. **Preparation of stakeholder engagement plan** – this plan should specify who must be consulted and engaged with in order for the project to be successful and sustainable. This may include waste generators (e.g., households and farmers); local authorities to ensure that they approve and support the project; local NGOs or other organizations that can help promote the project and support with awareness raising; and funding agencies and donors that can provide financial resources for either technical assistance or implementation.

4. **Identify and secure sources of funds for execution of works** – once the funding agencies are identified they must be consulted and

5. **Conduct further technical studies and permitting procedures** – prior to execution of works there may be additional technical studies that must be completed and approved by central authorities (e.g., Ministry of Environment). Other permitting procedures through the Ministry of Industry or Public works may be necessary prior to proceeding with construction works.

6. **Promote ending open burning of waste and landfill construction** – work with local authorities can be taken upon as part of the consultation process to also urge an end to open burning of waste. The issue with the construction of the landfill which has been on hold for almost 2 years must be investigated and barriers to its implementation must be identified and an action plan for resolving this issue must be put in place.

8. REFERENCES

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9. Annex

9.1. Municipal Questionnaire for Tyr assessment

Village Name	
Official Representative Full Name	
Title	
Contact Information (Phone and Email address)	
Date of Data Collection	
Project Officer Full Name	

Relevant Village Solid Waste Management Contacts (If Any)			
Total Population living within the municipal boundary of the village		Low Season	
		High Season	

Waste Generation (tons/day)	
Date and source of information	
Where is MSW disposed of (existing village dumpsite, central controlled dump, other)	
Since when have these practices been in place	
What proportion of the waste is open burned	
Distance travel to disposal site	
Number and type of vehicle	
Number of trips per vehicle per week	
Other machinery uses and frequency	

Presence of Commercial establishments				Contacts where available
Are there any Educational Institutions within the municipal boundaries? (Y/N)				
If Yes, what is the number of these institutions?	Type of Institution	Availability (Y/N)	Number of Institutions	
	Universities/Colleges			
	Schools/Nurseries			

	Other:			
Number of students per institution	Universities/Colleges			
	Schools/Nurseries			
	Other			
Are there any Government Departments or Military Bases within the municipal boundaries? (Y/N)				
If Yes, what is the number of these institutions?	Type of Institution	Availability (Y/N)	Number of Institutions	
	Government Departments			
	Military Bases			
	Other:			
Occupancy per institution	Government Departments			
	Military Bases			
	Other:			
Are there any Hospitals or Clinics within the municipal boundaries? (Y/N)				
If Yes, what is the number of these institutions?	Type of Institution	Availability (Y/N)	Number of Institutions	
	Hospitals	Select from list		
	Other	Select from list		
Occupancy capacity per institution	Hospitals			
	Other:			
Are there any Poultry or Livestock Farms within the municipal boundaries? (Y/N)				
	Type of Farm	Availability (Y/N)	Number of Farms	
If Yes, what is the number of these farms?	Poultry Farms			
	Livestock Farms			
Number of heads (Poultry or Livestock) per farm	Poultry Farms			
	Livestock Farms			

Are there any Restaurants or Hotels within the municipal boundaries? (Y/N)				
If Yes, what is the number of these establishments?	Type of Establishment	Availability	Number of establishme nts	
	Restaurants			
	Hotels			
Occupancy capacity per establishment	Restaurants			
	Hotels			
Are there any Butchers or Slaughterhouses within the municipal boundaries? (Y/N)				
If Yes, what is the number of these sites?	Type of Site	Availability	Number of Site	
	Butchers			
	Slaughterhouses			
Daily slaughter rate per site	Butchers			
	Slaughterhouses			
Are there any Wholesale or Retail Vegetable Markets within the municipal boundaries? (Y/N)				
If Yes, what is the number of these Markets?	Type of Market	Availability	Number of Markets	
	Retail Vegetable Markets			
	Wholesale Vegetable Markets			
Are there any Food Processors within the municipal boundaries?				
If Yes, what is the number of these processors?	Type of Processor	Availability	Number of Processors	
	Agricultural Cooperatives			
	Mills			
	Factories			

9.2. Methodology for Calculation of Transportation Parameters

9.2.1. Conversion of Descriptive Text into Categories

Table 16 Conversion of Descriptive Text into Categories

Description given	Categorization
Pick-up	Light
Big	Heavy
Small	Light
Medium	Light
Tipper truck	Heavy
Pick-up Medium	Light
Tractor trailer	Light

9.2.2. Analysis of Truck and Waste Data for the Determination of Truck Categories

Table 17 Analysis of Truck and Waste Data for the Determination of Truck Categories

Municipality	Waste Prod. (tpd)	Truck Description	Categorization
Berj Rahhal	9	1 truck for the mixed waste and 2 truck for the recycled waste daily trips	Light
Zebqine	1	1 truck, Mercedes truck 3 tons capacity, 1 trip/day, 6 trip / week	Light
Chaitieh	6	2 trucks per day, 2 trip per day, 6 times a week	Light
Chehabieh	10	3 pickups everyday 6 days / week	Light
Saddiqine	8.5	1 truck, 1 pickup everyday	Heavy
Ain Baal	14	1 pickup 2 trips per day, 1 truck 2 trips per day 6 days a week	Light
Qlaileh	9.5	1 truck 3 times per day daily	Light

9.3. Estimated Waste Generation Rates for Municipalities Surveyed

Table 18 Estimated Waste Generation Rates for Municipalities Surveyed

Village	Average Population	Adjusted Waste Generation (Tpd)
Aabbasiyyeh	56,000.00	35
Aalma Ech Chaab	1,325.00	4.968
Aaytit	5,200.00	3.5
Ain Baal	11,500.00	14
Arzoun	2,750.00	-
Baflay	5,000.00	4
Bareesh	3,500.00	3
Batoulieh	5,000.00	10
Bazourieh	14,500.00	4
Bedias	2,250.00	5
Berj Rahhal	6,250.00	9
Berj Shmali	6,250.00	6.476349
Bestiat	400	-
Chaitiyeh	4,800.00	6
Chehabiyeh	16,000.00	10
Chehour	3,500.00	1.75
Chihine	900	0.5
Debaal	4,500.00	2
Deir Amis	3,750.00	9
Deir Deghya	65	0.4
Deir Kifa	3,000.00	3
Deir Qanoun El Nahr	10,500.00	10
Deir Qanoun Ras El Ain	4,500.00	3
El Bayyad	250	0.8
El Bestan	2,400.00	1.13355
El Hallousieh	2,250.00	2

El Henneyye	2,000.00	10
El Jbeen	3,500.00	2
El Ramadiyye	1,950.00	3
El Shabreeha	2,500.00	2
El Smaieh	3,000.00	-
Hanaway	2,500.00	3.7785
Jannata	3,000.00	3
Jibal El Batem	2,250.00	1.5
Jowayya	9,000.00	14
Kneisseh	565	0.5
Maarakeh	15,000.00	10.5
Maaroub	7,600.00	10
Mahrouna	1,250.00	1.1
Majdel Zoun	5,375.00	1.125
Mansouri	5,850.00	2
Marwahin	2,000.00	1
Mazraat El Mechref	1,400.00	-
Mjadel	6,750.00	8.5
Naffakhiyeh	655	2.25
Naqoura	3,600.00	4.5
Qana	8,875.00	7.557
Qlaileh	7,100.00	9.5
Recheknanay	1,450.00	0.75
Saddiqine	10,500.00	8.5
Salaa	3,850.00	0.75
Srifa	11,000.00	10
Tawra	8,200.00	6.5
Tayr Debba	6,250.00	9.615

Tayr Falsay	4,700.00	3.5
Tayr Harfa	1,125.00	0.857
Tyre	60,000.00	37.785
Wadi Jeelo	-	-
Yanouh	1,800.00	1
Yareen	5,500.00	-
Yarin	1,400.00	-
Zalloutieh	400	0.428
Zebqine	3,850.00	1

9.4. Estimated Major Commercial Waste Generation Rates for Municipalities Surveyed

Table 19 Estimated Major Commercial Waste Generation Rates for Municipalities Surveyed (full 0 row indicates unreported)

Name	Touristic	Farms	Education	Agriculture	Total
Aabbassiyet Sour	35	7	22	4	68
Aain Abou Abdallah	0	0	0	0	0
Aain Baal	3	18	5	2	28
Aaiyé	0	0	0	0	0
Aalma Ech-Chaab	4	2	3	1	10
Aaytit	8	2	3	1	14
Aaziyé	0	0	0	0	0
Abou Chech	0	0	0	0	0
Arzoun	1	1	0	0	2
Bafliyé	0	2	1	0	3
Barich	1	3	0	0	4
Batoulay	1	0	2	0	3
Bazouriyé	5	4	7	1	17
Bedias	1	0	1	0	2
Bestiyat	0	0	1	0	1
Biyad	0	3	1	3	7
Borj Ech-Chemali	2	0	15	0	17
Borj En-Naqoura	10	0	1	0	11
Borj Rahhal	1	5	3	0	9
Boustane	0	0	1	0	1
Btaychiyé	0	0	0	0	0
Chaaitiyé	4	1	1	0	6
Chamaa	0	0	0	0	0
Chehabiyé	10	12	3	5	30
Chehour	0	1	2	0	3
Chihine	0	1	1	1	3

Debaal Sour	0	0	1	0	1
Deir Aames	0	3	0	0	3
Deir Kifa	0	0	0	0	0
Deir Qanoun El-Aain	1	6	1	0	8
Deir Qanoun En-Nahr	3	0	1	0	4
Derdaghaiya	0	0	0	0	0
Dhayra	0	0	0	0	0
Halloussiyé	0	11	1	0	12
Hamoul	0	0	0	0	0
Hanaouay	0	0	1	0	1
Henniyé	0	1	1	0	2
Hmairi Sour	0	0	0	0	0
Iskandarouna Sour	0	0	0	0	0
Jbal El-Botm	0	2	1	0	3
Jennata	0	0	1	0	1
Jibbayn	0	0	0	0	0
Jijim	0	0	0	0	0
Jouaiya	5	0	4	0	9
Kneisset Sour	1	2	0	0	3
Maaraké	10	9	4	3	26
Maaroub	7	0	2	1	10
Majdel	3	0	2	1	6
Majdelzoun	1	9	1	1	12
Mansouri Sour	3	3	1	0	7
Marnba	0	0	0	0	0
Mazraat Ez-Zalloutiyeh	0	2	0	0	2
Mazraat Mechref	0	1	2	1	4
Mazraat Tayr Semhat	0	0	0	0	0

Merouahine	0	0	1	0	1
Mheilib	0	0	0	0	0
Neftakhiyé	0	5	0	2	7
Niha Sour	0	0	0	0	0
Ouadi Jilo	3	0	2	0	5
Qana	3	2	4	1	10
Qlailé Sour	8	0	4	0	12
Recheknanay	0	0	1	0	1
Rmadiyé	0	3	1	0	4
Sadiqine	10	11	2	2	25
Selaa Sour	0	2	1	0	3
Sour	53	1	17	2	73
Srifa	3	6	2	1	12
Tayr Debbé	3	2	0	0	5
Tayr Falsay	7	13	1	9	30
Tayr Harfa	0	0	1	1	2
Touayri	0	0	0	0	0
Toura	2	5	2	1	10
Yanouh Sour	3	2	1	1	7
Yarine	1	2	2	3	8
Zebqine	0	2	1	2	5

9.5. Estimated Biomass Generation Rates

9.5.1. Land Use Land Cover map and calculation procedure

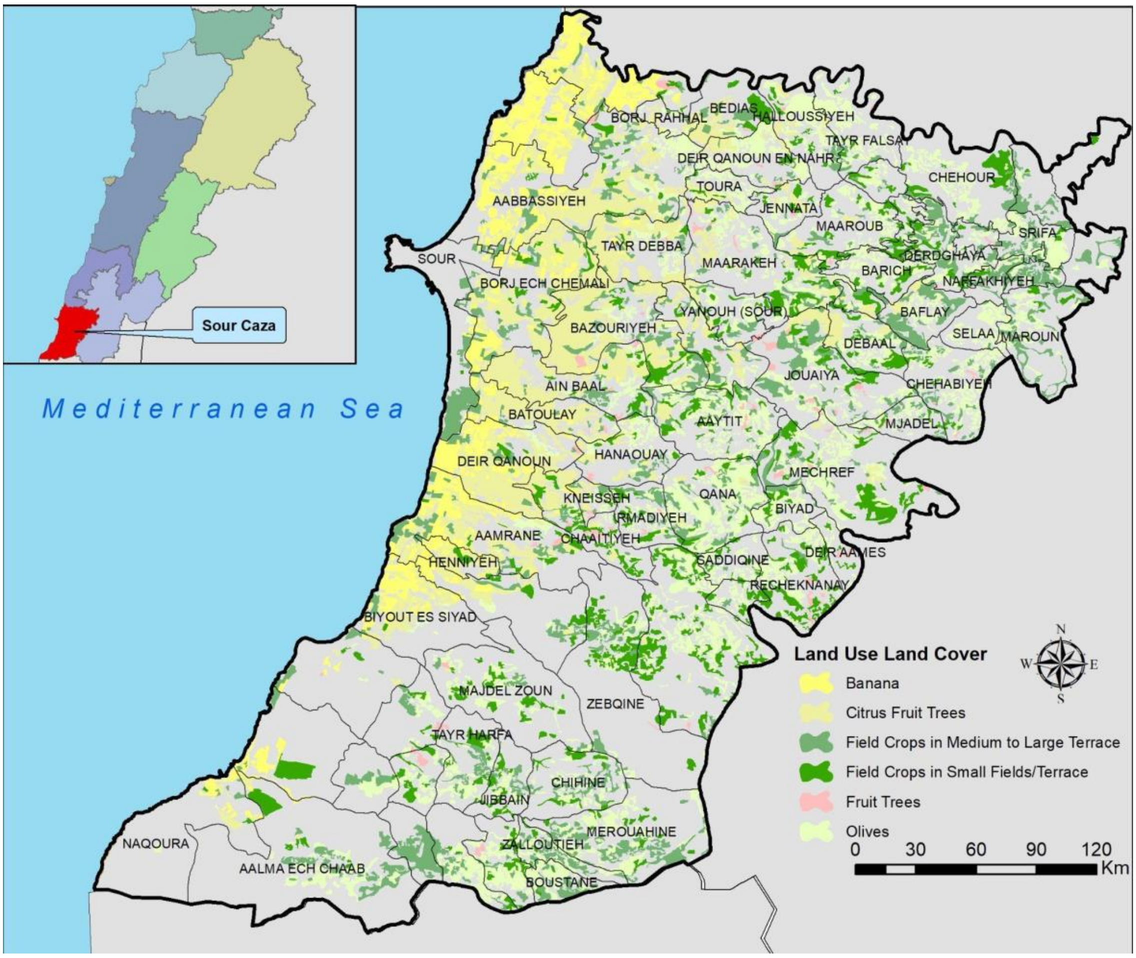

Figure 34 Land use land cover map

As mentioned earlier, the agricultural areas of the villages of Tyr were obtained from the intersection of two maps.

To calculate the tonnage of biomass, the area (Ha) each type of crop covers was multiplied by the coefficient of biomass (ton/Ha) to obtain the total biomass per village.

For field crops, a coefficient of 0.3 was used. This coefficient is for tobacco since it is widely grown in the Tyr Caza. For citrus fruit trees a coefficient of 1.08 was used, for olive trees 1.3.

9.5.2. Biomass Quantity Table

Table 20 Biomass quantity

Village Name	Agricultural Area (Ha)	MSW tonnage	Biomass Tonnage Inc. Banana	Biomass Tonnage Exc. Banana
Aabbasiyyeh	1767.8	35	21262.7	759.7

Aalma Ech Chaab	1961.2	4.97	819.63	217.2
Aamrane	1063.1	9.5	15622.3	395.5
Aaytit	716.5	3.5	350.49	350.5
Aazziyeh	768.7	0	4530.3	123.6
Abou Chech	251.7	0	97.163	97.2
Ain Baal	695.4	14	1024.83	395.4
Arzoun	100.3	0	33.22	33.2
Baflay	344.6	4	125.49	125.5
Barich	403.6	3	177.1	177.1
Batoulay	439	10	3189	266.2
Bazouriyeh	994.2	4	830.81	664
Bedias	404.2	5	138.02	138
Bestiyat	121.8	0	37.12	37.1
Biyad	211.2	0.8	119.38	119.4
Biyada (Sour)	808.6	0	1237.25	32.7
Biyout Es Siyad	746.3	2	11632.2	176.2
Bmaryamine	1447.6	0	461.48	461.5
Borj Ech Chemali	1068.6	6.43	11342.6	500.1
Borj Rahhal	117	9	157.33	52.9
Boustane (Sour)	197.5	1.13	106.59	106.6
Btaychiyeh	259	0	30.82	30.8
Chaaitiyeh	481.9	6	750.1	195.3
Chamaa	413.7	0	63.73	63.7
Chehabiyeh (Tayr Zebna)	582.9	10	234.32	234.3
Chehour	780.8	1.75	207.61	207.6
Chihine	548.8	0.5	127.96	128
Debaal	358.5	2	175.7	175.7

Deir Aames	164.2	9	44.26	44.3
Deir Qanoun El Ain	796.4	3	16169.8	429.6
Deir Qanoun En Nahr	398.2	10	254.56	254.6
Derdghaya	375.6	0.4	150.45	150.4
Dhayra	372.1	0	140.27	140.3
Halloussiyeh	443.1	2	227.65	227.6
Hamoul	766.5	0	5212.62	24.6
Hanaouay	464.8	3.75	301.41	174.3
Henniyeh	164.6	10	2806.38	89.5
Hmairi Sour	154.9	0	40.42	40.4
Jennata	255.9	3	99.01	99
Jibbain	299.7	2	67.21	67.2
Jijim	316.1	0	58.09	58.1
Jouaiya	977.8	14	353.99	354
Khreibeh (Qana)	722.4	7.5	481.71	481.7
Kneisseh (Sour)	115.5	0.5	465.28	59.7
Maarakeh	979.1	10.5	405.82	405.8
Maaroub	541.6	10	191.12	191.1
Majdel Zoun	1086.1	1.13	183.59	183.6
Marnaba	240.1	0	2.57	2.6
Mazraat Aaiyeh	143.6	0	52.33	52.3
Mazraat Ain Ez Zarqa	689.4	0	23811.2	197.7
Mazraat El Mechref	1265.3	1.1	399.13	399.1
Mazraat Ez Zalloutieh	210.4	0.43	94.05	94
Mazraat Tayr Semhat	264.7	0	28.16	28.2
Merouahine	1000.2	1	284.94	284.9
Mheilib	630.6	0	25679.8	89.9
Mjadel	225.1	8.5	72.74	72.7

Naffakhiyeh	140.6	2.25	38.15	38.1
Naqoura	1054.7	4.5	3239.71	41.2
Niha (Sour)	127.6	0	45.88	45.9
Ouadi Jilo	433.4	0	172.61	172.6
Qalaat Maroun	620.1	3	146.57	146.6
Recheknanay	615.4	0.75	228.25	228.2
Rmadiyeh	304.6	3	94.23	94.2
Saddiqine	219.7	8.5	77.12	77.1
Selaa	219.7	0.75	112.56	112.6
Sour	656.5	39.5	1151.18	56.5
Srifa	261.1	10	137.12	137.1
Tayr Debba	577.7	9.62	1689.17	343.9
Tayr Falsay	518.2	3.5	195.9	195.9
Tayr Harfa	447.1	0.86	117.4	117.4
Touayri	256.8	0	21.58	21.6
Toura	203.5	6.5	125.91	125.9
Yanouh (Sour)	306.6	1	130.64	130.6
Yarine	328.1	0	175.87	175.9
Zebqine	1457.2	1	135.45	135.5

9.6. Different Waste Generation Rates

Table 21 Different Waste Generation Rates (full 0 row indicates unreported)

Village Name	Total Estimated MSW Generation	Total Per Person	Organic Portion	Organic Per Person
Aabbassiyet Sour	37.00	0.63	20.35	0.35

Aain Abou Abdallah	0.00	0.00	0.00	0.00
Aain Baal	14.00	1.22	7.70	0.67
Aaiyé	0.00	0.00	0.00	0.00
Aalma Ech-Chaab	4.97	3.75	2.73	2.06
Aaytit	3.50	0.67	1.92	0.37
Aaziyé	0.00	0.00	0.00	0.00
Abou Chech	0.00	0.00	0.00	0.00
Arzoun	0	0	0	0
Bafliyé	4.00	0.80	2.20	0.44
Barich	3.00	0.86	1.65	0.47
Batoulay	10.00	2.00	5.50	1.10
Bazouriyé	4.00	0.28	2.20	0.15
Bedias	5.00	2.22	2.75	1.22
Bestiyat	0	0	0	0
Biyad	0.80	3.20	0.44	1.76
Borj Ech-Chemali	6.48	1.04	3.56	0.57
Borj En-Naqoura	4.50	1.25	2.47	0.69
Borj Rahhal	9.00	1.44	4.95	0.79
Boustane	1.13	0.47	0.62	0.26
Btaychiyé	0.00	0.00	0.00	0.00
Chaaitiyé	6.00	1.25	3.30	0.69
Chamaa	0.00	0.00	0.00	0.00
Chehabiyé	10.00	0.63	5.50	0.35
Chehour	1.75	0.50	0.96	0.28
Chihine	0.50	0.56	0.28	0.31
Debaal Sour	2.00	0.44	1.10	0.24
Deir Aames	9.00	2.40	4.95	1.32
Deir Kifa	3.00	1.00	1.65	0.55

Deir Qanoun El-Aain	3.00	0.67	1.65	0.37
Deir Qanoun En-Nahr	10.00	0.95	5.50	0.52
Derdaghaiya	0.40	6.15	0.22	3.38
Dhayra	0.00	0.00	0.00	0.00
Halloussiyé	2.00	0.89	1.10	0.49
Hamoul	0.00	0.00	0.00	0.00
Hanaouay	3.78	1.51	2.08	0.83
Henniyé	10.00	5.00	5.50	2.75
Hmairi Sour	0.00	0.00	0.00	0.00
Iskandarouna Sour	0.00	0.00	0.00	0.00
Jbal El-Botm	1.50	0.67	0.82	0.37
Jennata	3.00	1.00	1.65	0.55
Jibbayn	2.00	0.57	1.10	0.31
Jijim	0.00	0.00	0.00	0.00
Jouaiya	14.00	1.56	7.70	0.86
Kneisset Sour	0.50	0.88	0.28	0.48
Maaraké	10.50	0.70	5.78	0.38
Maaroub	10.00	1.32	5.50	0.73
Majdel	8.50	1.26	4.68	0.69
Majdelzoun	1.13	0.21	0.62	0.12
Mansouri Sour	2.00	0.34	1.10	0.19
Marnba	0.00	0.00	0.00	0.00
Mazraat Ez-Zalloutiyeh	0.43	1.07	0.24	0.59
Mazraat Mechref	1.10	0.88	0.61	0.48
Mazraat Tayr Semhat	0.00	0.00	0.00	0.00
Merouahine	1.00	0.50	0.55	0.28
Mheilib	0.00	0.00	0.00	0.00
Neftakhiyé	2.25	3.44	1.24	1.89

Niha Sour	0.00	0.00	0.00	0.00
Ouadi Jilo	0	0	0	0
Qana	7.56	0.85	4.16	0.47
Qlailé Sour	9.50	1.34	5.22	0.74
Recheknanay	0.75	0.52	0.41	0.29
Rmadiyé	3.00	1.54	1.65	0.85
Sadiqine	8.50	0.81	4.68	0.45
Selaa Sour	0.75	0.19	0.41	0.10
Sour	37.78	0.63	20.78	0.35
Srifa	10.00	0.91	5.50	0.50
Tayr Debbé	9.61	1.54	5.29	0.85
Tayr Falsay	3.50	0.74	1.92	0.41
Tayr Harfa	0.86	0.76	0.47	0.42
Touayri	0.00	0.00	0.00	0.00
Toura	6.50	0.79	3.58	0.43
Yanouh Sour	1.00	0.56	0.55	0.31
Yarine	0	0	0	0
Zebqine	1.00	0.26	0.55	0.14

9.7. Transportation Data

Table 22 Transportation Data

Name	Heavy Trucks	Light Trucks	Disposal Method	Distance Travelled (km)
Aabbassiyet Sour	2	4	Dump	147
Aain Abou Abdallah	0	0	-	0
Aain Baal	-	2	Dump	36

Aaiyé	0	0	-	0
Aalma Ech-Chaab	-	-	Dump	95
Aaytit	-	1	Dump	52.5
Aaziyé	0	0	-	0
Abou Chech	0	0	-	0
Arzoun	-	-	Other	-
Bafliyé	1	0	Dump	10.5
Barich	1	1	Dump	11.19
Batoulay	1	1	Dump	12
Bazouriyé	3	1	Dump	56
Bedias	-	1	Dump	7
Bestiyat	-	1	Dump	4
Biyad	1	-	Null	-
Borj Ech-Chemali	4	3	Dump	196
Borj En-Naqoura	-	2	Facility	18.5
Borj Rahhal	-	3	Dump	-
Boustane	-	-	Dump	-
Btaychiyé	0	0	-	0
Chaaitiyé	-	2	Dump	36
Chamaa	0	0	-	0
Chehabiyé	-	3	Dump	18
Chehour	-	1	Dump	14
Chihine	-	1	Dump	24.5
Debaal Sour	1	-	Dump	12
Deir Aames	-	1	Dump	28
Deir Kifa	1	-	Dump	-
Deir Qanoun El-Aain	2	-	Dump	210
Deir Qanoun En-Nahr	2	-	Facility	28

Derdaghaiya	0	0	-	0
Dhayra	0	0	-	0
Halloussiyé	1	-	Dump	4
Hamoul	0	0	-	0
Hanaouay	-	1	Dump	-
Henniyé	1	-	Dump	10
Hmairi Sour	0	0	-	0
Iskandarouna Sour	0	0	-	0
Jbal El-Botm	-	1	Dump	49
Jennata	-	1	Dump	-
Jibbayn	-	1	Dump	10.5
Jijim	0	0	-	0
Jouaiya	2	-	Dump	28
Kneisset Sour	-	1	Dump	0.5
Maaraké	1	3	Dump	28
Maaroub	1	-	Dump	24.5
Majdel	-	1	Dump	38.5
Majdelzoun	1	-	Dump	10.5
Mansouri Sour	-	2	Dump	28
Marnba	0	0	-	0
Mazraat Ez Zalloutiyeh	-	1	Dump	4.5
Mazraat Mechref	0	1	Dump	8.75
Mazraat Tayr Semhat	0	0	-	0
Merouahine	-	1	Dump	15.75
Mheilib	0	0	-	0
Neftakhiyé	-	1	Dump	28
Niha Sour	0	0	-	0
Ouadi Jilo	-	-	Dump	-

Qana	-	3	Facility	42
Qlailé Sour	-	1	Dump	63
Recheknanay	1	-	Dump	5.25
Rmadiyé	2	-	Dump	7
Sadiqine	1	1	Dump	14
Selaa Sour	1	-	Dump	-
Sour	2	0	Facility	280
Srifa	-	1	Dump	7
Tayr Debbé	-	2	Dump	28
Tayr Falsay	-	1	Dump	21
Tayr Harfa	-	1	Dump	12
Touayri	0	0	-	0
Toura	-	-	Dump	-
Yanouh Sour	-	1	Dump	11.25
Yarine	-	1	Dump	27
Zebqine	-	2	Dump	32.4

9.8. Detailed Commercial Establishments

Table 23 Detailed Commercial Establishments (full 0 row indicates unreported)

Name	Government	Military	Restaurants	Hotels	RetailVeg	Wholesale Veg	Agri Coops	Agri Mills	Factories	Poultry	Livestock	Butchers	Slaughter	Univ	Schools
Aabbassiyet Sour	3	1	31	4	32	0	2	2	0	3	3	25	1	1	21
Aain Abou Abdallah	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aain Baal	3	0	3	0	30	0	0	2	0	10	8	2	0	0	5
Aaiyé	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aalma Ech-Chaab	3	1	3	1	1	0	1	0	0	0	2	0	0	0	3
Aaytit	1	0	8	0	3	0	0	1	0	1	1	5	0	0	3
Aaziyé	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Abou Chech	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arzoun	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Bafliyé	0	0	0	0	0	0	0	0	0	1	1	2	0	0	1
Barich	0	0	1	0	3	0	0	0	0	1	2	2	0	0	0
Batoulay	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2
Bazouriyé	0	0	5	0	0	0	1	0	0	2	2	0	0	0	7
Bedias	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Bestiyat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Biyad	0	0	0	0	0	2	0	1	0	0	3	2	0	0	1
Borj Ech-Chemali	0	0	1	1	50	0	0	0	0	0	0	22	0	3	12
Borj En-Naqoura	3	1	7	3	4	0	0	0	0	0	0	4	0	0	1
Borj Rahhal	0	1	1	0	12	0	0	0	0	1	2	7	2	0	3
Boustane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Btaychiyé	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaaitiyé	2	0	4	0	0	0	0	0	0	0	1	1	0	0	1
Chamaa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chehabiyé	2	0	10	0	20	0	1	0	4	0	10	20	2	0	3
Chehour	2	0	0	0	7	0	0	0	0	0	1	0	0	0	2
Chihine	1	0	0	0	2	0	0	1	0	1	0	0	0	0	1
Debaal Sour	0	0	0	0	3	0	0	0	0	0	0	1	0	0	1
Deir Aames	0	0	0	0	4	0	0	0	0	0	3	4	0	0	0
Deir Kifa	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Deir Qanoun El-Aain	0	0	1	0	8	0	0	0	0	5	1	0	0	0	1
Deir Qanoun En-Nahr	0	0	3	0	3	0	0	0	0	0	0	2	0	0	1
Derdaghaiya	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0

Dhayra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halloussiyé	0	0	0	0	1	0	0	0	0	6	5	1	0	0	1
Hamoul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hanaouay	0	0	0	0	3	0	0	0	0	0	0	5	0	0	1
Henniyé	0	0	0	0	2	0	0	0	0	0	1	0	0	0	1
Hmairi Sour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iskandarouna Sour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jbal El-Botm	0	0	0	0	3	0	0	0	0	2	0	0	0	0	1
Jennata	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1
Jibbayn	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Jijim	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jouaiya	0	0	5	0	8	0	0	0	0	0	0	10	0	1	3
Kneisset Sour	1	0	1	0	0	0	0	0	0	0	2	2	0	0	0
Maaraké	2	0	10	0	50	0	0	3	0	5	0	19	4	0	4
Maaroub	2	0	7	0	6	0	0	1	0	0	0	4	0	0	2
Majdel	2	0	3	0	3	0	1	0	0	0	0	5	0	0	2
Majdelzoun	1	0	1	0	10	0	1	0	0	6	3	1	0	0	1
Mansouri Sour	2	2	2	1	3	0	0	0	0	1	2	2	0	0	1

Marnba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mazraat Ez-Zalloutiyeh	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Mazraat Mechref	1	0	0	0	3	0	1	0	0	0	1	1	0	0	2
Mazraat Tayr Semhat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merouahine	1	3	0	0	0	0	0	0	0	0	0	0	0	0	1
Mheilib	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neftakhiyé	1	0	0	0	1	0	1	1	0	1	4	0	0	0	0
Niha Sour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ouadi Jilo	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2
Qana	1	2	3	0	15	0	1	0	0	2	0	2	0	0	4
Qlailé Sour	2	1	7	1	10	0	0	0	0	0	0	5	0	0	4
Recheknanay	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Rmadiyé	0	0	0	0	2	0	0	0	0	3	0	1	0	0	1
Sadiqine	1	0	10	0	10	0	0	2	0	2	8	12	1	0	2
Selaa Sour	1	0	0	0	1	0	0	0	0	0	0	0	2	0	1
Sour	1	0	47	6	0	2	0	0	0	0	0	0	1	3	14
Srifa	1	0	3	0	20	0	1	0	0	0	6	8	0	0	2
Tayr Debbé	1	0	3	0	5	0	0	0	0	2	0	5	0	0	0

Tayr Falsay	3	0	7	0	3	0	0	6	3	7	6	5	0	0	1
Tayr Harfa	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1
Touayri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toura	1	0	2	0	5	0	0	1	0	0	5	2	0	0	2
Yanouh Sour	1	0	3	0	0	0	1	0	0	2	0	2	0	0	1
Yarine	0	0	1	0	3	0	2	1	0	0	2	0	0	0	2
Zebqine	2	0	0	0	5	0	1	1	0	1	1	0	0	0	1