

**An-Najah National University**

**Faculty of Engineering & Information Technology Energy and Environment Department**

“Solid Waste sorting and pre-feasibility study in Wadi Shaer transfer station “

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# Shortcuts

|  |  |
| --- | --- |
| Shortcuts | Stands for : |
| GHGs | greenhouse gasses |
| SWM | solid waste management |
| SW | Solid Waste |
| WB | West Bank |
| ZF | Zahrat Al Finjan Land Fill |
| WS-JSC | Wadi Shaer Joint Service Council |
| JSCs | Joint Service Councils |
| LF | Land Fill |
| TS | Transfer Station |
| WS | Wadi Shaer |
| DPP | Discount Payback Period |
| 3Rs | Reduce, Recycle and Reuse |
| OECD | Organization for Economic Co-Operation and Development |
| IRR | Internal Rate of Return |
| WB | West Bank |
| AW | Annual Worth |
| PW | Present Worth |
| SPP | Simple Payback Period |
| IRR | Internal Rate of Return |

# Abstract

Palestine is part of the world that faces problems in the disposal of waste, in addition to the restrictions imposed on the establishment of new landfills, so we have to think of other solutions to get rid of waste, such as waste separation and composting. Where the waste is separated either in the homes and this requires a high culture of the community, or sorting at the transfer stations. Where glass and metals are separated by one unit, plastic materials by unit and organic materials by unit.

Palestine is an agricultural country; it is better to build a composting plant. Composting food and other organic waste provides a range of environmental benefits, including improving soil health and reducing greenhouse gas emissions. As the population grows, SW generation is increasing until it has now become a global problem. With the exacerbation of this problem, interest in SWM has increased.

SWM is a process that includes collection, transporting, treatment and disposal of solid waste together with monitoring and regulation. Through the principle of SWM, the current situation will be evaluated, the main problem identified, and solutions will be found. SW is managed with the 3Rs concept: Reduce, Recycle and Reuse. And by focusing on this concept, waste minimization can be achieved in an efficient way. The principle of the 3Rs contributes to reduce the produced waste, saving money, and increasing responsibility in the matter of waste production.

The produced waste can be treated by many ways, starting by sorting the waste in order of its type and this can be done in home or the transfer station or the final destination which is the landfill. after finishing the sorting part, it can be then separated from the other non-recyclable waste and this can be done manual and mechanical. and the final step will be by selling the sorted items to the factories that are interested in the recyclable wastes. And by that the environment will be protected from the danger of the solid waste in addition to achieving economic profits.

After studying the project and analyzing the economic data, the results were positive and economically feasible, as the net profit was **7,415,986.8 Nis/Year** with an initial investment of one million dollars **(3,500,000 Nis)** , the payback period was **half a year**, and the internal rate of return was **147%** . These results were sufficient to determine the project's success and economic feasibility.

# CH1: Introduction

## 1.1: Overview

As the years progressed and population growth increased, the problem of solid waste in the world aggravated, as 11.2 billion tons are produced annually, according to the United Nations Environment Program. The organic waste from solid waste causes a danger to the environment, as it contributes to 5% of the greenhouse gases emissions. In addition to this danger, poor management of solid waste will lead to air pollution, as well as soil and water. (UNEP)

Waste: Anything that has been consumed, whether human, industrial or agricultural, and is no longer usable, there are several types of waste, including municipal solid waste, E-waste (electrical and electronic), industrial solid waste, agricultural waste and residues, hazardous waste.

Human being is considered as the main cause of the solid waste problem because of the various activities that they carry out. In addition, many people oppose the establishment of solid waste management stations in their neighborhood or near their homes for fear of unpleasant odor emissions or increased disturbance in the area, which makes finding solutions for the waste problem is more difficult.

The growth rate of SW is determining by several factors, including economic development and general customs. In general, the increase in economic development leads to an increase in the production of solid waste in any country. Figure (1) shows the current waste production rate for each region.

Figure Waste generation by region (Hoornweg & Bhada-Tata, 2012)

In the regions of the Middle East and Africa, the average production of waste is approximately 1.1 kilograms/person/ day. As for the Organization for Economic Co-Operation and Development (OECD), the waste production is between 1.1 to 3.7 kilograms/person/ day. In general, High-income countries produce the largest amount of waste per person compared to low-income countries that produce less solid waste per person. (Hoornweg & Bhada-Tata, 2012)

Figure (2) shows the percentage of waste production compared to the percentage of income, which clearly shows that with the increase in income, the production of waste increases.

Figure Waste Generation by income (Hoornweg & Bhada-Tata, 2012)

For low-income countries, the majority of their solid waste is organic waste, while for high-income countries, the majority of their solid waste is paper, plastic and other inorganic materials. As for the regions, the largest producers of organic waste are the countries located in the East Asia and Pacific region with 62%, and the least producers of organic waste are the countries working with the OECD at 27%. (Hoornweg & Bhada-Tata, 2012).

Based on the above, it can be concluded that the good management of solid waste is very important, it will provide several environmental and social positive effects, as well as economic. From an environmental point of view, air pollution and the problem of GHGs will be avoided. From an economic point of view, good SWM will enable us to obtain recycled materials and sell them in the market instead of dangerously disposing it. In short, SWM, collection and recycling will contribute to maintaining the general health of people and protect the environment from the various dangers of SW.

Due to the increasing population increase in addition to the increase in consumption in Palestine, the annual production of SW has increased. Palestinians produce 4,333 tons of SW per day (0.9 Kg/capita/day in the west bank and 0.7 Kg/capita/day in Gaza of waste), which means that there is a danger that must be resolved. There are 5 famous landfills (LF) in Palestine in the West Bank: Jericho LF in Jericho, Zahrat Al Finjan LF in Tulkarm, and AlMenya LF in Bethlehem. As for Gaza, there are two LFs, namely the Sofa LF and Johr al-Deek LF. (Atallah, 2020)

Figure (3) shows general information about SW in Palestine, including the quantity of production per capita, as well as the percentages and types of produced waste. (numbers are rounded by excel).

Figure Municipal SW in Palestine (Atallah, 2020)

Figure Municipal SW in Palestine (Atallah, 2020)

## 1.2 : Objectives and Scope Of Work

This research aims to find solutions to a significant problem in Palestine, which is how to reduce and at the same time invest in the field of SW through all its stages in terms of collection in order to obtain a financial return.

The scope of this project is to conduct a study on the management of municipal solid waste at the Wadi Shear Transfer Station. This will involve the following tasks:

* Conduct a review of current waste management practices at the WASI Shear Transfer Station, including collection, transport, and disposal of municipal solid waste.
* figure out the feasibility of a SW sorting project in this TS and sell the sorted waste in order to obtain revenues, and decrease the pressure of incoming waste on Zahrat Al Fenjan LF.
* Prepare a final report summarizing the results of the study and presenting the proposed recommendations.
* Present the recommendations to relevant stakeholders, including Wadi Shaear management and local authorities.

# CH2 : Theoretical Background

## 2.1 : Solid Waste Management (The 3 Rs)

For waste management, there is a hierarchy consisting of five basic steps (reduce, reuse, recycle, treat, and dispose of), but the principle of 3R in reducing waste, reusing, and recycling has priority in its application to waste management.

**1-Reduce:**

It is the most important of the three strategies of waste management because it contributes to reducing environmental damage, which is a result of waste, so the work that must be done is to reduce the waste that is generated by collecting the waste that can be recycled and used. The benefits of reducing waste include reducing emissions of harmful gases to the environment, such as carbon dioxide (CO2). However, there are many obstacles when implementing this strategy, so we have to reach an understanding with stakeholders to implement waste reduction because they will benefit from its application.

**2-Reuse:**

It is the practice of using a material over and over again. by finding alternate uses for the item rather than disposing of or recycling it, whether in its original use or another use to satisfy the purpose. Many benefit from the option of waste management, such as reducing gas emissions that increase global warming (which change the global climate). It also saves money and natural resources, reducing the harmful effects on the environment. Therefore, before you recycle or dispose of anything, be sure if it has any life left.

**3-Recycle:**

Reprocessing of waste material to use in a new product The main principle is to collect the waste materials and process them or remanufacture them into a new product. That will reduce emissions and pollutants in the environment, reduce the use and purchase of new materials, provide capacity in landfills, and reduce harmful effects on the environment. This strategy provides job opportunities, but to realize these benefits from the recycling process, they must be studied. Moreover, it was well applied.

Disposal methods in Palestine are mainly landfilling and dumping (based on random or controlled criteria). It is estimated that about 30–35% of municipal waste is dumped illegally, and 65%–70% is disposed of in one of the three operational landfills existing in Palestine. Landfills in Palestine face a lot of challenges that threaten the waste management system due to land restrictions and the high amounts of waste.

Disposal of solid waste is a widespread problem in many developing countries, such as Palestine. The majority of municipal solid waste (MSW) is organic (about 50%), followed by plastic and paper/cardboard (17% and 11%, respectively).Despite this percentage of recyclables, only a small fraction is reused (about 3%) and 1% is recycled. Organic materials, along with some plastic paper and cardboard, are the only materials recycled in the OPT. Other metal is collected and shipped out.

Despite its critical importance, solid waste management (SWM) has received little value, interest, or support, owing to a lack of legislation, a lack of data and information, programs and systems that assist with waste and its disposal, financial support, technical expertise and equipment, and a lack of public awareness.

The public's awareness of SWM issues should grow, as should the budgets allocated to SWM. Waste production in Palestine is affected by several factors, including location and time of year. In fact, three items affect the SWM system: first of all, the separation of waste at its source; second, the attitude toward solid waste reuse or recycling; and finally, the willingness to pay to improve the SWM services, which depends on the person's gender, age, income, educational level, and race. These items can decrease waste production and waste management costs, but they also cause environmental pollution that affects public health. Palestine generates about 1.1 million tons of solid waste, according to the National Strategy for Solid Waste Management. (NSSWM 2010).

## 2.2 : Separation and Sorting Methods

Waste management shows similarities to other industries that can be more efficient and improved by using analytical and technological tools. Many technological tools could enable waste treatment by providing data that is already required by legislation and measuring waste characteristics. Optical technologies and mathematical techniques will provide information about materials and fuel properties. Sensors play a critical role in the waste process; they provide the most quality indicators allowed by law and better tools to stakeholders. Sensors such as fluorescence, hydrophobicity, laser-induced breakdown spectroscopy, microwaves, resistivity and capacity, stiffness, ultrasound imaging, optical imaging using visible wavelength sensors, and X-ray imaging could not be found in Palestine. Another important process is the biological process, which is applied when the input waste contains biodegradable materials. Waste from industrial or commercial sources generally does not have a biodegradable fraction, so this process is not required. There are two types of this process, which are biodrying and anaerobic digestion. The biological process helps reduce the volume of waste and improve the quality of the fuel produced from waste.

**First of all**, the separation done at the **household** level, for example, plastic separated from carton and metal, is done according to clear information about what and how to separate. Then a special program should be set up to collect recyclable waste and bring it to a special container. That will transfer it to a station facility, where the staff will separate the waste.

Separation at the source: separation started at the source of waste generation by the residents, local government unit's employees, or private sector. When SW separation at source is used, many benefits emerge, such as reduced contamination, higher separation rates, and the promotion of clean, marketable materials. However, the disadvantage is the high cost of investment.

Methods of separation at source, such as curbside collection and/or drop-off centers Curbside collection is the system in which the waste is separated into different components and then put at the curbside to be collected by the waste employee, according to clear information about how and what waste can be disposed of. WS-JSC could set up programs to collect waste on a regular basis and place it in special containers that will transport it to the transfer station facility, where an employee will pick it up and separate it in compartments in the vehicle.

Drop-off centers are centralized locations where people dispose of their waste and waste laborers separate it based on its components. These centers must have been designed and located according to special criteria that consider the population, location, number of centers, and materials handled. These criteria increase the convenience of residents.

**Secondly, manual sorting** (hand picking) is an operation that is done by plant personnel who work in waste processing. Their goal is to separate the waste according to type or to remove waste that may reduce the performance of other processes. People can recognize materials in a matter of seconds. Many challenges affect this process, most commonly fatigue.

A manual separation scenario is possible when the total benefits of the recyclable materials are higher than the total expenses of the business's salaries. When the SW is unloaded by tractors and compactors at the transfer station floor space, the workers separate the SW manually in a way that it can be recycled from bulky materials such as metal, cardboard, and plastic. The remaining SW was loaded by bulldozer into the container to be transferred to ZF.

This scenario has many drawbacks, including the very low percentage of waste that is expected to be separated and recycled, the fact that the odor emissions will remain for hours, the poor view of the area, and the accumulation of rodents and insects.

**Finally, mechanical separation (recycling plant): A recycling facility is not a landfill or a transfer station for solid waste; it employs technology in the processing, separation, and classification of municipal waste and transfers waste materials to items that manufacturers can sell or reuse.** In contrast to the manual scenario, this scenario has a high percentage of recyclable materials that can be separated. The SW was unloaded by tractors or compactors at the reception area of the plant, and then the loader took the SW to the plant, where the waste was treated mechanically. That means there will be several classifications for the waste, including size and separation according to component: metal, glass, paper, and plastic. The organic fraction will go through aerobic fermentation for 8 to 10 weeks at the composting plant.. (Al-Sa'di, 2009)

Mechanical processes allow the separation of waste according to its shape, density, size, and magnetic properties. Its efficiency depends on purity grade (the level of cleanliness of a particular component in an output fraction as measured by the ratio of the mass of the particular component present in that output fraction to the total mass of that output fraction) and recovery rate, which is defined as the ratio between the mass of a particular component in the output fraction and the total mass of the component in the input. Many factors affect this process, including particle size and shape, the presence of hard or large particles, and moisture level. (C.VranckenP.J.LonghurstS.T.Wagland, 2017)

**Separation at the transfer station: The SW transfer station is where the waste is collected and transported later.** Before the waste reaches the landfill, it is collected and transported by collection vehicles, then unloaded at the transfer station, then reloaded onto vehicle trailers and transferred to the landfill. The WS-JSC transfer station in the west bank receives solid waste and temporarily stores it until it is transported to the Jenin governorate landfill (ZF), which is located 23 kilometers to the north of the WS-JSC transfer station.

The separation of SW is done at the WS transfer station by one of these different scenarios: first,  zero separation, then manual separation, and finally mechanical separation. Zero separation is the best scenario when the total expenses of SW separation (such as transfer stations, unloading and reloading the waste, using compactors and tractors, and the transport of SW to a ZF landfill) exceed the total benefits from selling the recyclable materials. So the separation of SW will have been done at the ZF landfill because the ZF-JSC signed an agreement with the private sector for the SW separation at the ZF landfill. This separation will have created many job opportunities, will have reduced the bad aesthetic view or odor emissions at the transfer station and nearby locations, will have reduced the SW tariff for the beneficiaries, and will have extended the life of ZF.. (Al-Sa'di, 2009)

# CH3: Solid Waste situation in Palestine

## 3.1 : Solid Waste In Palestine

In recent years, interest has increased in trying to solve the SW problem in Palestine. However, the Palestinian authorities faces many problems that make this process difficult for them, including the restrictions imposed by the Israeli occupation on the region and its imposed policies, which determine the powers of the Palestinian authorities to act in the matter and solve the problem, regardless of the lack of cultural awareness of the Palestinian community and their lack of cooperation in solving this problem.

The Joint Service Councils (JSCs) are the main responsible for SWM in Palestine. their work is based on the collection and transportation of SW, as well as the management of LFs in the country. There are 15 JSCs in Palestine, 11 councils whose job it is to collect and transfer SW only, and 3 councils manage the existing LFs. Hebron and Bethlehem Higher council and Gaza JSC are the only JSCs in Palestine that treat the medical waste in limited quantities.

Table (1) shows information about the availability of collection, transfer and LFs in the Palestinian governorate:

Table : Collection, Transfer and LF information.(Rawan A. Tayeh 2020)

|  |  |  |  |
| --- | --- | --- | --- |
| Palestinian Governorate in WB | Collection | Transfer | Landfill |
| Tulkarm | 🗸 | 🗸 | 🗴 |
| Jenin | 🗸 | 🗸 | 🗸 |
| Nablus | 🗸 | 🗸 | 🗴 |
| Tubas | 🗸 | 🗸 | 🗴 |
| Qalqilya | 🗸 | 🗸 | 🗴 |
| Salfit | 🗸 | 🗴 | 🗴 |
| Jericho | 🗸 | 🗴 | 🗸 |
| Ramallah | 🗸 | 🗸 | 🗴 |
| Jerusalem | 🗸 | 🗸 | 🗴 |
| Hebron | 🗸 | 🗴 | 🗸 |
| Bethlehem | 🗸 | 🗴 | 🗸 |

Table (2) Shows the transfer stations (TS) in Palestine in addition to the amount of waste and the distance traveled to reach the final disposal LF:

Table : List of TS in Palestine.(Jabareen, 2019)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Area | Name of TS | Transferred Quantity ( tons/day) | Transferring Distance (KM) | Final Disposal | Management Responsibility |
| Jenin | Western Jenin | 50 | 35 | Zahrat Al Fenjan | Jenin JSC |
| Tubas | Tubas | 43 | 28 | Zahrat Al Fenjan | Tubas JSC |
| Nablus | Al Sayrafi | 180 | 40 | Zahrat Al Fenjan | Nablus Municipality |
| Tulkarem | Tulkarem | 132 | 30 | Zahrat Al Fenjan | Tulkarem JSC |
| Qalqelia | Qalqelia | 123 | 60 | Zahrat Al Fenjan | Qalqelia JSC |
| Jericho | No TS , Wastes sent directly to Jericho sanitary LF A small part of the collected waste ( AVG. 2.1 tons/day ) is sent to Zahrat Al Fenjan sanitary LF through the TS of Nablus ( Al Sayrafi ) . | | | | |
| Ramallah | Ramallah | 100 | 120 | Zahrat Al Fenjan | Ramallah Municipality |
| Al Bireh | 100 | 80 | Zahrat Al Fenjan | Al Bireh Municipality |
| Northeast and Southeast Jerusalem | Al Abdaly | 60 | 353 | Al Menya | Israeli Side |
| Wadi El Nar | Not functional yet | 30 | -- | Southeast Jerusalem JSC |
| Al Ram | 60 | 55 | Al Menya | Al Ram Municipality |
| Hebron | Tarqumia | 100 | 39 | Al Menya | Hebron& Bethlehem Higher council |
| Yatta | 200 | 35 | Al Menya | Hebron& Bethlehem Higher council |
| Al Fahs | 350 | 33 | Al Menya | Hebron& Bethlehem Higher council |
| Gaza | El Yarmouk | 700 | 15 | Juhr Eldik | Gaza Municipality and JSC North |
| Khan Younis (Not started yet ) | Khan Younis | Newly constructed | 24 | Sofa | JSC South |
| Rafah ( Under construction ) | Rafah | -- | 26 | Sofa | JSC South |

In 2019, the annual rate of Palestinian SW production was 1.58 million tons, at a rate of 0.87 KG/Capita/Day. It was expected that these values ​​would increase by 4% annually as a result of the increasing population, where we conclude from that with the arrival of 2022, it is assumed that the value of SW generation should have reached 1.83 million tons by now based on the annual increase rate. (UNEP, 2019)

This high increase in the production of SW will make the LFs operate at a capacity above their normal capacity which may cause a problem on the long term. (Atallah, 2020)

The most common types of SW produced in Palestine are organic waste, which constitutes nearly half of the solid waste produced in Palestine, the least SW produced is glass. (UNEP, 2019)

As for solid medical waste in Palestine, it is divided into two types: normal waste collected with household waste, and hazardous waste. The main responsible for managing this type of waste is the Ministry of Health, under the responsibility of whoever generates it.

Regarding the calorific values, plastic waste contains the highest calorific value among the rest of the waste produced in Palestine. Table (3) shows the calorific values ​​of SW generated in Palestine, in addition to the percentages produced for each of the mentioned wastes:

Table : composition percentage and calorific value of SW in Palestine.(Rawan A. Tayeh 2020)

|  |  |  |
| --- | --- | --- |
| Fraction | Calorific Value ( Mj/Kg ) | Palestinian MSW (%) |
| Paper | 16 | 12.6 |
| Organic | 4 | 50 |
| Plastic | 35 | 14.6 |
| Glass | 0 | 1.8 |
| Metals | 0 | 205 |
| Textiles | 19 | Others – 18.5 |
| Others | 11 |  |

Figure (5) in the next page , shows the SW flow for the collected quantities by the JSCs in the WB Which clearly shows the arrival of large quantities of waste to landfills. If These SWs were properly managed, the preservation of environmental integrity and public health, and good financial gains will be achieved :

Total Collection by 12 JSCs

1,672 Ton/Day.

Direct (414 Ton/Day )

4

Sanitary LF

(1,383 Ton/Day)

TS ( 969 Ton/Day )

Recycle in TS (13 Ton/Day )

Random Dumpsites (276 Ton/Day)

Figure : SW flow of collected quantities by the JSCs *(Rawan A. Tayeh 2020)*

## 3.2 : Solid waste in Wadi Shaer Landfill.

Wadi Shaer LF's daily waste income was estimated to be 160 Tons per day, including all types of waste. Most of these wastes were organic, including plastic, paper, and cartons. For other types of waste, like glass waste, metal waste, and wood waste, the percentage was low since a lot of people collect these wastes and use them or sell them on their own. The yearly incoming waste to the LF is 58,400 tons per year. These wastes are currently being transferred to Zahrat Al Finjan LF at a cost of 70 Nis per ton. If SWM was applied on the LF, according to the quantity of the incoming solid waste, a high profit would be achieved.

## 3.3 : Manual separation at home for WS-JSC area

a questionnaire was formed to study the ability of citizens to separate waste in their homes, a sample of 51 person distributed on Wadi Shaer`s areas whish are (Anabta, Bal’a, Beit Lid, Kafr Allabad, Iktaba, Ramin and Saffarin),  most of them are from Anabta with a percentage of 26.5%, followed by Tulkarim with a percentage of 18.4%, the rest were distributed on other areas of Wadi Shaer.

A total of 28 males submitted to the questionnaire, in addition to 23 females, where the average age of the applicants was 21 years. In addition, most of them were university students, with a percentage of 70%. The family members have a highest percentage (20.8%) of 7 person in the family. With regard to the economic situation, the percentage was approximately 50 percent of the applicants, whose economic situation was good, and the other half had an average situation.

Through the questionnaire, the question was asked about the place where the waste is disposed of, and the answer in the questionnaire was mostly in the containers near the house. Those who submitted the questionnaire were asked if they knew anything about waste separation in homes or landfills, so the ratio of those who knew and those who did not know was very close, as 49% of people did not know about this matter, and 51% of them did. Those who answered yes were asked to clarify what they know about this matter, so most of the answers carried the same meaning, which is that waste is separated according to its types, Plastic has special containers, as does glass, as do organic materials and other waste classifications, and each type of waste usually has its own container near the homes of residents.

The respondents were also asked in the questionnaire: "Do you think that it is feasible to separate the waste in the landfill into types such as organic materials, metals, and paper and then recycle them?" The answers expressed their approval of this, and the reasons given by the presenters were similar in that this preserves the environment from the accumulation of waste of all kinds. which reduces pollution in addition to the economic return that will accrue through the recycling of that waste.

It was also asked if people are willing to separate waste in their homes into types such as organics, metals, paper, and plastics. The answers ranged from the majority in favor of this to the minority who rejected it. One of the answers of those who agreed to this was that it protects the environment from pollution by reducing the large quantities of plastic and glass waste and other types of waste that harm the environment. In addition, some of the waste can be used in many fields, such as the production of agricultural fertilizers or the production of natural gas from organic waste. One of the conditions of those who agreed was also that, in the event of separating waste in the house, there should be a financial return on this matter. As for those who rejected this matter, their answers stated that this would consume their time, or, in other words, that they did not have enough time for that.

We conclude from these answers that the majority of those who answered the questionnaire are willing to separate waste in their homes, but it is not that easy, as there are not a high percentage of people who reject this idea at its foundation, which will make this task difficult. In order to implement the idea of separating waste in homes, It will take a long time to be implemented, as the first step should be to spread awareness about the importance of separating solid waste and the negative effects of not doing so. In addition, government should provide new laws that stipulate the violations of those who do not commit to sorting their waste at home.

# CH4: Methodology

The start will be by identifying the problem of waste in general and who is responsible for managing it in Palestine. , the principle of the 3R’s will be explained, which talks about waste reduction, reuse and recycling, and its importance in the waste management process in WS-JSC.

Secondly, there is different ways to separate recyclable waste from non-recyclable waste, including separation at home, manual separation at the station, and finally mechanical separation at the transfer station, these separation ways will be explained and ending with choosing the best method of separation. For manual separation, a questionnaire must be done and given to the living people of WS-JSC area .

Considering the most important information is available, including quantity of waste , the waste components must be detailed, and depending on a certain schedule that will be given in the calculations section, quantity of the recyclable percentage of each SW type will be calculated.

Now, after choosing the preferred separation method, knowing the quantities of SW, the calculations and economic analysis will be started based on the requirements that the chosen method will require, and several information will be collected starting from the annual production of waste in WS-JSC and then the economic analysis of the chosen method, then the annual costs and revenues that will be obtained from the project will be determined in an estimated manner..

This type of project need a yearly amount of money to keep it running, and there for the yearly operation cost of the working machines and vehicles in the project place and relying on the current cost of fuel and the number of working days through the year in addition to the plant operation running cost through the year should be calculated. that’s not it though, we also have the workers’ salaries and the yearly maintenance cost which must be taken into account. And by all of this we will have now the annual cost of the project. Next up, the revenues of the project through the recyclable waste that will be calculated after dividing the waste quantities in the second step and depending on the Recycled waste prices , the final value of the yearly revenues of the project will be obtained.

To review the feasibility of the project , calculations will be done depending on the most famous economic indicators such as:

1. Annual Worth (The net of all the benefits and costs incurred over a one-year period) :
2. Present Worth(The sum of money that must be invested in order to achieve a specific future goal) :
3. simple Payback Period(Determined by counting the number of years it takes to recover the funds invested) :
4. internal Rate of Return (IRR): The discount rate that makes the net present value (NPV) of a project zero.

**.**

At the end, different scenarios will be presented where some data will be changed To determine whether the project will remain economically viable or not.

# CH5: Results and Discussion

## 5.1 : Economic Analysis

Economic analysis is concerned with evaluating the costs and benefits of the project and comparing them to reach a conclusion whether the project is successful or not.

According to Estimations, The daily quantity of incoming waste to Wadi-Al Shear landfill in 2022 was **160 Ton/Day** , which is **58,400 Ton/Year** . This Number will be considered in our calculations.

After that , analyzation of waste components and its recyclable percentage depending on the following Table will be done .

Table : recyclable percentage of each SW material .(Al-Sa'di, 2009)

|  |  |
| --- | --- |
| SW Type | Recyclable Percentage |
| Paper and Carton | 40 |
| Plastics | 60 |

1. Paper and Carton Waste: it represents 12.5% of the total waste which is around 7300 Ton of the total generated waste in WS-JSC area. 40% of Paper and Carton Waste are only recyclable, which is around 2,920 Ton.
2. Plastics Waste: it represents 14.6% of the total waste which is around 8,526.4 Tons of the total generated waste in WS-JSC area. 60% of Plastics Waste are only recyclable, which is around 5,115.84 Ton.

the remaining quantity of waste which will be 42,573 Ton in addition to the non recyclable SW which is 7,790.56 Ton , and that’s in total 50,363.56 Ton out of 58,400 Ton that will be transferred to Zahrat Al Finjan LF at a cost of 70 Nis/Ton .

**Note :** other solid waste types were neglected because it present in small quantity , and some time people pick it up from LF and sell it personally

1. **First of all , analyzation of initial investment Wadi Shaer LF “**

According to Estimation , the initial investment which include site preparation and needed equipment is **(1,000,000 $)** which is almost (3,500,000 Nis) it also represents the capital cost. This amount will be paid half cash (500,000 Nis), the other half will be a loan with an interest of 5% . through calculations, the yearly payment will be $115,487.40 which is (404205.9 Nis/Year) and the total interest over the loan is 77,437$ which is (271,029.5 Nis) . this make the total investment = **(3,771,029.5 Nis)**

Note that the initial investment includes the prices of different needed equipment like the sorting line, washing line, grinding line , etc.

1. **The Annual cost for the project has been taken from the same report of WS-JSC:**

For fuel cost :

Table : Fuel Consumption calculations for the mechanical separation scenario at WS-JSC. (Al-Sa'di, 2009)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| # | Number | Working Day / year | Fuel consumption ( Liter / Km ) | Distance ( Km/Day ) | Nis / Liter | Cost Nis/Year |
| Staff Vehicles | 3 | 310 | 0.077 | 50 | 5.99 | 21,447.2 |
| Truck | 2 | 310 | 0.4 | 60 | 5.99 | 89,131.2 |
| Lifter | 1 | 310 | 0.67 | 150 | 5.99 | 186,618.45 |
| Total Cost | | | | | | 297,196.85 |

Electricity cost was calculated by the following information:

Table : electricity calculations for the mechanical separation scenario

|  |  |  |  |
| --- | --- | --- | --- |
| Item | Electricity Cost ) Nis/KW) | Monthly Electricity bill (Nis) | Yearly Electricity cost for the operation(Nis) |
| Plant Operation | 0.5621 | 15,000 | 180,000 |

* The Maintenance cost represent 5% of the initial investment cost which is 175,000 Nis/Year.
* Salaries is Fixed amount, 25 employees with a 2500 Nis/month salary .

For the total annual cost we have the following table:

Table : Running costs for the mechanical recycling plant at WS-TS

|  |  |
| --- | --- |
| Cost Item | Nis/Year |
| Salaries – 25 employees | 765,000 |
| Fuel | 297,196.85 |
| Electricity | 180,000 |
| Maintenance | 175,000 |
| Transferring non-usable waste to ZF landfill | 3,525,449.2 |
| Total Cost | 4,942,645 |

**The total annual cost for WS-JSC is (4,942,645 Nis/Year)**

1. **For the revenues, first of all the percentage of SW contents which is mentioned in Figure (3) must be considered. the following table mention the selling prices of the recycled materials per ton :**

Table : selling price of each SW material.

|  |  |
| --- | --- |
| SW Type | Selling Price (Nis/Ton) |
| Paper & Carton | 160 |
| Plastics | 2300 |

1. Paper & Carton: We have 2,920 Ton of recyclable Paper & Carton waste with a total selling price of (467,200 Nis Year)
2. Plastics: We have 5,115.84 Ton of recyclable Plastics waste with a total selling price of (11,766,432 Nis/Year)

**The total revenues in the end of 2022 for WS-JSC will be (12,233,632 Nis/Year).**

**Taking into account the annual costs of the project, the annual net profit will be (7,290,986.8 Nis/Year).**

**Economic indicators:**

The following calculations has been done depending on the book of “Engineering Economy - Eight Edition”.

1. **Annual Worth (AW):**

Considering the cost represent the initial investment, the annual worth for the project is:

AW= Initial investment + Annual Cost + Revenues:

* Initial Investment = 3,771,029.5 Nis 🡪 3,771,029.5x (A/P, 10%, 20 Years) = 3,771,029.5x (0.11746) = 442,945 Nis/year
* Annual Running Cost = 4,942,645 Nis/Year
* Annual Revenues = 12,233,632 Nis/Year

1. **Present Worth (PW):**

Considering the lifetime of the project is **20 years,** and the minimum attractive rate of return (MARR) is 10%, the present worth is: (Blank, 2012)

PW= AW x (P/A, I, n)

(P/A, I, n) = (P/A, 10%, 20yrs) = 8.5136



1. **Simple Payback Period (SPP):**

SPP is the length of time it takes to recover the cost of an investment or the length of time an investor needs to reach a breakeven point.

1. **Internal Rate of return (IRR):**

(IRR) is a metric used in financial analysis to estimate the profitability of potential investments, and these were the results:

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Net Cash Flow | Year | Net Cash Flow |
| 0 | -3500000 | 14 | 7,290,986.8 |
| 1 | 3474282.3 | 15 | 7,290,986.8 |
| 2 | 6958447.5 | 16 | 7,290,986.8 |
| 3 | 6941819.8 | 17 | 7,290,986.8 |
| 4 | 6924361.8 | 18 | 7,290,986.8 |
| 5 | 6906028.8 | 19 | 7,290,986.8 |
| 6 | 7,290,986.8 | 20 | 7,290,986.8 |
| 7 | 7,290,986.8 | - | - |
| 8 | 7,290,986.8 | - | - |
| 9 | 7,290,986.8 | - | - |
| 10 | 7,290,986.8 | - | - |
| 11 | 7,290,986.8 | - | - |
| 12 | 7,290,986.8 | - | - |
| 13 | 7,290,986.8 | - | - |

* Net Cash Flow : it will equal the following: -Investment + ( the Yearly Annual revenues + Yearly Annual Running Cost.
* The following figure shows the Cash Flow of the project .

Figure : Cash Flow Diagram for the project

* Using the IRR function in EXCEL = **IRR = 141%**
* **Project feasibility** is the study of a project's various elements to determine if it has the potential for success. and Since **AW and PW > 0,** then the project is **feasible**.

## 5.2 : Sensitivity Analysis

In this subsection , sensitivity analysis will be performed by changing the following parameters through different scenarios : Selling Price, Recyclable Percentage, Initial Investment, Breakeven Point, Amount of Loan, No Revenues, and Amount of Waste.

**Scenario(1) : Selling price cut into half**

1. Revenues will be reduced to half current value ( 6,116,816 Nis/Year ).
2. Net profit will equal (1,174,171 Nis/Year)
3. SPP = 2.9 , almost 3 years
4. **Project still Feasible**
5. Cash Flow Diagram :

Figure : Cash Flow Diagram for Scenario(1)

**Scenario(2) : Investment half doubled to 1.5M $**

1. Amount of loan will be doubled to 1M $ ( interest rate = 5% ).
2. Total Initial investment will be higher (4,042,058.965 Nis).
3. SPP = 0.54 , half a year which is almost the same still .
4. **Project Still Feasible.**
5. **Cash Flow Diagram :**

Figure : Cash Flow Diagram for Scenario(2)

**Scenario(3) : Recyclable percentage for each type reduced to half .**

1. Revenues will be less ( 6,116,816 Nis/Year )
2. Annual running cost will be higher since now we have more non-useful waste that will be transferred to ZF landfill ( 5,644,238.8 Nis/year )
3. Very Low Net profit ( 327577.2 Nis/Year)
4. SPP = 7.9, Almost 8 Years .
5. **Project still feasible .**
6. Cash Flow Diagram :

Figure :Cash Flow Diagram for Scenario (3)

**Scenario(4) : breakeven where the annual running cost equal the annual revenues .**

1. No profit or loss will occur .
2. Project is not feasible .
3. Cash Flow Diagram :

Figure : Cash Flow Diagram for Scenario(4)

**Scenario(5) : No revenues, where the sorted waste is given to the concerned authorities for no price .**

1. Will cost the owners a significant amount of money (4,942,645 Nis/Year ) without any income .
2. Project is not feasible.
3. Cash Flow Diagram :

Figure : Cash Flow Diagram for Scenario(5)

**Scenario(6) : The whole investment is a Loan.**

1. The total initial investment will equal (4,042,055.5 Nis) at an annual payment of (808,409 Nis)
2. Project still feasible .
3. Cash Flow Diagram :

Figure : :Cash Flow Diagram for Scenario(6)

## 5.3 : Results

Based on the economic analyzes for WS-JSC that was carried out in the previous action, which were based on the most famous economic indicators (Note that these calculations are relative to the end of the year 2022). several important results were obtained, including:

* The total initial cost of the project with the total interest is **(3,771,029.5 Nis),** and the life of the project will be **20 years.**
* The project will cost annually **(4,942,645 Nis/Year)** , and these costs include the most important cost through the year, such as workers’ salaries, operating costs, etc.
* The project will bring high revenues which is **(12,233,632 Nis/Year)**, and with deduction of annual costs, we will have an annual net profit of **(7,290,986.8 Nis/Year).).**
* When using the AW and PW indicators, their values ​​appear to be greater than zero (AW, PW > 0), which is the indicator that tells us that **the project is economically feasible**.
* When using the standards of SPP, DPP and IRR, the results show that **in the first year,** the initial amount paid on the project will be recovered, which is an indication of the success of this project in a quick time. In reality this project is impossible to be feasible without governmental involvement Unfortunately , The government must ensure that there are buyers who are interested in taking this sorted waste and recycling it, otherwise, the project will become economically unviable.

## 5.4 : Recommendation

* In this study, the solid waste problem in the world was mentioned and detailed it in Palestine, in addition to that paying attention to the importance of solid waste management in the country is a must.
* Looking at the economic analysis that have been made, the project will achieve very excellent profits, **through which it has been confirmed that the project is economically feasible.**
* An Integration from the government needed to support the creation of Organic waste treatment planet. If this happens, the stakeholders of this project will be able to sort the organic waste and sell it to the treatment planet.
* signing a long-term agreement with the government on the specifications of the incoming waste so that the waste flow of plastic, paper, and carton to the station is ensured in a stable manner , and to ensure that the government does not sign another agreement that gives this type of waste to other companies and stations.
* It must be ensured that spare parts for the main sorting equipment are available so that if one of the sorting lines fails, the sorting process does not stop completely, or that a large storage capacity is available to store the accumulated waste quantities if one of the main sorting equipment fails.
* For the project's success, a government Integration is needed to resolve the issue of selling sorted waste to the concerned organiztaions . if this doesn’t happen, the project won’t be feasible .

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