Recycling Business Opportunities in Iraq
Reflection Study Final Draft – December 2021

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Chapter 1:

Introduction and background

Iraq's population is expected to reach 65,559,682 by 2050 (Iraq population (LIVE)). As the population increases, the demand for using resources will increase since the consumption of natural resources increases as they need to consume more freshwater, land, clothing, etc. to fulfill their needs. According to World Bank, "With rapid population growth and urbanization, annual waste generation is expected to increase by 70% from 2016 levels to 3.40 billion tones by 2050" (Solid waste management). With having no accurate data available on whole Iraq's waste disposal amount, Alnajjar stated, "Iraq is estimated to produce 31,000 tons of solid waste every day with per capita waste generation exceeding 1.4 kg per day. Baghdad alone produces more than 1.5 million tons of solid waste each year" (Alnajjar). Solid waste is useless and sometimes hazardous material with low liquid content. The solid waste will usually end up in land fields of the cities in Iraq. For most of the rubbish, that is the end of their journey since they will not reach the next level of treatment which is reusing or recycling. Please see figure 01.

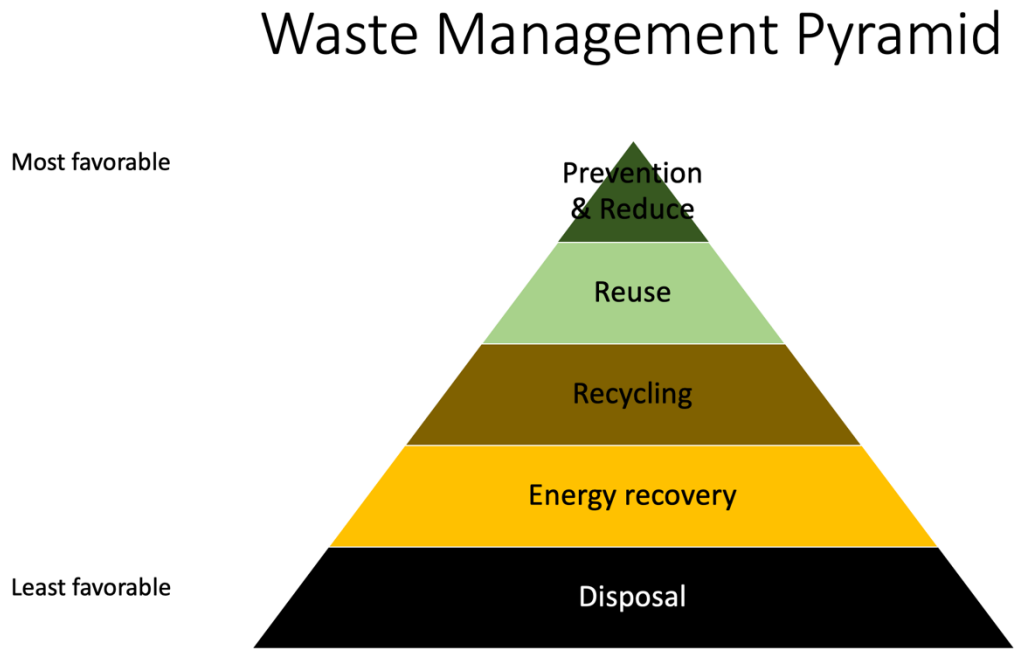


Figure 1 Waste Management Pyramid: an ideal journey of any kind of waste items

In Iraq, there are some small recycling businesses and one RDF (Refuse Derived Fuel) plant, Faruk Holding and Ecocem RDF plant at Sulaimani, and one MRF (Material Recovery Facility) MATERIAL RECYCLING at Akre. Both plants are located in the north of Iraq (Business News). They claim to recycle 80% of the solid waste they receive. This solved a portion of the problem of waste accumulation in Iraq; however, the other parts of Iraq are still in need of similar projects. Many profitable businesses are influenced by the idea of "wealth from waste." Therefore, this is necessary to conduct this study to find recycling business opportunities in Iraq. In this study, small and medium-sized enterprises (SMEs) are targeted only since the purpose of the research is to implement recycling businesses on small scale.

Even though recycling conserves resources and protects the environment, recycling strengthens one country's economy by contributing to jobs, wages, and government tax revenue. According to Unites States Environmental Protection Agency, in 2012, recycling and reuse activities in the United States accounted for: 681,000 jobs; $37.8 billion in wages; $5.5 billion in tax revenues (EPA).

Chapter 2: Stakeholders Mapping

There are many stakeholders that influence the recycling industry in Iraq. Stakeholders are those individuals who have the most influence over the business. The key stakeholders in recycling businesses in Iraq are private sectors, entrepreneurs, manufacturers, consumers, researchers, suppliers, importers, and government. Their roles will differ based on the project. Their effects will vary depending on the type of the business. For example, businesses that use waste as raw material and recycle them into something that can be used by a person will be

more monitored and controlled by the government compared to a business that has materials recycled to produce farming tools. The reason behind this difference is that the government will consider the health standards and the safety standards of the product before it is consumed by the person. Please see Figure 2.

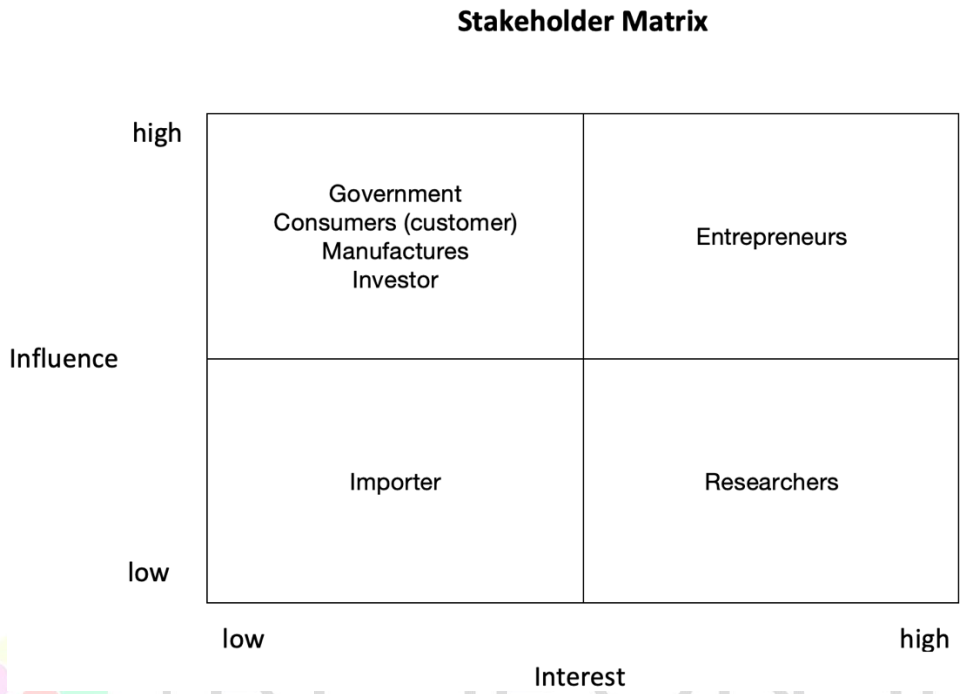


Figure 2 Stakeholder Matrix

Figure 2 shows the stakeholder matrix. It comprises four groups:

1. High Power - Interested stakeholders:
   Entrepreneurs fall to the category of high power-interested stakeholders. In this case, entrepreneurs are those who are interested to work on recycling business.
2. high power - less interested Stakeholders:
   The government falls into this category because they are the rule makers and have the power to implement their plans. They are less interested in recycling since they run by old rules and the whole concept of recycling is new to them. Therefore, setting new rules and regulations takes years for the government to do that. As a result, they are less interested in creating new rules and regulations in favor of recycling. Also, consumer (customer) falls to the same category since they buy their products and may choose what to buy and what to consume (Baird). They are less interested in recycled products since the cost of some recycled materials is higher than the other imported products (Baird). Manufacturers are interested in creating a product that cost least and have high selling rate. Using the old materials as row material to create new products require them to learn new techniques and purchase new machines (depends) (The 10

biggest problems facing the waste / recycling industry - and how to solve them). Sometimes recycling will cost more than using raw materials. This will increase the cost of manufacturing, which is not in their favor. Investors who are willing to invest a small amount of money into a business have prime influence, but less interest in the topic since they are not willing to invest their money in a business that is not promising a high profit for them.

3. low power, less interested people:
   Most Importers fall into this category since they have least interest in recycling, and they are not willing to invest in innovative recycling businesses. For more information on this please refer to this report.
4. Low power, high interested people:
   Researchers fall into this category since they are enthusiastic about doing research in the field; however, most of them do not have the prime influence over implementing the innovative recycling businesses.

Chapter 3: Example of Existing social enterprises from different countries.

Example 1: Let's Recycle

Let's Recycle is an initiative of Nepra Resource Management Pvt. Ltd.. Nepra is a group of companies that work as an enterprise too, with the aim of giving back to the society that is located in India. Let's Recycle is a social enterprise that operates in the segment of dry waste management & recycling in India. This company has been operational since 2012. Let's Recycle's services and core focus have always been on people, process, and infrastructure. The waste collection services are customized and scheduled as per the requirements of the varied stakeholders in the system with a tech-driven system and technology at the MRF ensuring proper closing of the waste loop. To further simplify; the household utilize an application that is developed by the company and through the application the household (app user) notifies the company that usable waste is available in that house. A freelancer that has registered himself/herself in the app and hired/ certified by the company will visit the house, as its location is marked in the app, and the freelancer will collect the solid waste and pay an amount of money to the household. The waste is already separated by the household. Example, the glasses go together, plastic goes together, etc. Following this, the freelancer takes the separated waste to the company, and then gets paid by the company. As an extra layer of refining and separation, the company classifies and separate the solid waste again over the following categories, (RDF, HDPE Granules, PET Flakes, Paper and Cardboard Blades). As the final step, the company sells the finalized and separated wastes or products again to the recycling companies that need the waste or products as raw materials, also sells the RDF products to cement and energy plants. The company hired most of the former waste pickers to improve their lives (let's recycle). They are in different sections of the facility, such as

transportation, collecting from households, collection checkpoints, and inside the segregation plant. Please see figure 3 to learn more about the money flow at Let's Recycle.

Figure 3 Waste material handling by Let's Recycle

The Cash Flow of the above Diagram (Figure 3) is as follow:

- Customer (Person A) spends money on goods, which part of it will turn into waste.
- (Person A) will receive money from Certified Freelance (waste picker) (Person B), by giving away separated waste.
- After delivering the separated waste to the Company, (Person B) receives money from the company.
- After Separation process by the company, the Company generates income by selling the final waste or raw material to the manufactures.
- Manufacturers generate income from selling products that is made from the raw materials.
- Then the cycle repeats.

Example 2: Empower

Empower is another organization that is very active in Europe. Empower is based on using technology to enable a circular economy and create a cleaner and better world. From world Economic Forum, the circular economy is defined as an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse

and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models (From linear to circular-accelerating a proven concept). Empower was established in 2018. Empower is now in over 15 countries advocating for the collection of plastic waste, launching waste management systems, and building transparency with the use of blockchain technology. They attempt to solve the problem of plastic waste by giving plastic value (The future of plastic is circular). This start-up mainly focuses on providing consultancy services and linking the existing actors that work on recycling to give them the chance to advertise their products on their platforms. The recycling companies have to subscribe to the website to be able to do their marketing activities.
For a monthly subscription paid by recycling facilities, Empower provides the following services:

1. Linking the community to the recycling centers, so first users know where to take their plastic wastes.
2. Linking the recycling centers to the buyers, factories that need recycled waste as raw material.

Example 3: Zhinga W Zhian

Zhinga W Zhian is a start-up company based in Iraq, Sulaeamni. The group collects solid waste, such as plastic and cardboard at the city's blocks. They collect solid waste from the direct users and households. After meeting with the team on October 13th 2021 at their factory, located in Iraq, Sulaemani, Tanjaro, Zirgwez, they provided all information mentioned in this section. Tanjaro area in Sulaemani is full of different factories, such as oil refineries, plastic factories, bag factories, brick factories, animal feed factories, etc... This enabled the group to transport their segregated waste to the other factories at a low cost and sell it to them. Also, there are more details from the meeting:
Types of non-biodegradable items segregated in the factory are plastic (HDPE, PET, and LDPE) cardboards, soda cans, iron, copper, … etc.

About the factory:

The total area of the factory is 300 m^2. The factory is fully closed, which means it has a roof, walls, and two doors. Please see figure 4 and figure 5.

Table 1 List of Devices and Tools used at Zhinga W Zhian Segrigation Factory

Name of Item	Use of Item	Quantity
Plastic Shredder	To change the size of the plastic to small pieces	1
500 KG weight scale	To measure the mass of the plastic received and sold	1
Winches	To load and unload the truck	1
special tools	Simple hand tools used to fix the devices at the factory	10 – 12 in total

2 Ton KIA Vehicle	Used for transportation	1

In this small factory, all the items are collected at various places, such as closed-type residential complexes, companies, shopping malls, schools, and households daily by a 2-ton vehicle. Agreements have been made with some closed-type residential complexes to allow him to collect the SW. The materials are segregated by hand inside the facility. Regarding collecting the items, he mentioned, “It had been almost a year that I had created a Facebook page where I had been publishing my work and how I took the collected waste to the recycling centers. People had begun to follow my Facebook page and leave a reaction to my posts.” He added, “The community had been helping me in collecting the solid wastes since then by collecting solid wastes in their houses and contacting him throughout the Facebook page to visit their house and collect the solid wastes that had been accumulated for me. After collecting the solid waste, they were delivered to recycling factories for further processes.” Please see figure 6.

Figure 4 inside the factory of Zhinga W Zhian before segrigating

Figure 5 After first segregating received plastics

Figure 6 Screenshot of Zhinga W Zhian Facebook page

The page also serves him as an educational channel where he can post on recycling and educate the people to segregate their waste before they throw them away.

Example 4: GrubTubs

GrubTubs Inc. started in Austin, Texas. They support family farms and cities across Texas by turning food waste into economical animal feed. GrubTubs collects food from restaurants uses it to help local farmers turn it into suitable animal feed. The process starts at the table and in the kitchen. Leftover food is collected and stored in their proprietary air-tight, sanitized tubs, allowing them to preserve nutrients for animal feed. They pick up tubs from restaurants and take them to the farm, where there is a large team of hard-working insect grubs to help them turn the food waste into nutrient-rich food, which chickens, pigs, and fish can eat. Insect grubs are one of the many edible insects and animals. They claim that restaurants love their service because it is easy, affordable, super clean for the community. Farmers utilize their service

because it saves them thousands of dollars a month, plus it makes for healthy, happy animals (Grubtubs Inc..).

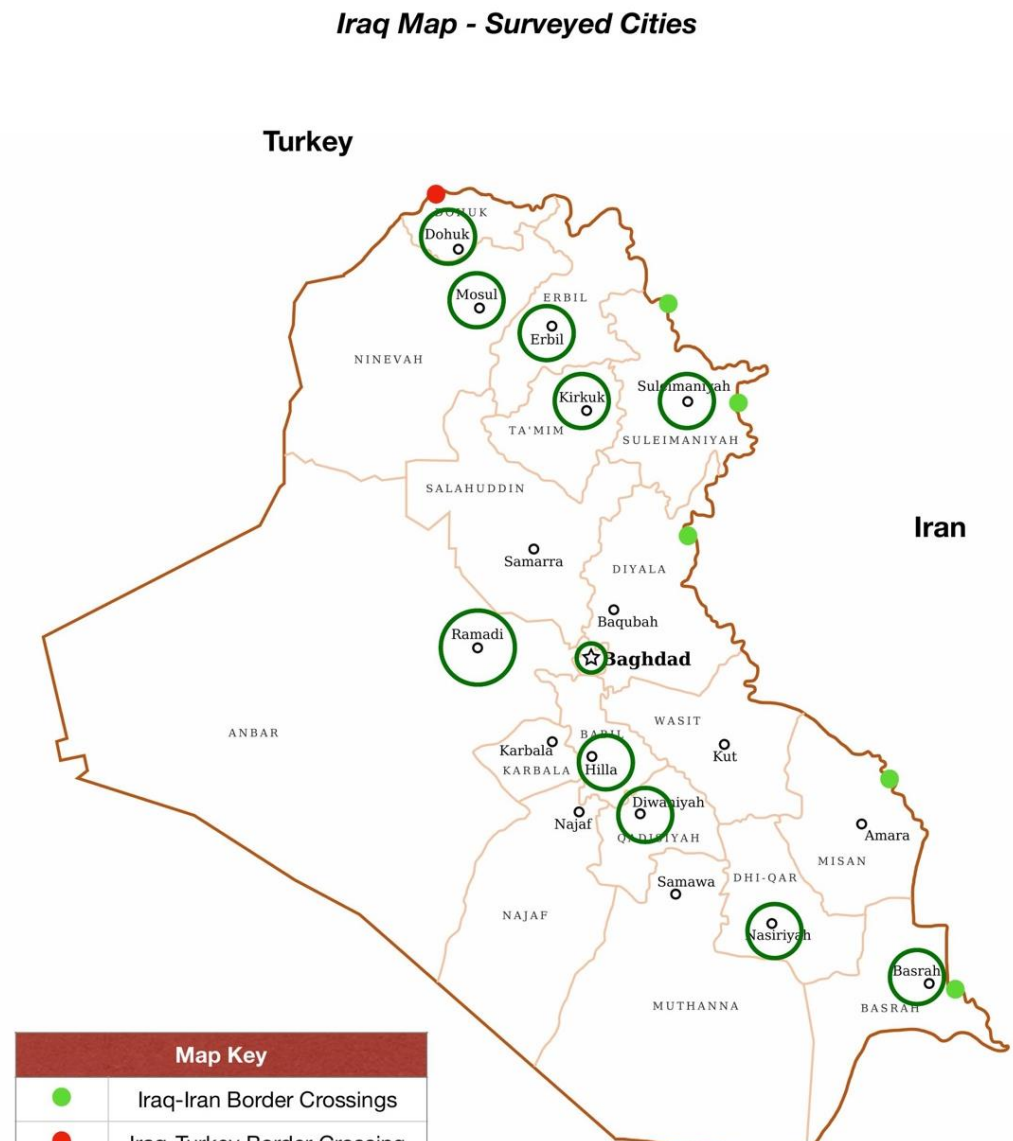
This business makes money in the following steps:

1. Restaurants pay the company to provide them with trash collection services. Each restaurant pays $ 200 per month for this service.
2. The company sell the food waste and insect larvae eggs to the farmers.

Chapter 3: Research Survey

The objectives of this survey were to enlighten the path forward of recycling in Iraq. Data were collected in 11 cities in Iraq, such as Hilla, Basra, Baghdad, Mosul, Ramadi, Al Diwaniya, Al Nasrya, Erbil, Kirkuk, Sulaemani, and Duhok. With the help of seven environmentalists in Iraq, the data collection was conducted between October 13 – 25, 2021. Please see Figure 7. The survey is divided into two different categories.

- The first category is collectors, who collect valuable items in the trash and sell them to the recycling factories.
- The second category is the manufacturers and unofficial recycling sectors. This survey aimed to collect information on the factories that work around recycling in the targeted cities mentioned above in Iraq.



Collector's survey:

A total of 26 collectors were surveyed in 11 cities in Iraq.

The collector's survey is divided into three major parts, such as demographic questions, and general questions regarding their operations. The answer to these questions will appear in different parts of this paper.

Unofficial recycling sectors' survey

The questions were designed to help us understand the size of these factories and their scope of operation. Our team surveyed 15 different representative dealers and unofficial recycling sectors. The survey is divided into five sections:

1. Primary questions regarding the unofficial recycling sectors/manufacturer
2. Questions about the operation
3. Questions market research survey
4. Detailed technical questions
5. Challenges and recommendation

The result of these questions will appear in different sections of this paper.

Chapter 4: Recycling in Iraq

Dictionary definition of biodegradable*: (of a substance or object) capable of being decomposed by bacteria or other living organisms and thereby avoiding pollution.

Section 1: Recycling biodegradable items

There are many challenges ahead this path in Iraq since the government regulations are very restricted. Please refer to Appendix 1 to learn more about Iraq's laws and regulations. According to the animal feed factories introduced in this research, the price of animal feed is between $ 380 to $ 780 per ton. All animal feed factories are under the direct supervision of the government since the animal feed can cause diseases for the animal, and some diseases can even pass to the next consumer (human). Therefore, the product can only be sold after they gain the government quality control's acceptance. The factory provides a guarantee to the product they sell, and they take full accountability for any circumstances that affect their livestock. Such factories are expensive to establish; therefore, they are excluded from our study. In Iraqi culture, bread is considered sacred and never thrown away; instead, it is collected and used as animal feed for various animals, such as poultry, cattle, sheep, etc. According to the survey, bakery waste is picked up in the eleven cities surveyed in this research. The collectors sell them to $ 140 to $ 200 per ton to the unofficial recycling sectors, they sell them to the next customers for $ 350 per ton. On the other hand, there are arguments against feeding leftover slices of bread to the animal since accumulated leftover bread can have mycotoxins that are contaminants that are resistant to heat and several treatments, so only good hygiene practices can protect the animals (Fink-Gremmels).

Recommendations for recycling biodegradable waste in Iraq:

Recommendation 1: Farming Black Soldier Fly in Iraq

A business similar to GrubTube is possible to start in Iraq. This idea can be implemented with some alterations to match the culture and market. It is possible to make grub harvesting machine with simple tools and components. Therefore, it does not require a capital exceeding $2000 for the machine and harvesting equipment. On the other hand, collecting food waste at restaurants and supermarkets needs a large-scale investment.

Requirements of collecting the food waste:

1. Due to the hot periods in Iraq, a refrigerated vehicle is essential to transport the collected food waste (kitchen waste and modern market waste) daily. Food and vegetables have limited life-spam, so keeping them in a cold and proper place is crucial. Food waste is full of nutrition for grubs; however, protecting the food waste at the right temperature and feeding them to the larvae will increase the probability of having proper production. The price of a refrigerated vehicle starts from $15,000 to more dependent on the brand and size of the refrigerated vehicle. Using the aforementioned vehicle in the hot seasons is crucial.
2. Having hundreds of airtight containers is another requirement. The containers need to be washed and cleaned carefully before they are being sent back to the kitchen of the restaurants. The price of one single airtight container is between $ 8 to $ 20. Depending on the size and quality of it.
3. Providing training to the workers in the kitchen to put their kitchen waste in the assigned container.

A small harvesting machine needs to be installed at the yard poultry farms. The “company” collecting the food waste needs to provide the farmers with the devices, grub egg, trainings on how to grow fully grown grubs, and the collected food waste.

Challenges:

This business might face the following obstacles:

1. The price of these grubs might be higher than the existing feeds. The cost of chicken feed is between $ 300 to $ 450 per ton in Iraq.
2. In Iraqi culture, yard poultry livestock is not dealt with like poultry house livestock. For example, chickens raised at poultry houses are under restricted inspection by the government. According to the vegetarian directory of Sulaemani, this diet will not fulfill the requirements for a chicken raised at a poultry chicken house. The waste of the chicken will have some bacteria that might cause diseases to the rest of the chickens. Therefore, we don’t allow chicken poultry houses to add insects to the chicken’s diet. Finding the right customer will be a challenge for this business since yard chickens are

fed with food waste that the farmer can gain for free. Therefore, they might not be interested in paying anything for insect grubs.

3. Finding qualified workers might be another challenge because the process of raising grubs is quite complex.

Recommendation 2: Food waste to mushroom compost

Although it is almost impossible to turn food waste into animal feed in Iraq, we can still prevent the food waste from ending up in landfills by turning it into compost. Compost, such as mushroom compost, is in high demand. According to findings, the price of imported 50 kg - mushroom compost is $ 30 to $ 40 in Iraq. It is possible to make mushroom compost by mixing soil, food waste, and paper waste. Therefore, making compost can be an effective way to recycle waste food and paper. List of requirements for this business:

1. A truck or pickup to collect the food waste at the restaurants and hotels. This might cost between $ 10,000 to $ 25,000.
2. Having hundreds of airtight containers is another requirement. The containers need to be washed and cleaned meticulously before they are being sent back to the kitchens of the restaurants and hotels. The price of one single airtight container is between $ 8 to $ 20. This depends on the size and quality of the container.
3. Having a fully closed building to do the following operations (Jasińską and Krzesinski):
    1. Mix the food waste, paper, and soil by a rotating drum. The device can be locally made, and its cost will be between $ 1000 to $ 3000. Depending on the size and motors used. Letting the mixture stay in this device for 3 to 4 days.
    2. Store the mixture in an insulated container with controlled airflow. The stored mixture needs to be rotated every 2 to 3 days. This can be done by a Bobcat 863 shovel. A second hand one costs $ 15,000 in Iraq to purchase.
    3. After three weeks, the mixture needs to be transported to the pasteurization room.
    4. Bagging the product.

*Remark: Some steps are not mentioned above, depending on the size and design of the factory, the steps will vary.

*Remark: This factory might cost more than the limited capital of this project. Therefore, a careful calculation has to be made to make the factory in small size to meet our financial requirements, while making sure it generates profits.

Section 2: Recycling non-biodegradable items in Iraq

Dictionary definition of non-biodegradable*: non-biodegradable materials are often synthetic products like plastic, glass and batteries.

In this study, several non-biodegradable items are studied, such as cardboard, plastic, ferrous metals, and non-ferrous metals. The following graphs show the current situations for recycling them.

Recycling cardboards in Iraq:

Remark: Even though cardboards are scientifically categorized as biodegradable item, in this research, we categorized them as non-biodegradable since a cardboard product might survive for 10 years without breaking down if it is stored at a dry condition. New packaging cardboards are mixed with plastics and other materials to improve its integrity.

According to the results, only seven cities tried to tackle cardboard waste. Cardboards are mostly recycled outside; however, there is a small company in Sulamenai that produces new cardboard and makes 2 to 3 products. Please see figure 8.

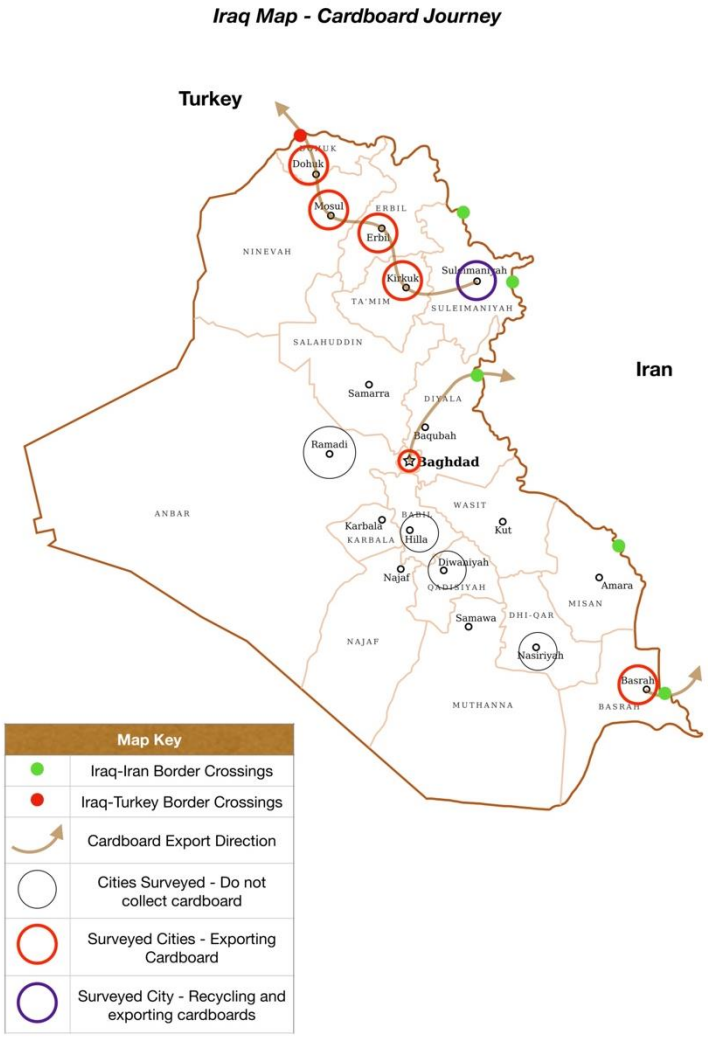


Figure 8 Cardboard recycling status in Iraq, 2021

Recycling cardboard is a complex process. Below is a diagram showing the steps of recycling cardboard.

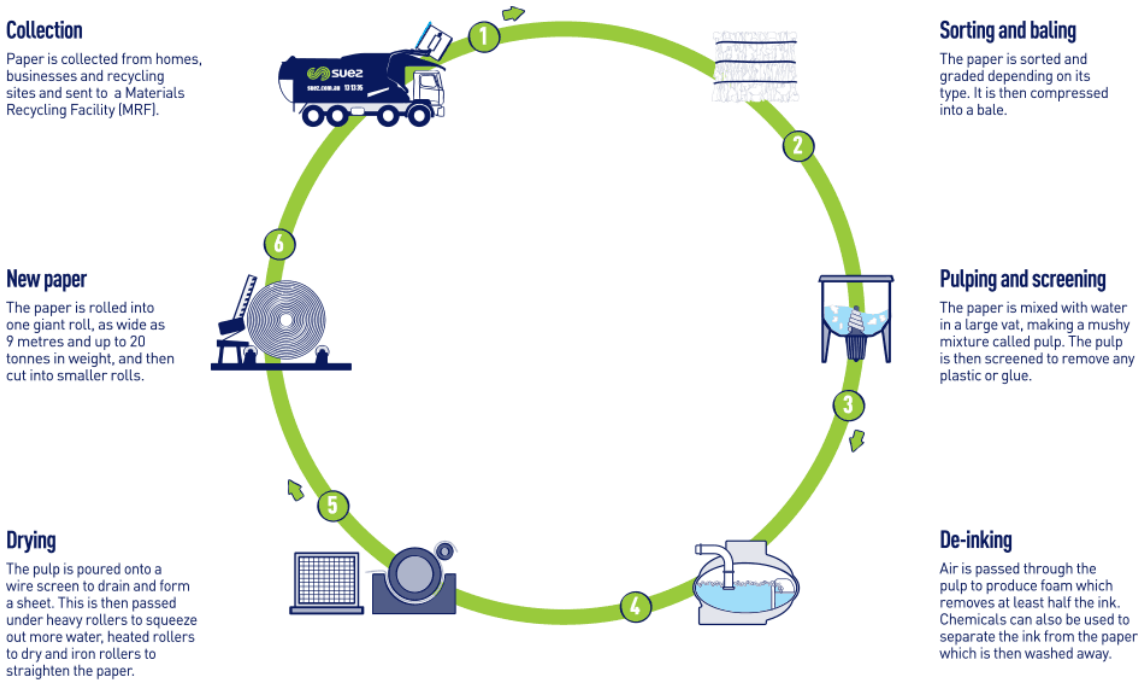


Figure 9 Recycling cardboard process

Sadly, only steps (1 and 2) are executed in 7 out of 11 cities surveyed in Iraq. The collectors sell one ton of cardboard for only $ 140. The manufacture sells it for $ 250 to $ 300 per ton after sorting and baling.

Recycling plastic in Iraq:

According to the results, mainly two types of plastic are collected in Iraq, such as PET, HDPE, and few LDPE. Please see Appendix 4. LDPE is mostly mixed with HDPE to make some products.

Recycling PET in Iraq:

According to the results, PET plastic is picked up in the 11 cities surveyed. Please see figure 10. Only in one city PET plastic is turned into a raw material called PET flakes. The price of bailed PET sold to neighboring countries is between $ 300 to $ 350 per ton. The collectors sell the bottles to the large-scale collectors or recycling centers locally for $ 120 to $ 200 per ton. Depending on the season, the demand for post-consumer PET changes. In the survey, we learned that during cold seasons the price increases since the availability of these bottles decrease, so the collectors need to spend more time to find the bottles at the dump sides. On the other hand, during the hot seasons, its price decreases due to having a higher amount of waste received to the factories and treatment centers. Please see figure 11 to learn more about

the process of recycling PET.

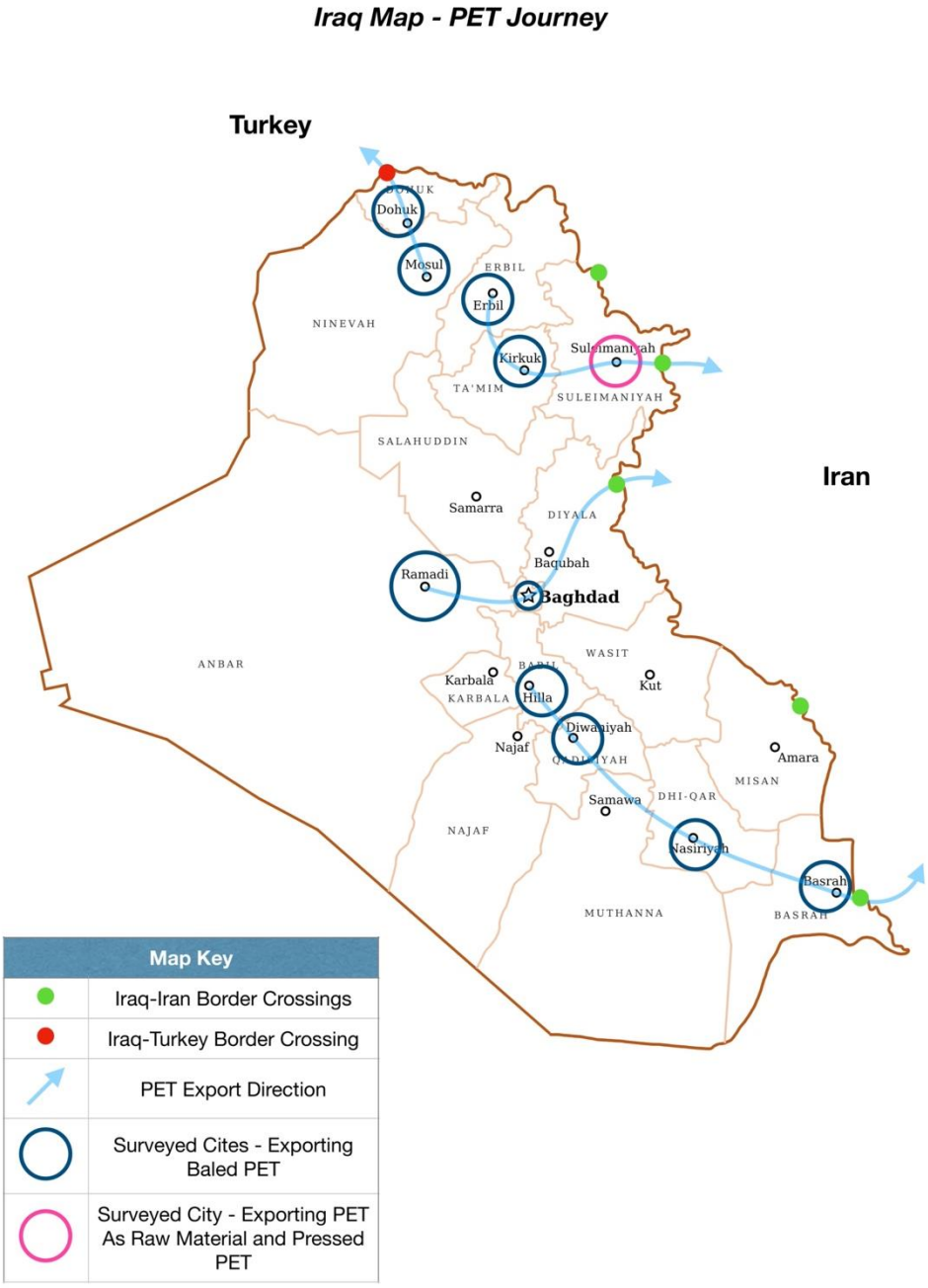


Figure 10 PET recycling status in Iraq

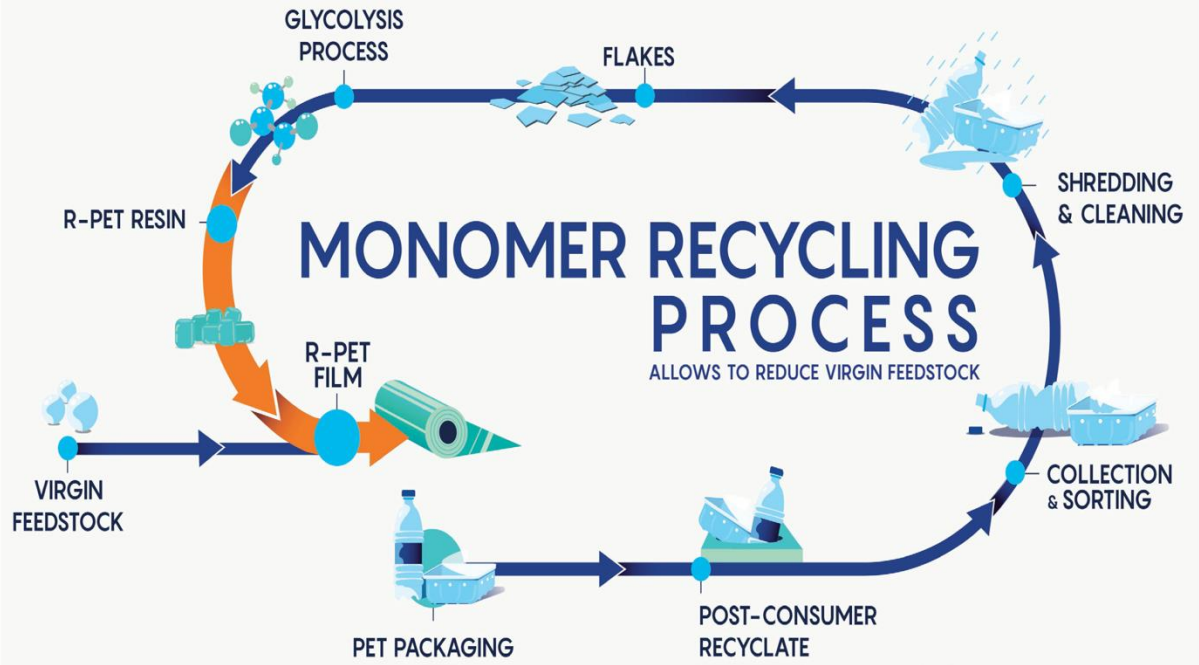


Figure 11 PET recycling process

In Iraq, there is only one recycling company that can turn PET bottles into flakes. The flakes will be treated outside since, in our country, there is not a factory that produces products that need flakes as raw material. Please see figure 12.

Figure 12 Example of white flake

Recycling HDPE plastic in Iraq:

Fortunately, HDPE plastic is recycled locally in Iraq. There is countless use of this type of plastic. Depending on the product, sometimes it is mixed with one or two other types of plastic. In Iraq, only in 3 cities surveyed, HDPE plastic is recycled and turned into a raw material called plastic granules. Plastic granules are used in products like cleaning containers, fruit boxes, and mechanical joints for hoses. Please see figure 13. Collected HDPE are collected, segregated based on color and type, and shredded. HDPE plastic waste is not bailed since all the dealers and recycling centers have shredders that can process the received post-consumer plastic. Please see figure 14. Bases on the survey result, collectors or trash pickers sell the mixed HDPE waste for around $ 200 per ton. After segregating based on color plastic and shredding the HDPE, its selling price increases from $ 200, to $ 350 to $ 450 per ton. Black color HDPE is the cheapest, yet white color HDPE is the most expensive one. As the shredded HDPE is further processed and turned into granules (raw material), its price increases. Colorful granules' prices are between $ 450 to $ 650 per ton. White color granules price is $ 700 to $850 per ton. The size of granules changes their value. Small size granules have the best value. Please see figure 15, an example of HDPE plastic granules.

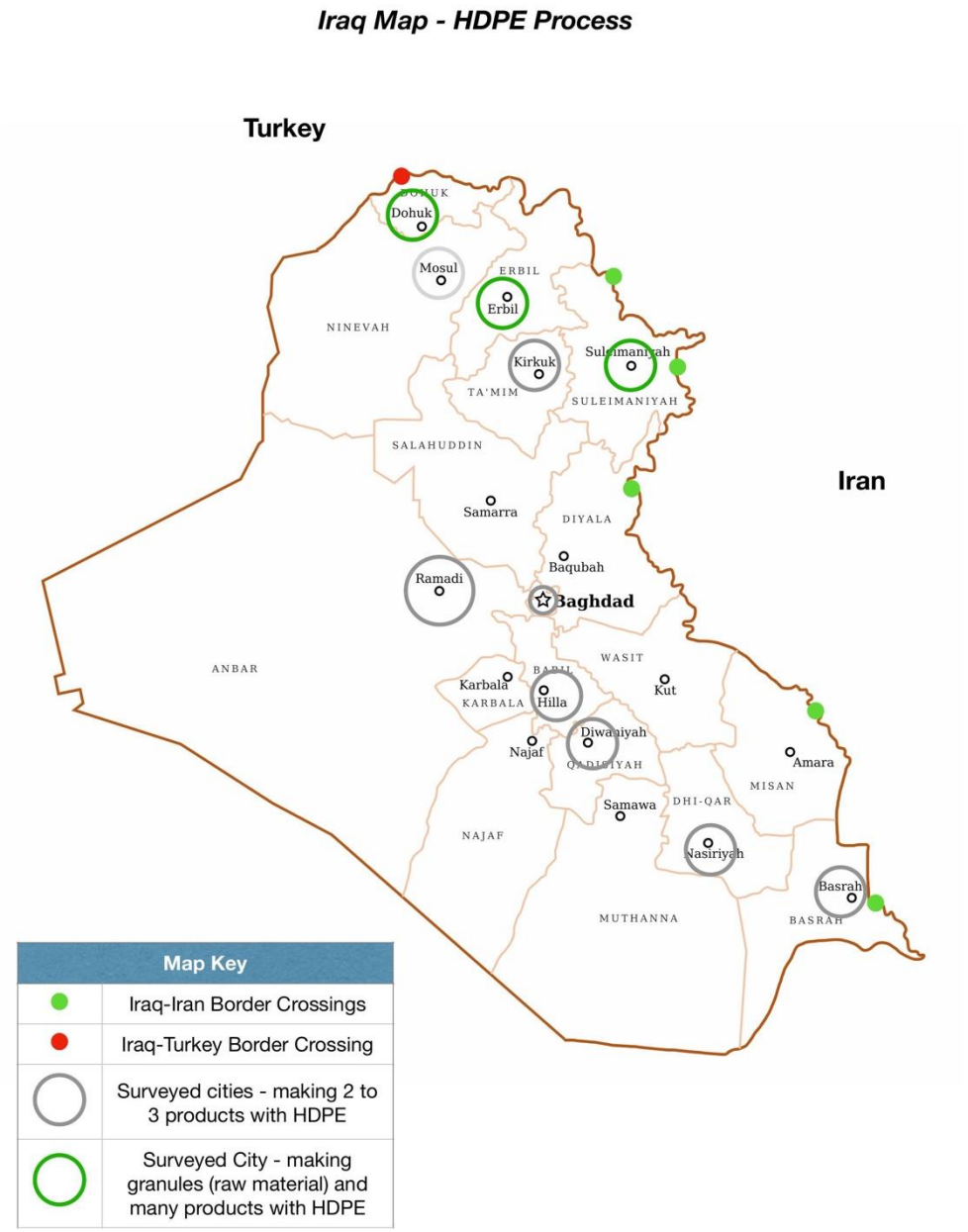


Figure 13 HDPE recycling status

Figure 14 HDPE recycling status in Iraq

Figure 15 HDPE plastic granules

Recycling ferrous metals in Iraq:

In Iraq, ferrous metals are collected and recycled locally. The collectors take the collected metals to car junkyards. Here, the metals will be minimized in size before being transported to the steel factories in Iraq. Please see figure 16. According to the study, most steel factories are located in four cities, which are Baghdad, Erbil, Sulaemani, and Duhok. Therefore, the metals collected from the other cities will be locally shipped to mentioned cities. Bases on the survey

result, the collectors sell it to the dealers for $ 120 per ton. The dealers sell it to the steel factories for $ 200 per ton.

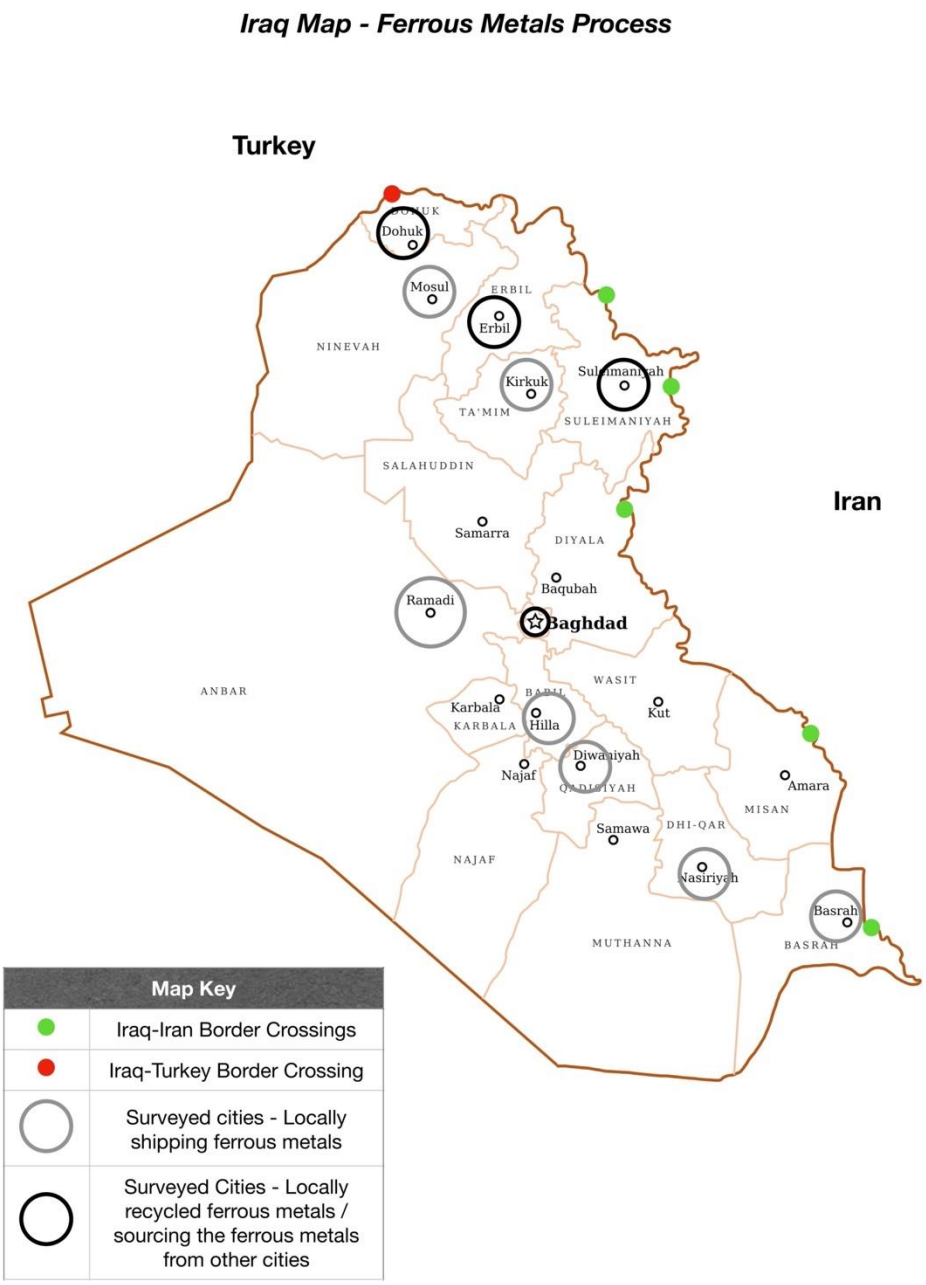
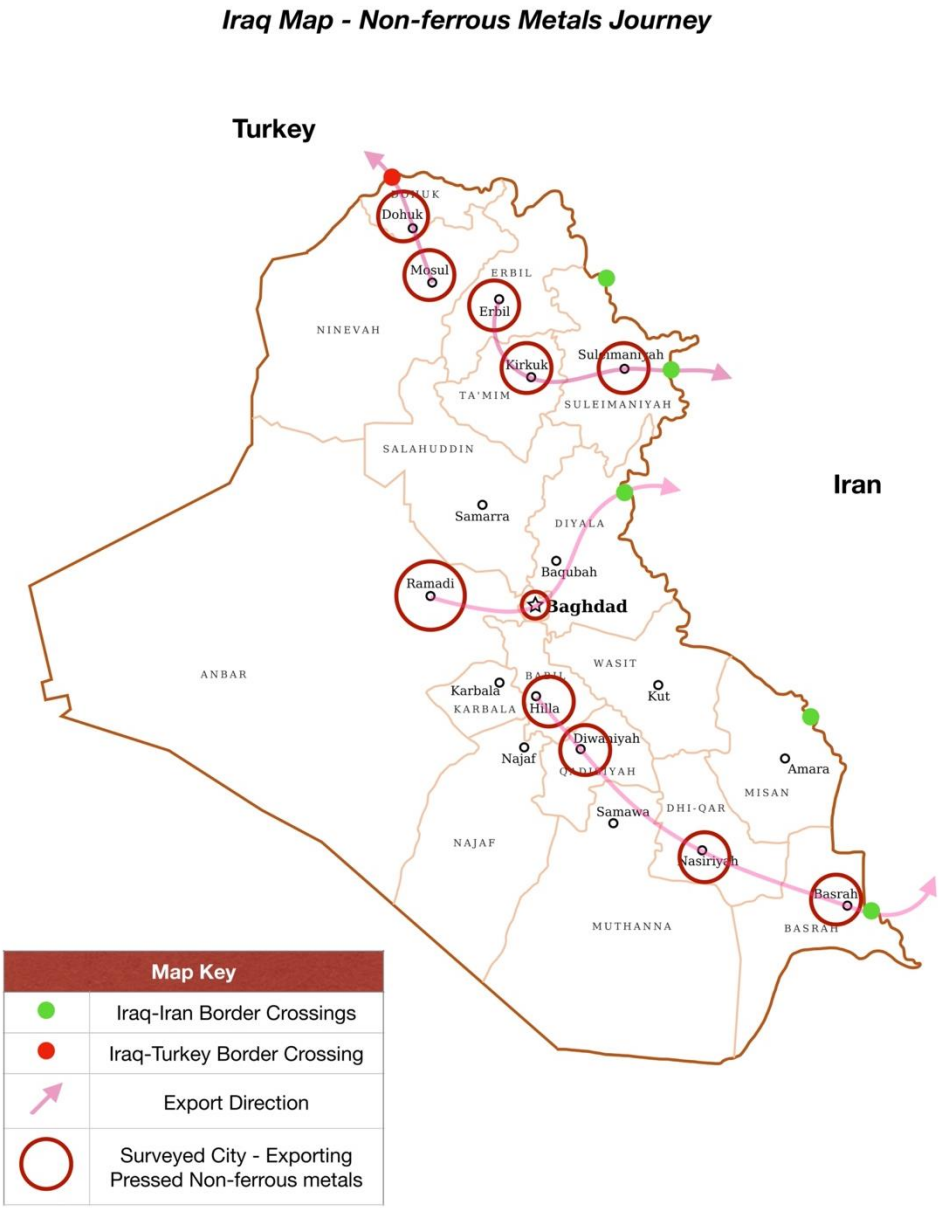


Figure 16 Iraq Map - Ferrous Metals recycling status

Recycling non-ferrous metals in Iraq:

Based on our findings, non-ferrous metals are collected and exported to the neighboring countries. They are not recycled locally due to a lack of factories, such as cable, car batteries, electronic factories. Please see figure 17. The price of 1 ton of various non-ferrous metals is between $ 800 to $1300.

Figure 17 Non-ferrous metals recycling status



Existing gaps in Iraq

Based on the survey results and KIIs done in this research, Iraq has the following gaps in term of recycling:

1. Government regulations
    a. The government does not help the existing recycling sectors in Iraq.
    b. The government miss categorized the recycling sectors in Iraq, so the recycling factories will end up paying high tax.
    c. The government's regulation in animal feed sector is so restricted
2. Lack of sorting/collection phase
    a. On the household level, there isn't a sorting system. Therefore, separating the waste is almost impossible to achieve.
3. Lack of contribution/awareness from the community
4. Lack of organized existing collectors
    a. Collectors are the only middle men that made recycling possible in Iraq. Based on the survey findings, these collectors are not organized, and they do not work collaboratively with each other. This affected their efficiency.
5. Having limited animal feed available in the market
    a. There are no more than 5 different types of animal feed in Iraqi market.
6. Lack of innovative solutions for animal feed
    a. Due to the restricted rules of the government, introducing a better alternative of animal feed to Iraq is almost impossible.

Recommendation: potential business idea for recycling non-biodegradable waste

Recycling non-biodegradable items are various and can be done in many ways; however, in this study, we only focused on fixing the main issues that exist in Iraq in the phases of collection and segregation of SW. Therefore, it is the objective of this study to propose solutions that are economically feasible and in our scope range.

Recommendation 1: MRF for SW

Who are the people that can work in this business?

This factory requires workers with a variety of specialties; however, due to capital limitations, only very crucial specialties are chosen.

Everyone in this factory should have multi-tasking skills since the factory is small, so the workers who can perform more than one task are preferred to work at the facility.

1. Job requirements:
    a. Manage the waste collection operation by utilizing the application.
    b. Manage the factory workers.
    c. Measure the mass of received items from local collectors, manage invoices, and manage cash inflow and outflow.
    d. Manage conflict at the facility.
2. Two to three workers to operate the following tasks:
    a. Identify foreign materials before it is fed into the shredder or compactor on the waste conveyor belt.
    b. Unload or load the shredder, compactor, and conveyor belt.

What are some devices that can be used in this factory?

Horizontal conveyor belt:

This is powered equipment that is commonly used for moving bulk or unit load continuously or intermittently, unidirectionally from one point to another over a fixed path, where the

primary function is conveying of the material with the help of movement of some parts/components of the equipment. Please see figure 18. Moreover, 110 L containers must be positioned next to the horizontal conveyor belt to allow different waste items to be stored separately.

Figure 18 Horizontal conveyor belt

Advantages and disadvantages of horizontal conveyor belt:

Advantages:

1. Increase the efficiency of the segregation process.

2. Easier for the workers to separate the received waste by hand on the belt than on the floor since doing the activity on the floor while they sit or bent will have negative results on their health.
3. It is one of the cheapest conveyor belts since its price will not exceed $ 3000.
4. It will help in transporting the materials to a longer horizontal distance with speed and ease.

Disadvantages:

1. It requires maintenance and cleaning regularly.
2. It requires the existing factory to provide power to the belt.
3. It is noisy while operating.

Inclined Conveyor Belt

Inclined conveyors are used to bringing products from one level to another via a hinged or flexible belt. Please see figure 19.

Figure 19 incline conveyor belt

This device will be positioned between the horizontal conveyor belt and the bottle shredder.

Advantages and disadvantages of incline conveyor belt:

Advantages:

1. Speed up the process of feeding the shredder.
2. Enhance safety at the field by avoiding having workers feeding the shredder by hand since the shredders have sharp metal blades that cut anything that goes through it.
3. It is one of the cheapest conveyor belts since its price will not exceed $ 3000.
4. It can be easily fixed with little technician support.

Disadvantages:

1. It requires maintenance and cleaning regularly.

2. It requires the existing factory to provide power to this belt.
3. It is noisy while operating.

Bottle shredder:

A shredder is a device that changes the shape and size of a material. It is used in a variety of industries. In our case, the bottle shredder used is a specific type of shredder that is designed to cut plastic bottles into small pieces. Please see figure 20.

Figure 20 Shredder

Advantages and disadvantages of plastic shredder:

Advantages:

1. It works efficiently and can shred bottles at a high speed.
2. It is the most crucial device in such factories in Iraq, and it's the most used and common one.
3. It is used to reduce the size of the received waste HDPE bottles and other types of plastic with low rigidity. It means the received plastic should not be tough to cut into pieces.
4. It can be easily fixed with little technician support.
5. The capital needed to own one shredder can vary between $3000 to $8000 depending on the size and quality of the device.

Disadvantages:

1. While operating, it is noisy.
2. If a worker touches the blades by mistake, it could lead to serious injuries since the shredder's blades are very sharp and spin at a very high speed.
3. The shredder blades are the most fragile part of the device.

4. It requires 100 A to 300 A of 380 V electric power, depending on the size and motor of the device; however, the source of power input can be changed to deasil. This can be achieved by adding a diesel motor to it and connecting the pully of the motor to the pully of the shaft of the shredder. It is a simple mechanical process. When the factory is far from electrical grids, or if the factory wants to reduce the cost of electricity, adding a diesel engine is suitable.
    a. Disadvantages of adding diesel motor:
        i. It adds more noise to the factory.
        ii. It adds more cost of maintenance.
    b. Advantages of adding diesel motor:
        i. It removes the dependability of electricity to run the shredder.
        ii. In some cases, the company can reduce the cost of operating the shredder since the price of diesel in Iraq is between IQD 400 to IQD 600 per litter ($ 0.27 to $ 0.41 per 0.22 UK gallon).

Vertical waste compactor baler:

Vertical balers are an innovative waste management solution and are used for the compaction of materials. Commonly employed in any recycling process, a baler unit condenses materials into a bale for easy storage, transport, and handling. Designed with space restriction in mind, our range of vertical balers is suited to many commercial applications. Typical recyclable commodities often baled include plastic packaging, plastic bottles, paper products, cardboard packaging, light gauge ferrous and non-ferrous metals, and shrink wrap. While all balers work in a similar way to each other, various models with different sizes are available to suit varying requirements (Vertical Balers). Please see figure 21.

Figure 21 Vertical Waste Compactor Bale

Advantages and disadvantages of Waste Compactor Baler:

Advantages:

1. The second most important device to be employed at the factory.
2. Reduces labor intensity.
3. Reduces the size of the fed waste material by 80%. Therefore, it reduces transportation costs, and it is environmentally friendly.
4. Mostly used to compact paper, PET plastic, and soda cans in Iraq.
5. The price ranges from $ 3000 to $ 10,000 depending on the brand, country made from, and size of it.
6. This device can be fed automatically or manually. In the case of automatically feeding, there is no need for labor to come and put the material under the press while if it is manually fed, a worker needs to fill the cabin under the press. In Iraq, only a few places have automatically feeding vertical waste compactor balers. This is due to the price and complex maintenance procedures they require. The manual fed compactors are mostly built locally in Iraq.
7. Makes low noise while operating
8. Easy to operate
9. Easy to clean
10. Easy to maintain

Disadvantages:

1. It takes a lot of time to make one pack, especially while packing plastic since it keeps going back to its original place when the pressure is removed on it. Therefore, the labor

needs to repeat the process several times to make the packing effective; however, it is not the case with cardboards, ferrous and non-ferrous metals.

2. In Iraq, only 17 L PET plastic bottles are compacted with this device. Therefore, the other smaller sizes of PET plastic are not treated with this device. This is due to the following reasons:
    a. The sizes of 0.2 L, 0.33 L, 0.5 L, 1 L, and 1.5 L PET single-use plastic bottles are small, so they will separate themselves from the pack due to their irregular shapes.
    b. It takes a lot of time and labor to feed the compactor with these bottles, therefore all the recycling companies in Iraq avoid purchasing taking these bottles.
    c. In Iraq, only a few recycling companies can accept the small size of plastic bottles since they have shredders that can process these small bottles.
    d. A regular 0.2 L, 0.33 L, 0.5 L, 1 L, and 1.5 L PET single-use plastic bottle are composed of three different types of plastic, such as PET, HDPE, and PP. This makes it extremely hard for the company to separate them before processing them; however, the advanced recycling centers have three more devices that are very expensive, but they get the job done and separate the different types of plastic used in a single disposable water bottle. For instance, a factory in Iraq, Sulaemani welcomes 0.2 L, 0.33 L, 0.5 L, 1 L, 1.5 L, and 17 L PET single-use plastic since they can recycle them. The capital of establishing such factories might reach $ 150,000, which is out of the scope of our study.

Lifting devices:

Depending on the size and kinds of operation carried out in a factory, several lifting devices might be utilized to meet the logistic operations. Below, three essential lifting devices are discussed in detail.

Type 1: Forklift

A forklift is a small industrial vehicle, having a power-operated forked platform attached at the front that can be raised and lowered for insertion under a cargo to lift or move it. Forklifts serve

the needs of various industries including warehouses and other large storage facilities (What is forklift? Working Mechanism & where it is used?). Please see figure 22.

Figure 22 Forklift working in open area of a recycling factory

Advantages:

1. Makes lifting and transporting easy.
2. Speed up the process.
3. It has a variety of applications that enables the owner to utilize this equipment for more than one purpose.
4. It only needs a trained driver to use this device.

Disadvantages:

1. They are pretty expensive if they are newly purchased. In Iraq, its price can range between $ 30,000 to $ 80,000, depending on the brand and size of the tool. If the owner seeks a second hand, their cost range would be between $8,000 to $20,000, depending on the cleanness and size of the machine.
2. They need maintenance regularly. This will add an additional cost to the factory.
3. The power input is diesel fuel.

Type 2: Hoists

A hoist is a device used to lift or move material. The lifting force is provided by a drum (or wheel) on which wraps a rope or a chain. Please see figure 23.

Figure 23 An advanced hoist

Advantages:

1. The cost to build this locally would not exceed more than $2000. Therefore, it is less expensive than the other types of lifting equipment.
2. The company can lift to 1000 kg with this machine safely.

Disadvantages:

1. It needs 2 trained workers to operate this device safely.
2. It needs constant contribution from the truck driver since the truck needs to move forward and backward as the vehicle is loaded or unloaded.
3. It requires low electrical energy input.

Type 3: Hand forklift

This tool is used to lift and carry heavy items to short distance. Please see the figure 24.

Figure 24 hand forklift

Advantages:

1. It is very cheap, and its price does not exceed $200 in Iraq.
2. It can be used by any worker at the factory.
3. It makes transporting heavy items much easier.
4. It does not need any energy input, such as electricity or fuel.

Disadvantages:

1. Its application is limited.
2. It cannot be used to carry goods up and down.
3. It works the best on smooth floors, such as concrete floors. Therefore, in our case, since most of the existing factories do not have concrete floors. This will be quite challenging to utilize this manual hand forklift in the factories.

Weighbridge:

Weighbridges or truck scales are purpose-built machines dedicated to weighing large industrial vehicles and their contents, usually for commercial purposes (Scales). Please see figure 25.

Figure 25 Weighbridge diagram

Advantages:

1. It makes the process of measuring the mass of received waste items faster.
2. It helps in gaining accurate measurements.
3. It requires low energy input.
4. It does not require frequent maintenance.

Disadvantages:

1. It takes an area of 40 to 100 m^2 to fit the device and the enter and exit pathway.
2. A cabin needs to be installed to keep the devices, such as a printer, computer, and device hardware from the surrounding environment.
3. It is very expensive compared to the other measurement tools. Its price ranges between $3,000 to $10,000 depending on the brand and capacity of the weighbridge.

Hand tools:

Every factory needs different hand tools to fix their devices. Some potential hand tools are screwdrivers (electrical or manual), hammer, level, etc. The total price of them will not exceed $ 500.

Where should this business be located?

Location of the building:

In Iraq, the factories that welcome non-biodegradable items are divided into two categories, which are ferrous/non-ferrous metals and cardboard and plastics. Ferrous/non-ferrous metals welcoming factories are usually located in industrial areas. Cardboard and plastic welcoming

factories are located near the landfills of the cities. The motives behind choosing the location are the followings:

1. Most materials are allocated in those areas. For example, plastic and cardboard are transported to landfills. Then, they are usually picked up by the collectors and sold to the factories nearby.
2. The renting price of the building or land in those areas is fairly lower compared to the other parts of the city.
3. Collectors tend to take their collected waste to the nearest facility form them, so they can save transportation cost and time.

Integrity of the building:

There are two suitable types of building for this business:

Type 1: Fully closed:

Such buildings are the most expensive ones to own since it needs a lot of material and engineering techniques to build them.

Advantages:

1. Gives security advantages.
2. Keeps the materials clean and out of the dust, sunlight, rain, heat, and cold.
3. Gives the advantages of working in unstable climates, such as rainy days or dusty days.

An ideal building should have:

1. A total area of 300 m^2 or more.
2. The floor should be concrete.
3. Its height should not be less than 7 m.
4. It should have at least a 5 m wide and 6 m tall gate
5. It should have an open area of 50 m^2 at least to establish the Weighbridge (if applicable).
6. The factory needs to possess the following to ensure a safe place to work:
   i) Several fire extinguishers
   ii) First aid kits
   iii) Fire warnings

The total cost of constructing such a building with the requirements mentioned above will be between $ 80,000 to $ 150,000 depending on location and material used. The monthly rental fee will be $ 800 to $ 2000 depending on the location.

In Iraq, since such buildings are fairly expensive for this business to rent or own, they usually find a building that does not have the majority of the requirements mentioned above. Therefore, the monthly rental fee will not exceed $300.

Type 2: Semi-open building:

A semi-open building has a floor, roof, and some caulomes in between.

Advantages:

1. Have a vision of the operation happening inside and outside the roofed place.
2. Cost less than fully closed building.

3. Only keep the sensitive items out of rain and sunlight, so dust will still find its way into the material or device kept under the topper.

An ideal building should have:

1. A total area of 300 m^2 or more. In Iraq, most of the factories are like this type.
2. The floor should be concrete.
3. Its height should not be less than 4 m.
4. It should have an open area of 50 m^2 at least to establish the Weighbridge (if applicable).
5. It should have an open area of 200 m^2 at least to store processed materials.
6. The factory needs to possess the following to ensure a safe place to work:
    a. Several fire extinguishers
    b. First aid kits
    c. Fire warnings

The total cost of constructing such building with the requirements mentioned above will be between $ 5,000 to $ 9,000 depending on location and material used. The monthly rental fee will be $ 200 to $ 1000 depending on the location.

In Iraq, the factory owners are renting flat lands, they set temporary roofs and shelter cabin to do their operations.

Mobile application to ease the collection process of waste materials:

A mobile application can be utilized to mark the location of the waste materials on the map. This will reduce the time and effort needed to collect the waste materials. On this app, direct consumers and recycling centers are connected directly. Then, the factories' collectors will be scheduled to pick the waste materials at the consumers' locations.

How is the mobile application working?

The consumer uploads the following information to the mobile application:

- A photo of the waste.
- Location of the waste
- A contact information
- Send a pick-up request

The factory receive the request, after analyzing the waste size and type, they will send a collector to pick up the collected waste.

A reliable and locally made app can be obtained with a capital ranging between $ 4000 to $ 6000.

Terra Cycle is a similar example of this application (Recycle your waste). Please see figure 26.

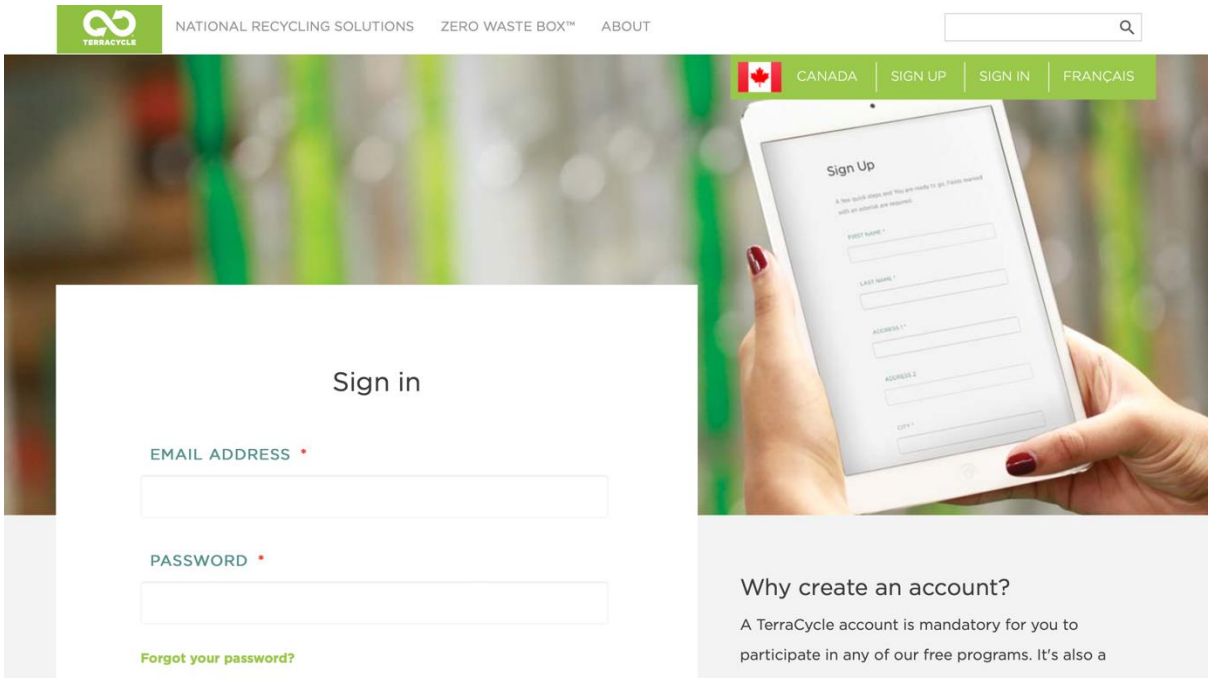


Figure 26 Terra Cycle mobile application

The application should have an attractive front page where users can find their sign-in section or for the new user registration section. The application needs to be in the main languages spoken in Iraq which are Arabic and Kurdish; however, having the English language added to the application is an advantage. The mobile app should allow users to submit a request and upload photos of their accumulated trash. If the app has some educational materials like locally made videos on the environment and encourages the community to contribute to the case of recycling, this would encourage users to spend more time on the application while building their skills and knowledge around recycling and protecting the environment.

Risk assessments:

When a new practice is introduced to an old business, it is challenging to convince the existing generation to follow the new practice. Therefore, the main challenge ahead of this project is to convince existing actors to use the mobile application and have scheduled pickups. Challenges will be faced as well with the collectors since a basic smartphone with an internet connection is mandatory while using the app. Also, making the app as simple as possible is a mandator since based on the research 61.5 % of the collectors surveyed are unschooled, therefore, constructing the app in a user-friendly way should be considered. Please see figure 26. Assuring the public that this app only serves them to schedule pick-ups while keeping all the personal information confidential.

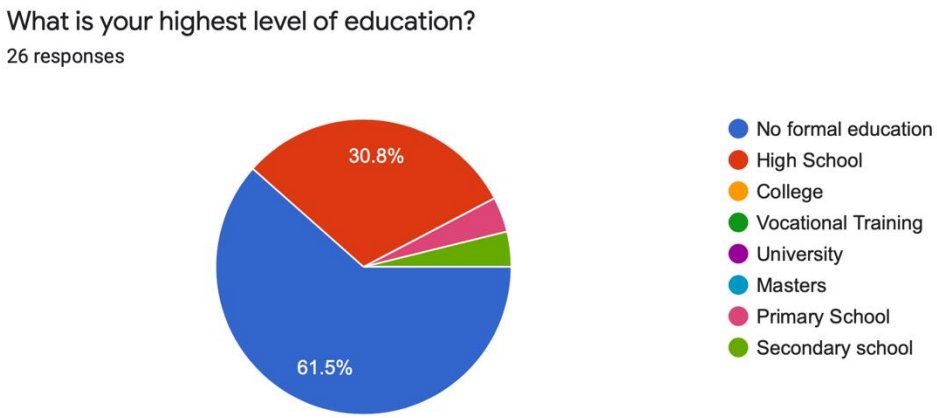


Figure 27 Educational background of collectors

Recommendation 2: A modified vehicle to collect waste:

The regular vehicles used by collectors to collect waste items are not specifically designed for the purpose. Therefore, they face many challenges, such as the volume of the non-biodegradable waste being high, and their masses being very low. This results in having the vehicle fill sooner with a low amount of waste loaded. Therefore, fitting a satisfactory and profitable amount of waste items is quite a challenge. Please see figure 27. 59 % of collectors surveyed in this research reported that they need a bigger vehicle to do their business efficiently. This simple engineering solution will solve the problem efficiently. Please see figure 28.

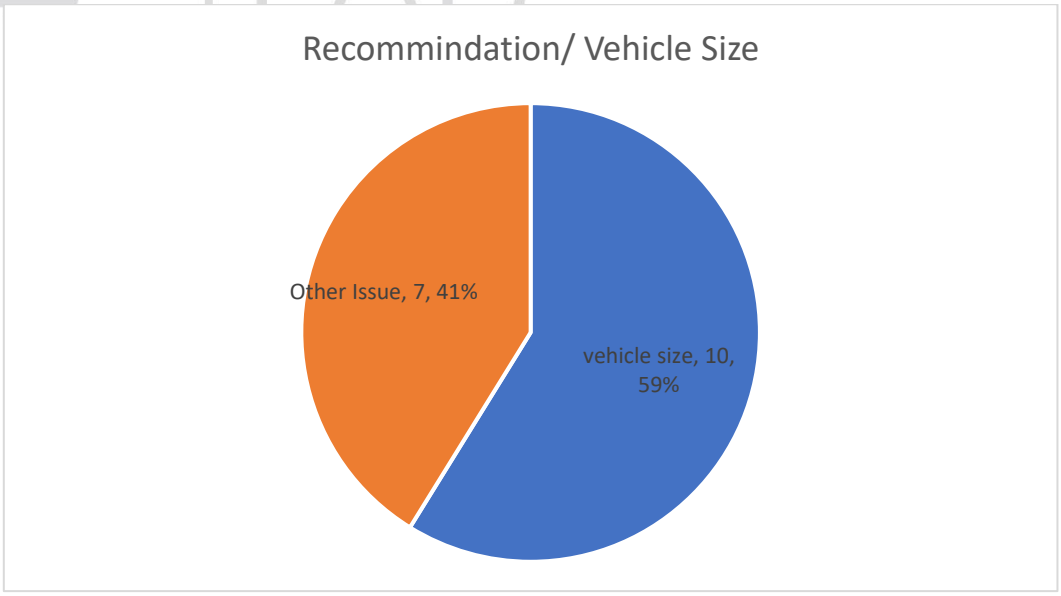


Figure 28 Pie Chart, vehicle size

Figure 29 Customized vehicle for collecting items. Segregating item at on the go. This company is operation in UK

The vehicle comes with a small compactor that will press the plastic bottles and cardboards since they have low density and large volumes. This results in having the vehicle load more item before it is full (Simmons).

Advantages:

1. This truck enables the collector to fit 30 % to 50 % more material than a regular truck since it will be equipped with press machines that will minimize the size of collected plastic items and cardboards. This press machine can be made locally with the help of skilled technicians.
2. Its appearance and design encourage the community to contribute to recycling.
3. In Iraq, the motor tricycle is mostly used which can carry a maximum of 50 kg of plastic and cardboards based on the survey done in this research; however, they tend to put up to 150 kg without considering the traffic rules and the danger it brings to the other drivers and themselves as well.
4. With the help of the application mentioned above, this truck could collect a huge amount of waste in a day without making useless travels.
5. Iraqi people are interested in the idea of recycling; however, Iraq still lacks the sorting phase of recycling, which is the first step of recycling.

Disadvantages:

1. Based on the market survey we did in the local automotive industry in Iraq, the initial capital to purchase one machine could range between $ 20,000 to $ 50,000. This machine if locally made with the existing vehicles brands could cost between $15,000 to $ 80,000.

Recommendation 3: Recycling fabrics in Iraq

Fabric recycling in Iraq was excluded in our study since the price of brand-new clothes is fairly modest. Therefore, there is not a great market for recycled clothes. Please read more on this topic in Appendix 3.
There is a huge market for second-hand clothes in Iraq, and in this market, all expensive and good quality brands can be found for a price ranging between $ 0.2 to $ 10 per piece. There is still a small window for this business in Iraq; however, the changes it makes might not be as effective as the other types of recycling.

Recommendation 4: Recycling oil waste to soap

There are many different types of oil waste, such as car oil, kitchen oil, industry oil waste, and generator' engine oil. Car oil, industry oil, and generator's engine oil are recycled in Iraq. The only type of oil that has not been recycling in Iraq is kitchen oil. Therefore, tackling kitchen oil waste could be an opportunity in Iraq to build some innovative businesses on it. Creating a small factory to produce the soaps by using kitchen oil as main ingredient of the products.
As like any other recycling process, the process starts with the collection of oil waste. The ideal places to collect kitchen oil waste would be hotels, fast food restaurants, restaurants, and universities. Any kind of facility with a café or kitchen in it would be an ideal place to collect the waste oil. The households are not ideal to collect the oil waste since according to a study that has been done in Iran, Sanandaj, a total of 400 households were surveyed to gather information on their oil consumption per day. The oil consumption is 149 grams per day (Salehzadeh et al.). Therefore, if the factory aims to mass produce soap from oil, then the best place to collect the oil waste is not the households since their waste generation is considerably lower compared to a fast-food restaurants or other restaurants. This business might face the challenge of finding a market for their products. Therefore, carful study of the market needs to be conducted before investing in such projects.

Recommendation 5: Car Tire Recycling in Iraq

Vehicle tiers are categorized into two categories, such as truck mid-condition post-use tires and all the other low-condition post-use tiers.
Truck mid-condition post-use tires are sent to the recycling factories located in Iraq, Erbil, Diwaniya, and Babylon to be recycled to produce vehicle tires again or extracting by products. (State Company for rubber and tires industries). The byproducts of these factories are utilized in production of rubber tiles.
Low-condition post-use tiers make the majority of tire wastes that go to cement plants and other massive plants to use them as a source of fuel or go to energy recovery. They tend to recover the energy from the waste item by scientifically burning the tire. This process has already been implemented all over Iraq.

Additional recommendations

Beside the recommendations mentioned before, the following recommendations are quite necessary to be considered:

1. Issuing certificates for workers or investors in this field.
2. Setting new and suitable regulations for recycling businesses in Iraq.
3. Providing training courses for different levels working at the recycling facilities.
4. Encouraging collaboration between different businesses.
5. Increase the awareness among people of different ages and backgrounds.

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List of abbreviations and keywords

Keywords and definitions:

Biodegradable: (of a substance or object) capable of being decomposed by bacteria or other living organisms and thereby avoiding pollution.
Non-biodegradable: Non-biodegradable materials are often synthetic products like plastic, glass and batteries.
Polyethylene: a polymer of ethylene, any of various partially crystalline lightweight thermoplastics $(CH_2CH_2)_x$ that are resistant to chemicals and moisture, have good insulting properties, and are used especially in packaging and insulation.
Solid Waste: Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas. It has low liquid content.
Pasteurization: heat-treatment process that destroys pathogenic microorganisms in certain products, such as food, milk, and compost.
Ferrous metals: ferrous metals contain iron, such as steel, cast iron, alloy steel (The difference between ferrous and non-ferrous metal).
Non-ferrous metals: are metals that do not contain iron, such as Aluminum, copper, lead, zinc, and tin (The difference between ferrous and non-ferrous metal).

List of Abbreviations:

HDPE: High-density polyethylene
PET: Polyethylene terephthalate
LDPE: Low-density polyethylene
MRF: Material Recovery Facility
RDF: Refused Drive Fuel
SW: Solid waste

Appendixes

Appendix 1: Key Informant Interview with Representatives from Veterinary Directorate of Sulaemani

List of attendees:

a. Dr. Dler Ahmed, head of the abattoir, butcher shops, and poultry animals.
b. Dr. Nawshirwan, assistant manager at the veterinary directorate of Sulaemani.
c. Mr. Ismael Jamal, recycling consultant at IRIL.

Date and Time: 14 Oct. 2021 9:30 am – 10:15 am
Location: Iraq, Sulaemani, Salim Street, veterinary directorate's building.

Summary:
Mr. Ismael requested the esteemed participants to check the feasibility of recycling food in Iraq. What is the government's regulation on establishing such factories?
Even though the discussion went very deep, only relevant key points will be mentioned in this section.

They said since the factory will be producing animal feed, our directorate needs to make the final decision on the product produced. In Iraq, the following steps are taken to by our directorate:

1. Once the factory is established and ready to operate. Then, our representative will visit the factory to check the process of making the products.
2. Product samples are tested in our laboratories to check the quality and list of ingredients.
3. Once the factory is ready to go to the mass production phase, we will have frequent visits to the factory.
4. The factory needs to test the product before the product reaches consumers.
5. The factory needs to take all responsibility in case of having any animal disses caused by their products.
6. The ingredients of each type of food must be constant over time.

Appendix 2: Key Informant Interview with Representative of Sulaimaniya Chamber of Commerce & Industry

List of attendees:

1. Ismael Jamal Ahmed, recycling consultant at IRIL.
2. Representative of Sulaimaniya Chamber of Commerce & Industry

Date and Time: 14 Oct. 2021 11:00 am – 11:30 am
Location: Iraq, Sulaemani, Salim Street, Sulaimaniya Chamber of Commerce & Industry

Summary:
Mr. Ismael requested the esteemed participant to give him guidelines for establishing a recycling factory and an animal feed factory;
What is the government's regulation on establishing a recycling factory?
Each kind of factory has different regulations. Below is an overview of the guidelines in Iraq:

1. All the machines of the factory need to be identified and the purchasing price of each of them as well.
    1. If the total price is less than $ 65,000, then the steps are as follows:
        1. Our directorate can give permission; however, other directorates are involved in giving the final permission to establish the factory.
        2. The possible directorates involved in permitting this factory are:
            1. City's directorate of environment.
            2. City's general directorate of municipality.
            3. City's security department.
            4. And a few others, depending on the type of recycling.
    b. If the total price is more than $ 65,000, then the steps are as follows:
            1. Ministry of Trade
            2. Ministry of Environment
            3. Ministry of Municipality
            4. Few other government departments are also involved, depending on the type and size of the factory.

*Remark: In some cases, the government will provide free land for the factory.

Appendix 3: Key Informant Interview with Jwane Design and Recycling

List of attendees:

1. Mrs. Jwana Abubakr Hama
2. Mr. Ismael Jamal, recycling consultant at IRIL.

Date and Time: 7 Nov. 2021 9:30 pm – 9:55 pm
Location: Online

Summary:

Mrs. Jwana, the co-founder of Jwane Design and Recycling, started the business back in 2019 with one of her friends. She mainly dedicated the Instagram page to advocating for clothe recycling. She has been recycling clothes by utilizing several simple tools and a sewing machine, whose total cost will not exceed $ 1000. She has been selling no more than 60 products since 2019, she said, “Since my main focus was to raise awareness on clothe recycling, that is why my sales are very low.” She also mentioned that she has not been promoting her products via Instagram. The main obstacle for her was to lower down the price and find customers for her products.

Appendix 4: Plastic Identification Code, Properties, Applications Virgin Grades, and Applications Recycled Grades

PLASTICS identification code

The Plastics Identification Code* identifies the type of plastic resin a product is made from. The code makes it easier for re-processors to identify and separate used plastics for a range of new applications. Single and mixed materials can be recycled into new products, and used plastics can also be converted into liquid fuel or other energy.

TYPE OF PLASTIC		PROPERTIES INCL. SPECIFIC GRAVITY	APPLICATIONS: VIRGIN GRADES	APPLICATIONS: RECYCLED GRADES MAJOR USE / MINOR USE
1 PETE	Polyethylene Terephthalate **PET**	Clear, tough, solvent resistant. Used for rigid sheets and fibres. **Softens:** 85C **SG** = 1.38	Carbonated soft drink bottles, fruit juice bottles, pillow and sleeping bag filling, textile fibres	**BEVERAGE BOTTLES** Clothing, geo-textiles, bottles for detergents etc., laminated sheets, clear packaging film, carpet fibres
2 HDPE	High Density Polyethylene **HDPE**	Hard to semi-flexible, waxy surface, opaque. **Softens**: 135° C **SG** = 0.96	Crinkly shopping bags, freezer bags, milk bottles, bleach bottles, buckets, rigid agricultural pipe, milk crates	**FILM, BLOW MOULDED CONTAINERS** Agricultural pipes, pallets, bins for compost and kerbside collections, extruded sheet, crates, garden edging, household bags, oil containers, pallets
3 PVC	Unplasticised Polyvinyl Chloride **UPVC**	Hard rigid, can be clear, can be solvent welded **Softens**: 70-100° C **SG** = 1.40	Electrical conduit, plumbing pipes and fittings, blister packs, clear cordial and fruit juice bottles	**PIPE, FLOORING** Pipe and hose fittings, garden hose, electrical conduit, shoes, road cone bases, drainage pipes, electrical conduit and ducting, detergent bottles
	Plasticised Polyvinyl Chloride **UPVC**	Flexible, clear, elastic, can be solvent welded **Softens**: 70 - 100°C **SG** = 1.35	Garden hose, shoe soles, cable sheathing, blood bags and tubing, watch straps, rain wear	
4 LDPE	Low Density Polyethylene **LDPE** Linear **LDPE**	Soft, flexible, waxy surface translucent, withstands solvents **Softens**: 115° C **SG** = 0.92	Garbage bags, squeeze bottles, black irrigation tube, silage and mulch films, garbage bins	**FILMS: BUILDERS, CONCRETE LINING AND BAGS.** Agricultural pipe, nursery & other films
5 PP	Polypropylene **PP**	Hard, flexible, translucent (can be transparent). Wide property range for many applications, good chemical resistance. **Softens**: 165° C **SG** = 0.90	Film, carpet fibre, appliances, automotive, toys, housewares, crates, palls, bottles, caps and closures, furniture, rigid packaging	**CRATES, BOXES, PLANT POTS** Compost bins, garden edging, irrigation fittings, building panels
6 PS	Polystyrene **PS**	Clear, glassy, rigid, brittle, opaque semitough, melts at 95° C. Affected by fats and solvents **Softens**: 90° C **SG** = 1.06	Refrigerator bins & crispers, stationery accessories, coat hangers, medical disposables. Meat & poultry trays, yoghurt & dairy containers, vending cups	**INDUSTRIAL PACKAGING, COAT HANGERS, CONCRETE REINFORCING CHAIRS** Moulded products, coat hangers, office accessories, spools, rulers, video cases and printer cartridges
	Expanded Polystyrene **EPS**	Foamed, light weight, energy absorbing, heat insulating **Softens**: 90° C **SG** = 0.90 – 0.93	Drinking cups, meat trays, clamshells, panel insulation, produce boxes, protective packaging for fragile items	**SYNTHETIC TIMBER** Picture frame mouldings, under slab void pods for buildings
7 OTHER	OTHER : Includes all other resins and multi materials (laminates) acrylonitrile butadiene styrene (ABS), acrylic, nylon, polyurethane (PU), polycarbonates (PC) and phenolics		Automotive, aircraft and boating, furniture, electrical and medical parts	**AGRICULTURAL PIPING** Furniture fittings, wheels and castors. Fence posts, pallets, outdoor furniture and marine structures.

* Information reproduced from Plastics Identification Code Brochure provided by: **CLAW Environmental, REPSA, PACIA**

Appendix 5: Survey questionnaires

Collectors Questionnaires:

1. A list of personal information questions
2. What type of items do you collect daily?
3. What type of biodegradable items do you collect?
4. What type of non-biodegradable items do you collect?
5. Where do you operate?
6. Where do you collect the waste items?
7. Do you buy the waste items?
8. If you buy the waste items, how much do you pay per kg?
9. Where do you sell your collected items?
10. What is the selling price of your collected product?
11. Do you work other jobs?
12. How long have you been doing this job?
13. How many hours do you work per day?
14. What kind of vehicle do you use to collect the waste items?
15. Do you use protection materials (gloves, masks, and googles)?
16. How much does this business yield monthly?
17. How much capital is needed to run the business on a monthly basis?
18. Have you received support (subsidies) from the government? Community? Private sectors?
19. Please list five main obstacles you face in this job.
20. Please list five main recommendations to enhance your business.

Unofficial Recycling Sectors Survey Questionnaires:

1. A list of questions about background of the company
    a. Company name
    b. Company address
    c. When was this company established?
2. What type of items does your company treat?
3. What type of biodegradable items does your company use in the factory?
4. What type of non-biodegradable items does your factory use?
5. In which city is your company based and do its operations?
6. How do you obtain the waste materials?
7. Do you buy the waste items (raw materials)? If yes, how much do you pay per Kilogram?
8. If you export the finished products, how do you sell them? Per Kg? Per volume?
9. What is the selling price of your exported product?
10. Do you pay for transportation, loading, and unloading?
11. Do your employees use protection materials? Gloves? Masks? Googles? Helmets? If not, why?

12. How much does this business yield monthly?
13. Locally recycled? If yes, what products are produced?
14. How much capital is needed to run the business monthly?
15. What tools and pieces of equipment are utilized to recycle the waste materials?
16. How much does this business yields monthly?
17. How much capital is needed to run the business on a monthly basis?
18. Have you received support (subsidies) from the government? Community? Private sectors?
19. Please list five main obstacles your company face
20. Please list five main recommendations to enhance your business
21. What are the most common technical problems?
22. How much are the purchasing costs for each of them?
23. What are the types of energy input?
24. How much energy do they require to operate?
25. How much does it cost to operate them?
26. Area of the factory
27. Does your factory have fire extinguisher, emergency path, and emergency kits?