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Waste Management Concept for the City Taraz (Kazakhstan)

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List of Abbreviations

DM	Dry Matter
e. g.	for example
IE	Individual Entrepreneurs
IEA	International Energy Agency
ISP	Informal Sector Participants
Mg	Megagram / Metric Ton
MSW	Municipal Solid Waste
oDM	Organic Dry Matter
UBA	Umweltbundesamt (engl. Federal Environment Agency Germany)
UN DEAS	United Nations Department of Economic and Social Affairs
WBG	World Bank Group
WC	Water Content
Zht LLP	Zhasyl El-Taras LLP

Executive Summary

Motivation

Taras is a city in southern Kazakhstan whose waste management system stands under great pressure due to growing population and urbanisation. As a result of this pressure the waste management system needs to be improved to prevent harmful influences on protected goods (flora, fauna, water, soil, air, humans). For more information see chapter 1.1.

Law

The environmental code is a detailed law on environmental protection in Kazakhstan with a large section on waste management laws that are similar to waste management laws in Germany and other high-income countries. For more information see chapter 1.2.

Structure

The city of Taraz is a city in a country that is considered to be a country of upper-middle income according to Data provided by the World Bank (2022).

The current annual growth rate is 1.3 % with a population of 367,684 inhabitants in 2022. The city has a high commuting activity due to its proximity to the border and an average household size of 3.5 Persons according to data from United Nations Department of Economic and Social Affairs (2017). For more information see chapter 2.2.

Current and Future Waste Management System

Kazakhstan currently resides between Phase 1 and 3 according to model of Klampfl-Pernold & Gelbmann (2006). Waste collection coverage is 100 % but gets landfilled in unsanitary fashion with low informal sector activities separating recyclable wastes. For more information see chapter 3.

Zhasyl El-Taras LLP is the municipal company to deal with cleanliness and sanitation in the city. It covers 70 % of the local MSW collection in the city. It doesn't own a treatment facility for mixed MSW, but a rented landfill outside of the city. The landfill has 30 ha space, but its capacity remains unknown.

There are several private and informal stakeholders involved in the city who deal with waste management. Separate collection of biowaste is not done properly and there is no treatment facility for biowaste in the city.

The current MSW composition according to data from Kaza et al. (2018) is shown in Figure a including absolute numbers for waste generation in 2017.

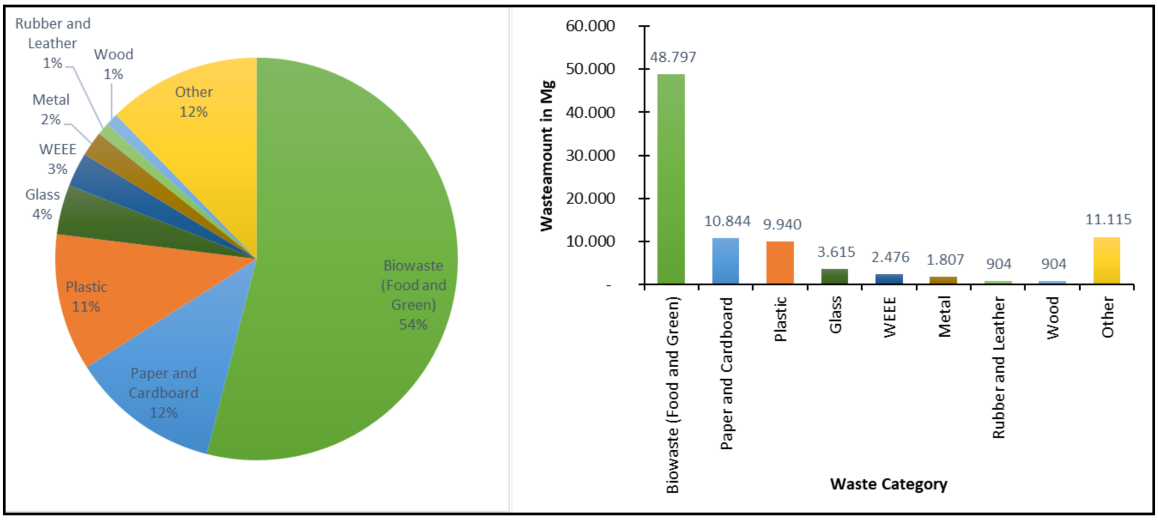

Figure a: Waste composition and waste amounts in Taraz in 2017

Altogether 1,275 waste bins and 354 collection points are currently installed in the city. 265 of which are for separate collection of plastic waste. Furthermore 600 legal entities are serviced by ZhT LLP. A model for the current collection and treatment system is shown in figure c.

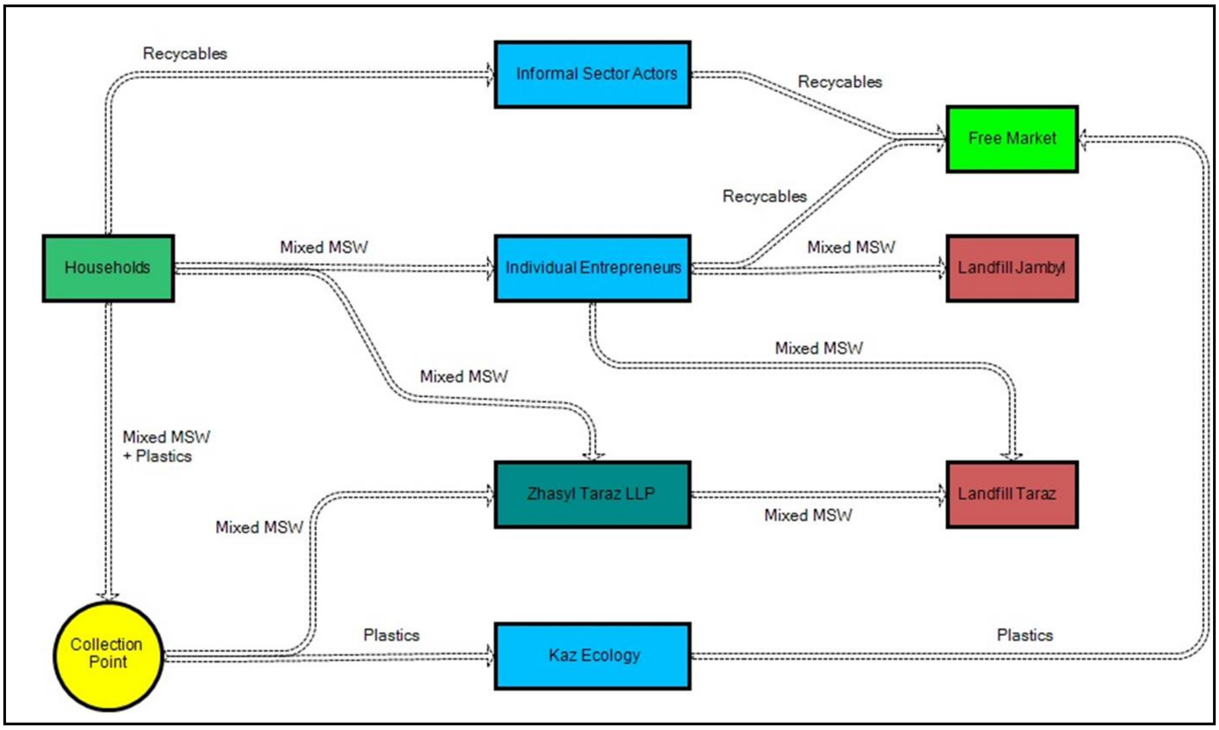

Figure b: Current waste collection system for MSW in Taraz

The current treatment options for the waste of Taraz are displayed in figure d including the sorting rate.

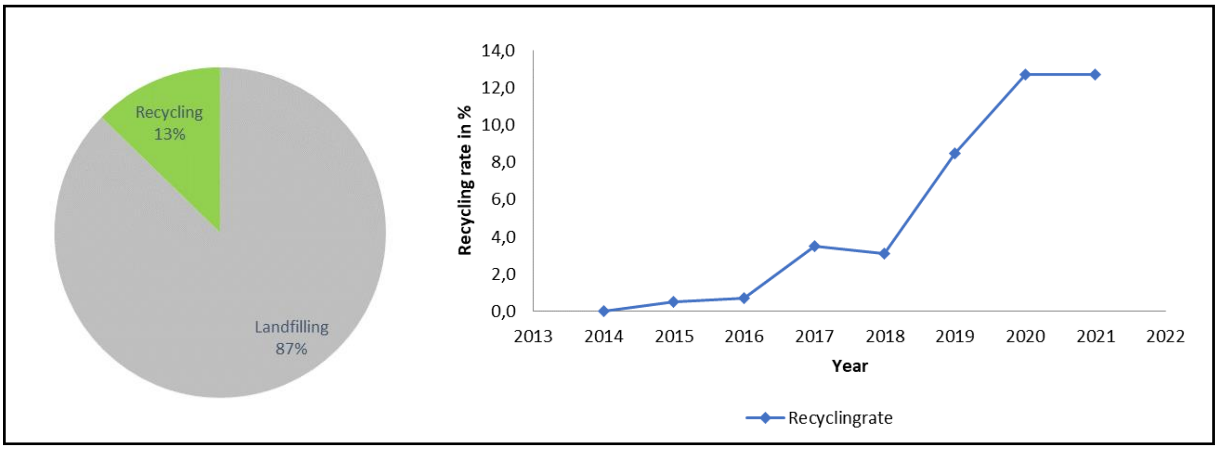

Figure c: Waste treatment options (2021) and sorting rate in Taraz in (2014-2021)

The total costs for the current waste management system allocated to 530 Mio. ₸ in 2021 with a cost coverage of 45 % based on the data provided to the authors. The current cost situation in Taraz is shown in figure d, including the cost development in the last five years.

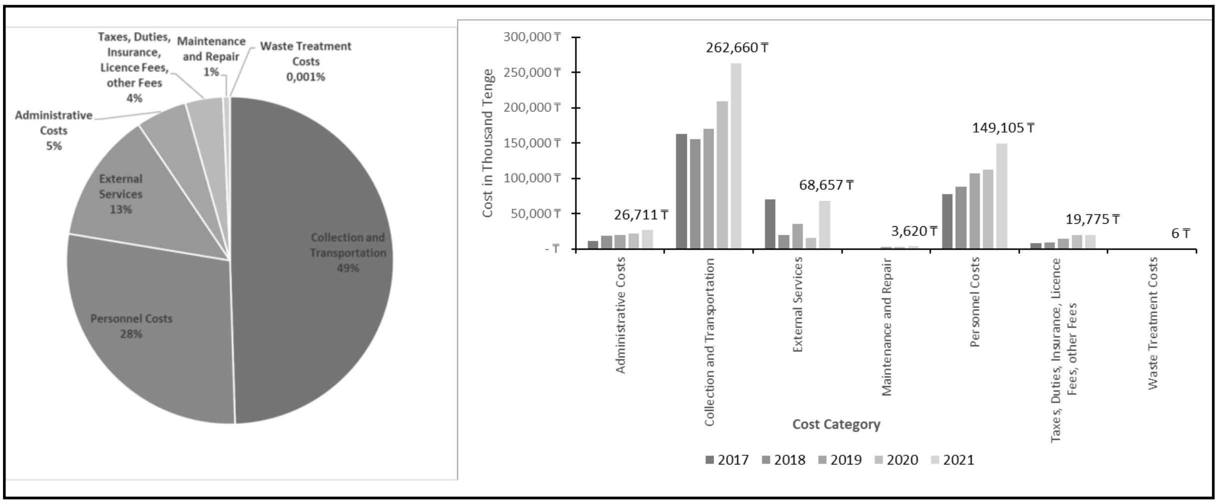

Figure d: Cost allocation and absolute costs for waste management in Taraz (2017-2021)

With growing population and improving economic situation for the citizens of Taraz the waste amounts in the future will possibly increase. Depending on the growth rate it could be possible, that the municipality has to deal with 32 to 53 % more waste in 2050 than in 2017. Figure e shows the comparison of two scenarios for the future of waste management in Taraz.

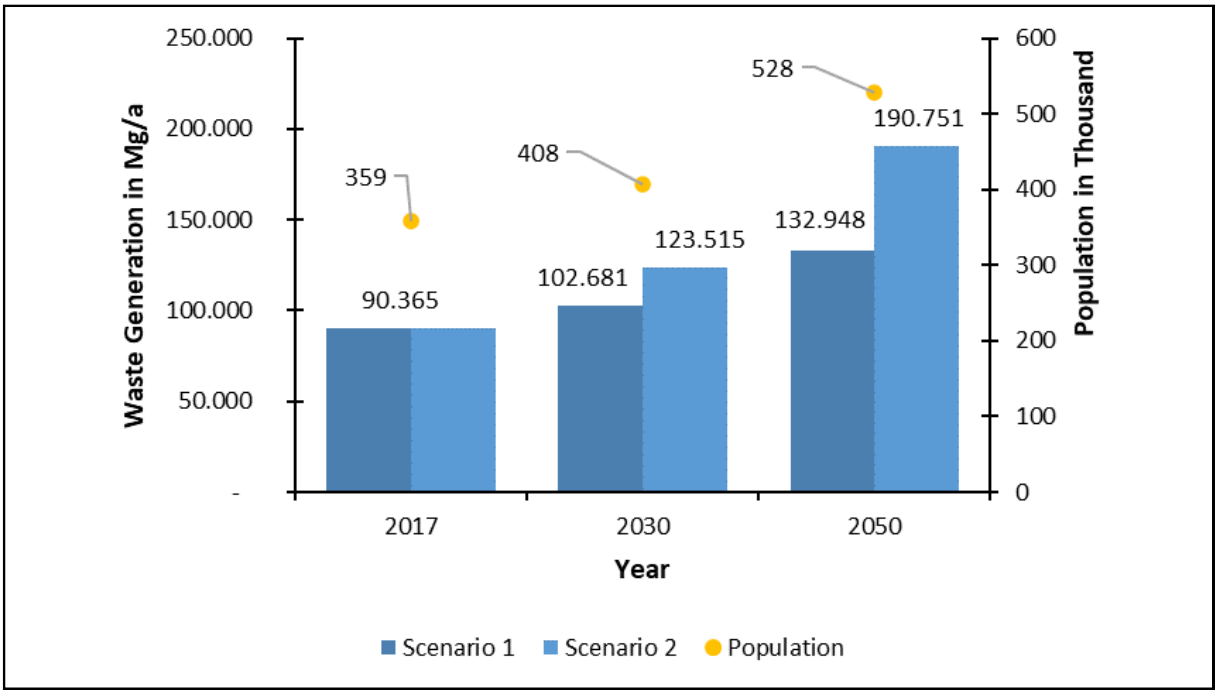

Figure e: Current and projected waste generation per year. Scenario 1: Steady waste generation rate and growing population; Scenario 2: Increasing waste generation rate and increasing population.

Depending on the data provided and a strength and weakness evaluation the authors designed a robust waste management system that is shown in figure f with a mechanical-biological treatment plant (MBT) for mixed MSW in the centre and separate collection systems for recyclables and hazardous wastes.

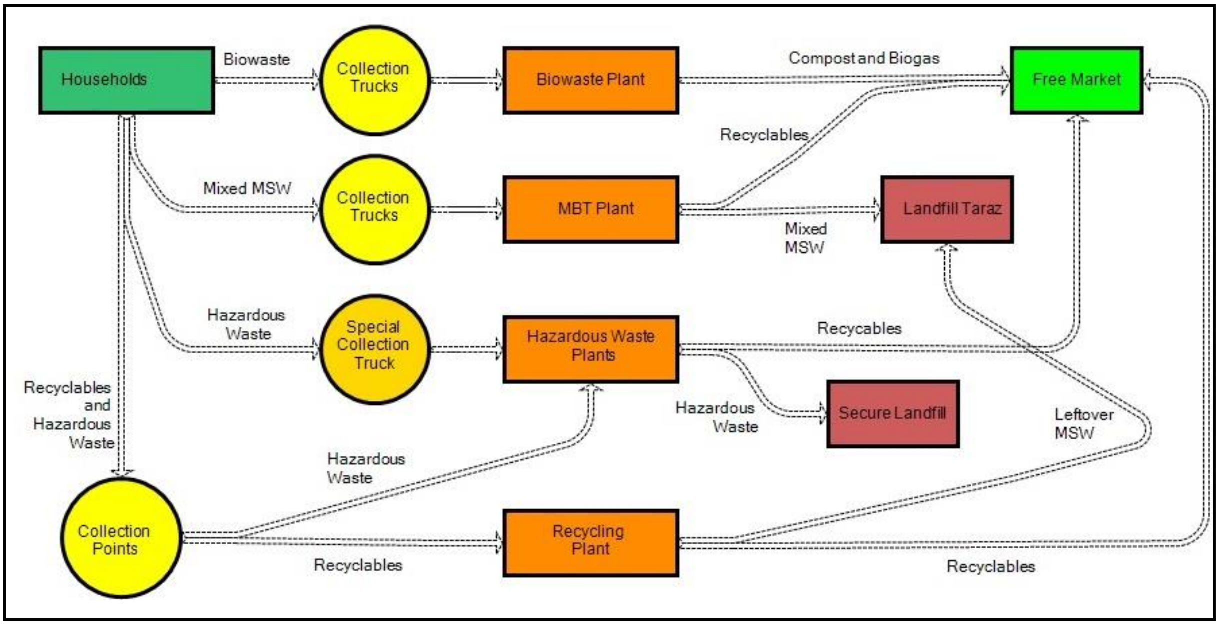

Figure f: Future waste management system for MSW in Taraz

For detailed information on the current and future waste management system in Taraz and the developed concept see chapter 4 and following.

1 Introduction

1.1 Motivation

With growing population and increasing urbanisation rates, cities and municipalities stand under a high pressure to secure the safety of its citizens and the surrounding environment from the negative impacts caused by mismanaged solid municipal waste (MSW). Due to this reason the project "Waste and Recycling Management in Kazakhstan" coordinated by DEinternational Kazakhstan was established in which a consortium of German and Kazakh stakeholders tries to improve the waste management situation in Kazakhstan.

In the chosen model city of Taraz a German expert group, represented by the Forum für Abfallwirtschaft and Altlasten e. V., a closely attached association to the Institute of Waste Management and Circular Economy at the TU Dresden, was commissioned to design a modern "Waste Management Concept". With the help of a local expert Ms. R. Mingazova and in close cooperation to the local team of the DE International Kazakhstan represented by G. Ospanova and Dr. V. Kim, the German association could set up this waste management concept that is based on the structure of a German waste management concept of a similar sized city like Taraz. Besides Ms Mingazova, Mr. Nurbekov – a local expert – was involved in the consultation stage of the project.

To get relevant information from the responsible people in the Akimat of Taraz and the municipal company a detailed questionnaire about the waste management situation in Taraz was provided to them, which was filled out hesitantly and incomplete due to a lack of data and reservation in relation to the German expert group. To gather more information about the waste management system in place the team of the DEinternational Kazakhstan filmed a visit to the local landfill and interviewed the landfill manager Ms. R. Uspanova who provided useful information about the landfill management. But major information about the system in the city was still missing.

Due to this lack of data - concerning the amount of waste and the composition of the waste in the city the of Taraz - the authors used data published by the World Bank Group (WBG), the United Nations Environmental Programm (UNEP) and other publicly available sources to calculate the waste composition and the waste amounts for the city of Taraz. Furthermore, different scenarios were set up to simulate the future development of the waste amounts in the city. To get a grasp of the economic value of waste and its relevance in the economy a cost and value comparison was done. A strength and weakness analysis followed by goals to be reached in the next five years, finish this report.

1.2 Legal Framework

There are several legal frameworks in Kazakhstan that have an influence on the waste management sector. The fundamental legal framework of Kazakhstan concerning waste management (including waste collection, handling, detection, and landfilling) is the so called "Environmental Code" that was first published in 2007 and most recently adapted in 2021. Building on this code the Republic of Kazakhstan set up different ordinances or decrees to further regulate the waste management situation. These are:

- Rules of implementation of expanded obligations by manufacturers (importers)
- Rules of production and turnover of organic products

- Sanitary Rules "Sanitary-epidemiological requirements for the collection, use, transportation, storage and burial of production and consumer wastes"

Furthermore, the Code “On Public Health and Healthcare System” gives information and guidelines how to maintain a sanitary situation in the population through correct treatment of waste from different sectors like medical waste, but also production and consumption waste.

In the following the most important mentions of waste in the environmental code are listed:

Article 4 “Ecological safety and ecological foundations of sustainable development of the Republic of Kazakhstan” mentions in subparagraph 2.1 “*The environmental foundations for sustainable development of the Republic of Kazakhstan are*”

[...] the formation and maintenance of sustainable models of production and consumption, characterized by an increase in the welfare and quality of life of the population while minimizing the anthropogenic impact on the environment, reducing the consumption of non-renewable natural resources, reducing the level of generation and disposal of waste, as well as stimulating their use as secondary resources; [...]”.

Article 37 “Environmental quality target indicators” states in subparagraph 7.8 a list of minimum indicators to characterize the qualitative and quantitative state of measures for environmental protection and efficient waste management, the “*types of municipal waste - the share of their separate collection, preparation for reuse, processing, recycling and disposal (destruction and (or) dumping);* [...]”.

Article 41 deals with “Waste accumulation limits, waste disposal limits” that has the goal “to reduce the amount of waste to be disposed and stimulate their preparation for reuse, processing and disposal”, by setting limits to disposal and waste accumulation on sites of category I and II meaning sites that have significant

(I) or moderate (II) negative impact on the environment. With waste management sites being in both categories according to “Appendix 2” of the Environmental Code depending on the kind of waste the sites are dealing with and the amount of waste that is treated.

“Section 19. Waste” of the environmental code is a specific section that deals with the topic waste divided in nine chapters with 75 articles in total. It includes the following chapters:

- Chapter 23: General provision on waste
- Chapter 24: Hazardous waste
- Chapter 25: Waste landfill sites
- Chapter 26: Features of mining waste management
- Chapter 27: Special features of the municipal waste management
- Chapter 28: Special features of radioactive waste management
- Chapter 29: Special features of the management of certain types of waste
- Chapter 30: State waste cadaster
- Chapter 31: Extended obligations of manufacturers (importers)

The environmental Code in general is very detailed and provides a solid basis for environmentally friendly waste management in Taraz.

2 Taraz – Location and Structure

2.1 Location

The city of Taraz is in the southern part of Kazakhstan in the region of Jambyl. The city is situated at the similar named river Taraz near the border to Kyrgyzstan. The climate is considered semi-arid with strong continental influences with an average annual temperature of 11.2 °C and an average precipitation of 355 mm (Wetterkontor GmbH).

The city is spread over a total area of 187.9 km^2 at an elevation of 610 m above sea level.

A picture of the city of Taraz can be seen in figure 1. The red line shows the boundaries of the city vicinity.

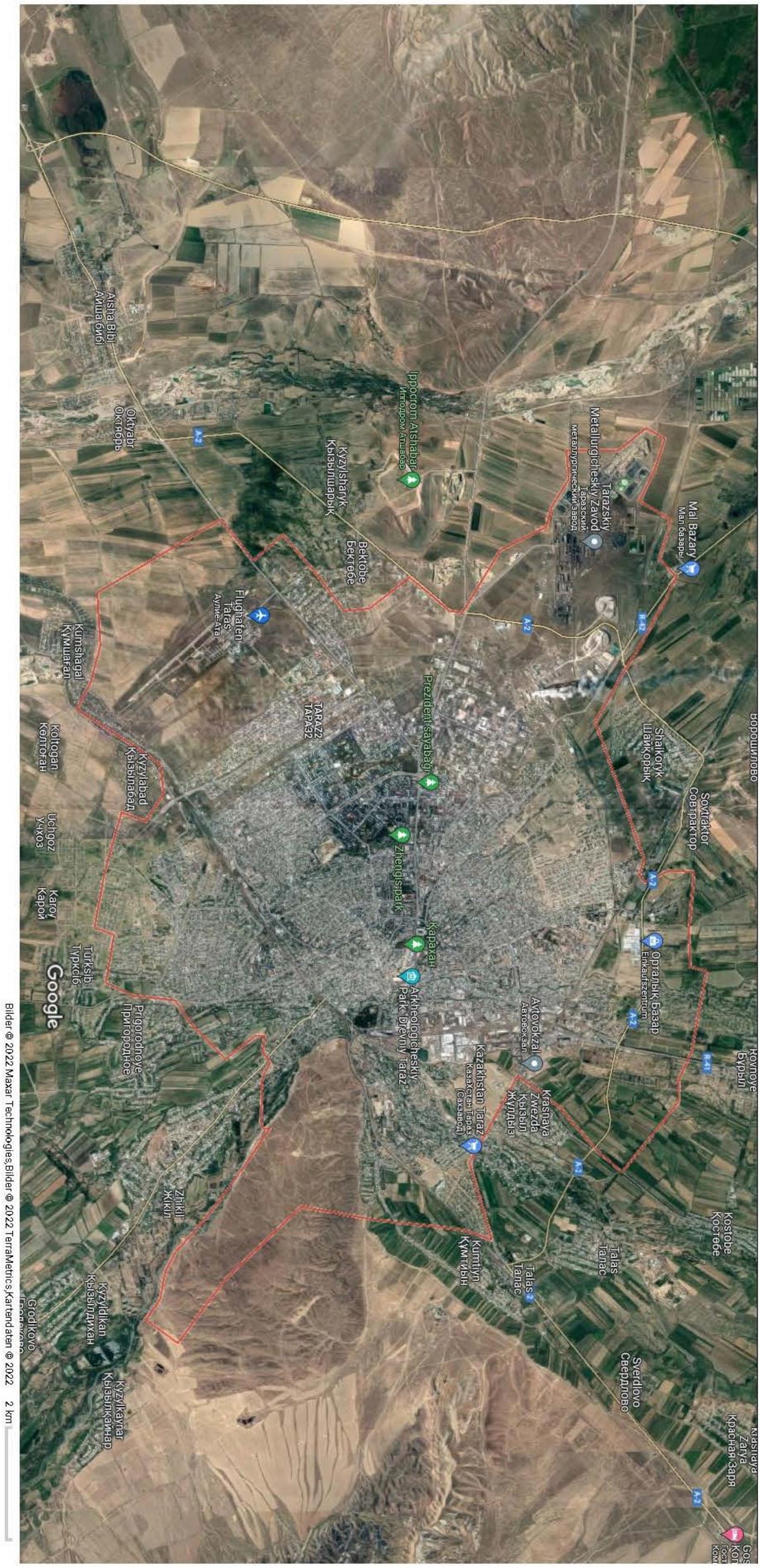

Figure 1: Map of the city of Taraz (Source in figure)

2.2 Structure

The gross domestic product per capita based on purchasing power parity (GDP per capita PPP) in 2021 in Kazakhstan was at a level of 28,600 USD (World Bank Group [WBG], 2022a), which places Kazakhstan and the city of Taraz in the range of upper-middle income countries respectively cities according to income level ranges of the WBG (2022b).

According to data provided for 2022 by the local expert most recently, Taraz has a population of 367,684 inhabitants. The population density is therefore 1,957 capita/km². The following Figure 2 gives an overview about the population development in the city in the last 5 years. It is showing a slow but steady increase in population since 2018. The population increased in total by 3.3 % since 2018. The growth rate being rather stagnant in the years before, it increased to 1.4 % (2020-2021) and 1.3 percent (2021-2022) with an average annual growth rate since 2020 of 1,37 %.

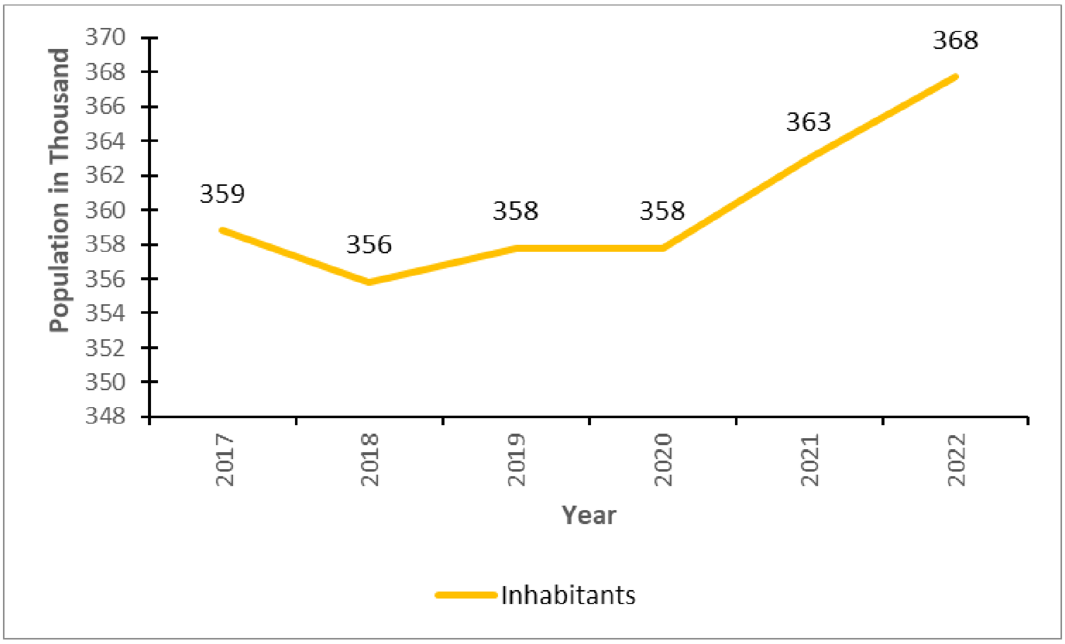

Figure 2: Population development in Taraz 2017 to 2022 (Akimat 2022)

As of now ,it is possible that only one person per household is registered with the municipality, but more than one person actually lives in the household. This leads to the issue for waste management cost calculation, as it is unclear how much average waste is produced per household/inhabitant and how high the waste costs per household/inhabitant should be. Further information about the cost situation in Taraz for waste management, see chapter 3.7.

The average household size in Kazakhstan according to data from United Nations Department of Economic and Social Affairs (2017) is 3.5 inhabitants per household. More detailed information about different household sizes in Taraz was not provided by the responsible persons.

Due to a local airport the city of Taraz is well connected to the other metropolitan areas in Kazakhstan like Nur-Sultan and Almaty. Furthermore, the highway A2 from Uzbekistan to China and the highway A14 to Kyrgyzstan run through Taraz. Because of the location next to the border of Kyrgyzstan, the city of Taraz has a high amount commuting activity between Kazakhstan and Kyrgyzstan.

The biggest industries in Taraz are Jambyl Gypsum, Knauf Taraz, KazPhosfat and Taraz Metallurgical Plant. Further information on the industrial waste situation see Chapter 3.5.7.

3 Waste Management System in Taraz – Current Status

According to modern waste management science the development of a waste management system can be divided into six different Phases. The different Phases are depicted in Figure 3. Phase zero is the phase in which no waste management at all takes place and wastes are not recognized as a problem. In Phase one uncontrolled and wild landfilling or dumping takes place emissions into the environment are still happening. In the following phases the management process gets more sophisticated through which the negative impacts onto the environment and protected goods are reduced. Hazardous wastes get separated and an awareness increases that waste can be used as a resource. In phase four the waste is used energetically and materialistic recycling takes place. In the last phase waste is viewed as a resource and everything is done to use this resource as efficient as possible.

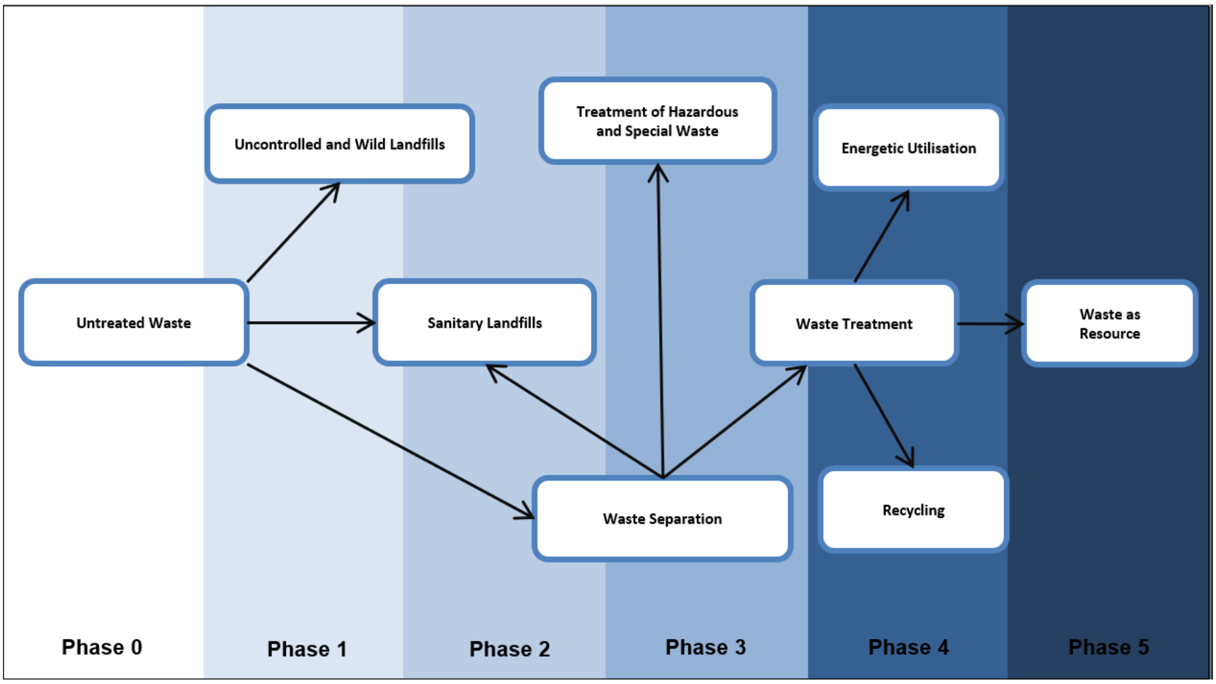

Figure 3: Phases of Waste Management Development (Klampfl-Pernold & Gelbmann 2006)

Kazakhstan can be put between phase 1 and phase 3, because in a few cities sanitary landfills are established, but the majority of the landfills is still uncontrolled and not sanitary. Furthermore, some waste separation takes place through informal sector activities. An important fact to keep in mind is that according to the theory a country or region always should go through all phases to build a working waste management infrastructure before going into higher phases. If leapfrogging takes place, the chances are high that the waste management system will fail due to a missing market for recyclables, missing finance schemes, missing infrastructure or missing knowledge about waste management techniques.

3.1 Organisation of the Waste Management System

The municipality of Taraz founded the company Zhasyl El-Taras LLP (ZhT LLP) to deal with the cleanliness and sanitation situation in the city. However, the company does not have its own waste processing facility, but a rented landfill area outside the city. The company does own waste collection trucks, but more information about the trucks was not provided. Most of the waste management system in the city is privatized or in hand of the informal sector.

All companies dealing with solid municipal waste in Taraz should be officially registered or under contract of the ZhT LLP according to Law of the Republic of Kazakhstan "On Permits and Notifications". But only one company is known to be registered. With help of a local expert several actors in the informal and private sector in Taraz and the greater region Jambyl could be identified. Further information, see Chapter 3.5.1

As there is no separation at source in place for the biowaste fraction of the waste stream, no company is responsible for composting or anaerobic digestion of this fraction. The missing separation at source is in contradiction to the environmental code of Kazakhstan that suggests a separate collection of a wet and a dry fraction in Article 321 for domestic waste.

3.2 Activities in Waste Minimisation

There are no known activities in Taraz to reduce waste production or the release of harmful substances into the environment.

3.3 Consulting in Waste Management

The Akimat of Taraz city conducts ecology studies and seminars in schools to further educate the citizens of Taraz about environmental issues. In total there are 60 Schools in Taraz that conduct eco measures once a month. Several schools have so called eco communities that do certain environmental activities together.

These activities could be for example:

- tree planting,
- cleaning of territories (e. g. school, public places),
- courses and events for specific topics like
- forums,
- competitions, among schools,
- different research works,
- handicrafts from waste.

Some schools combine social help with waste management aspects and collect recyclable paper waste to use the collected deposit to give to families with many children. All schools have waste bins for separate collection of plastic waste.

It is not known if the Akimat educates companies on waste minimisation or production integrated environmental protection possibilities.

3.4 Waste Quantities and Composition

The morphological composition of the generated waste in Taraz was provided by the ZhT LLP. It is shown in Table 1.

Table 1: Waste Composition of Taraz provided by Zhasyl El-Taraz LLP

Waste Fraction	Weight %
Food waste	43
Garden Waste	4
Glass	Not available
Paper, Cardboard	30
Metals	Not available
Wood	4
Plastics	2
Textiles	3
Leather and Rubber	3
Street Waste and Leaves	7
Fine Fraction < 15 mm	3
Stones, Plaster	1

The missing data for glass and metal wastes, the relative high amount of paper and cardboard waste and the low amount of plastic waste led to the decision to use morphological composition provided by publicly available sources, because it is not plausible why these waste fractions do not occur or do occur in the waste composition of Taraz.

Additionally, the fact, that the landfill of Taraz does not own a scale to measure the amount of waste generated in the city of Taraz has strengthened this decision.

For this reason, the following waste compositions and generation rates are estimated with help of literature provided by the World Bank Group called “What a waste 2.0” written by Kaza et al. (2018). The authors of the study used several waste management compositions from countries with a similar GDP to calculate an average waste composition for four income groups:

- Low income
- Lower-middle income
- Upper-middle income
- High income,

The waste composition of Taraz was calculated with the average composition given by Kaza et al. (2018) for upper-middle income countries, due to the GDP PPP of Kazakhstan, and the production rate of waste of electrical and electronic equipment provided by Baldé et al. (2018) for Kazakhstan. The calculated waste composition for the city of Taraz is shown in Figure 4.
The waste composition shows a high amount of biowaste with 54 % and a share of 32 % for recyclables (paper and cardboard, plastic, glass, metal and WEEE). The fraction “Other” is not clearly defined by Kaza et al. (2018).
Fractions that could be included in this waste fraction are:

- fine fraction (e. g. < 10 mm);
- inert materials but glass (e. g. stones);
- hygienic waste (e. g. diapers, tampons);
- bulky waste;
- with hazardous substances contaminated waste or
- other not mentioned waste.

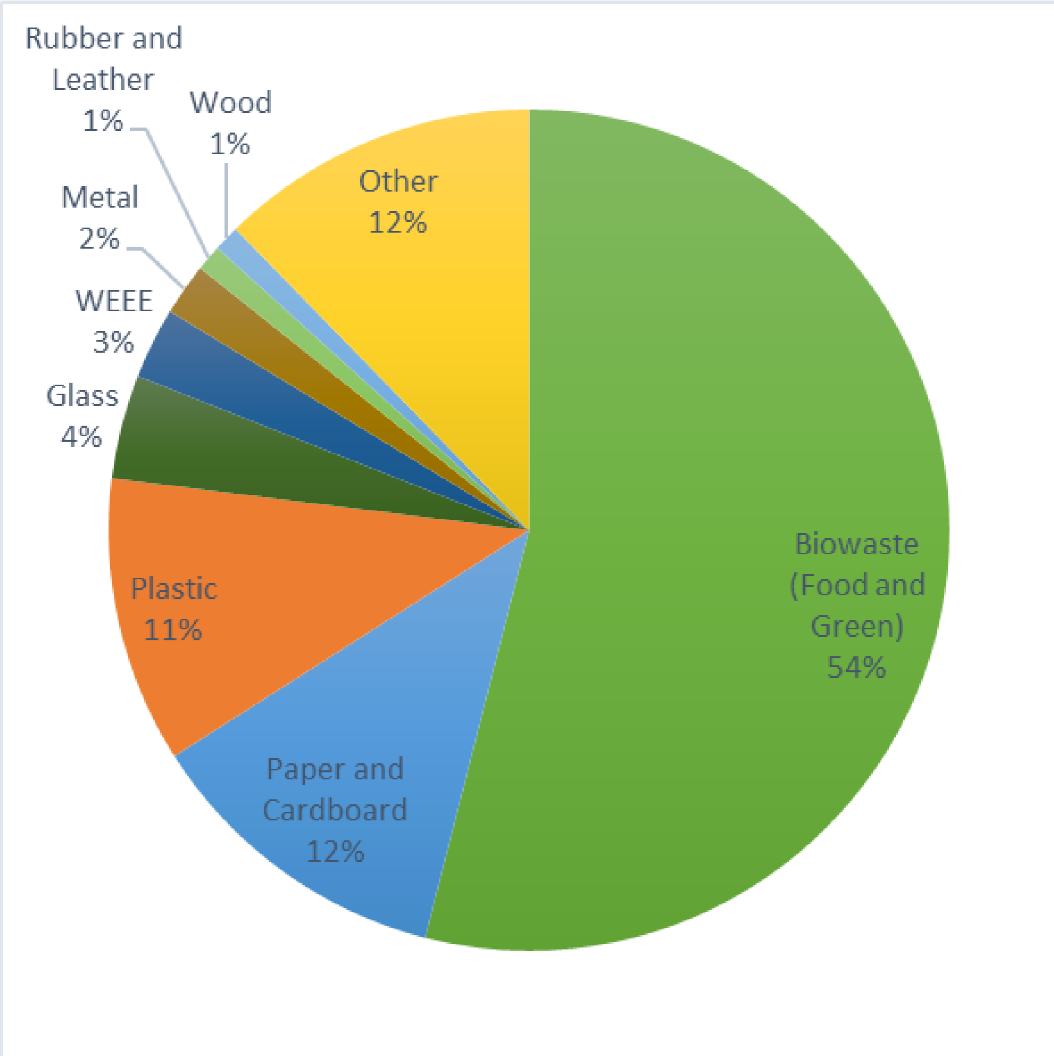

Figure 4: Waste composition of households in Taraz (Own Research adapted with Kaza et al. 2018 and Baldé et al. 2018)

Furthermore, it is not clear how high the amount of packaging materials or compound materials is in the recyclables fraction.

The authors of the concept estimate the waste generation of upper-middle income countries to be 0,69 kg/(capita*day) (equals 252 kg/(capita*year)). This leads to the result that the citizens of Taraz generated an amount of roundabout 90,365 Mg of MSW in the year 2017. 2017 was chosen because the year is closest to the data published by Kaza et al. (2018). As the year 2021 only has 4.159 inhabitants more than the year 2017 the waste amount differs by 1.047 Mg equaling 91.413 Mg not changing the used projection model significantly

The absolute masses for the different fractions of waste are given in Figure 5.

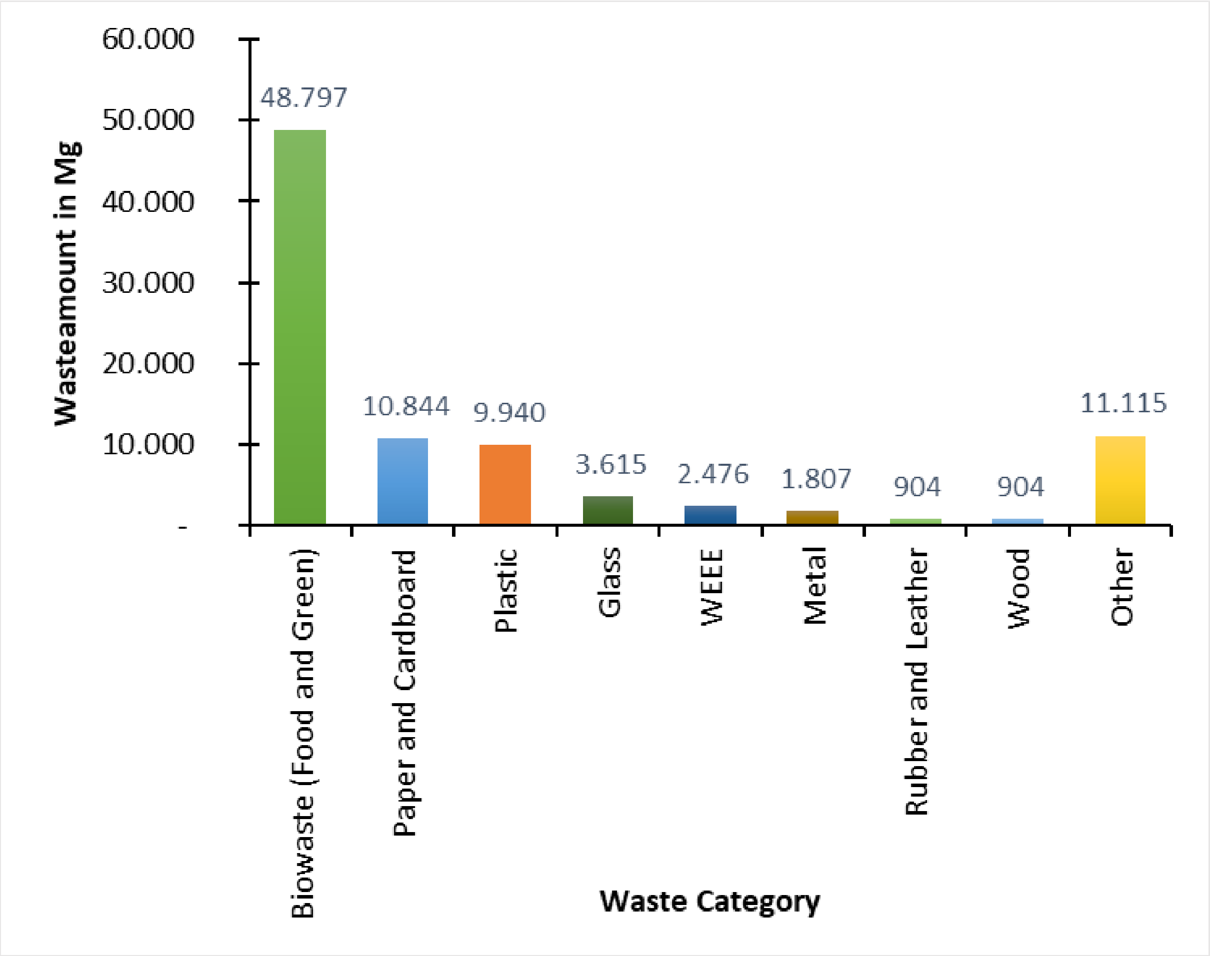

Figure 5: Waste amounts generated in households in Taraz in 2017 (Own Research)

3.5 Description of the Waste Management System

In the following chapter the authors explain the nature of the waste management system in Taraz.

3.5.1 Waste Collection and Transportation

The waste collection in Taraz is covered by 100 %. Roundabout 70 % is collected by the municipal company and 30 % is collected by the private entrepreneurs and the informal sector.

The city of Taraz installed 1,275 waste bins in the city including the waste bins at the 268 separate collection points for plastics that are contracted by the company Kaza Ecology. According to the provided information there are 354 public mixed municipal solid waste (MSW) collection points in the city that are serviced by the ZhT LLP including the 268 collection points already mentioned.

It remains unclear how batteries, pesticides, paints and other hazardous wastes are collected in Taraz. Reports from 2017 stated, that 30 collection points for hazardous waste fraction like mercury containing light bulbs were installed, but local sources negated this information.

Roundabout 600 legal entities in Taraz are serviced with waste collection and transportation by the ZhT LLP.

The collection in the Jambyl region takes place through 158 specialised waste trucks (Z. Nurbekov 2022).It is unknown how many waste trucks are responsible for the city of Taraz.

The informal sector participants and the waste stream which they are collecting and selling on the free market can be seen in Table 2 and Table 3. Table 4 gives an overview about the private sector participants.

Table 2: Informal sector participants in waste management in the city of Taraz (R. Mingazova 2022)

Company name	Waste Collection
IP Babich	Paper
DEMETRA.KZ	Paper
IPYassar	Paper
IP Zhumadilov	Paper
Eco-Alem.kz	Paper, Plastics
IP Amirkulov Aybek	Glass, Paper
Green Corporation	Glass
LLP ЭKO Taraz	Glass, Paper, Plastic, Tetra pack, metal

Table 3: Informal sector participants in waste management in the greater Jambyl region (R. Mingazova 2022)

Company name	Waste Collection
Begaliyev Samat	Glass
El Daulet	Paper
A Service	Glass, Paper
IP Inkar Assylym	Glass, Paper, Plastics

Table 4: Private sector participants in waste management in the city of Taraz (R. Mingazova 2022)

Company name	Task
IE Makhmudov	Waste Collection
IE Sarsenbay	Waste Collection
IE Sultangazy	Waste Collection
IE Nurly Sat	Waste Collection
IE Baimbetov	Waste Collection
IE Tazalyk	Waste Collection

The following Figure 6 shows a scheme of the waste collection and treatment system of Taraz.

The households produce waste that could be collected by different participants in the collection system.

The households can sell certain recyclables (old books, newspaper, plastic items, plastic bottles, aluminium cans etc.) to informal sector participants (ISP) mentioned in Table 2 and Table 3 and shown in Figure 6. These ISPs sell the recyclables on the free market.

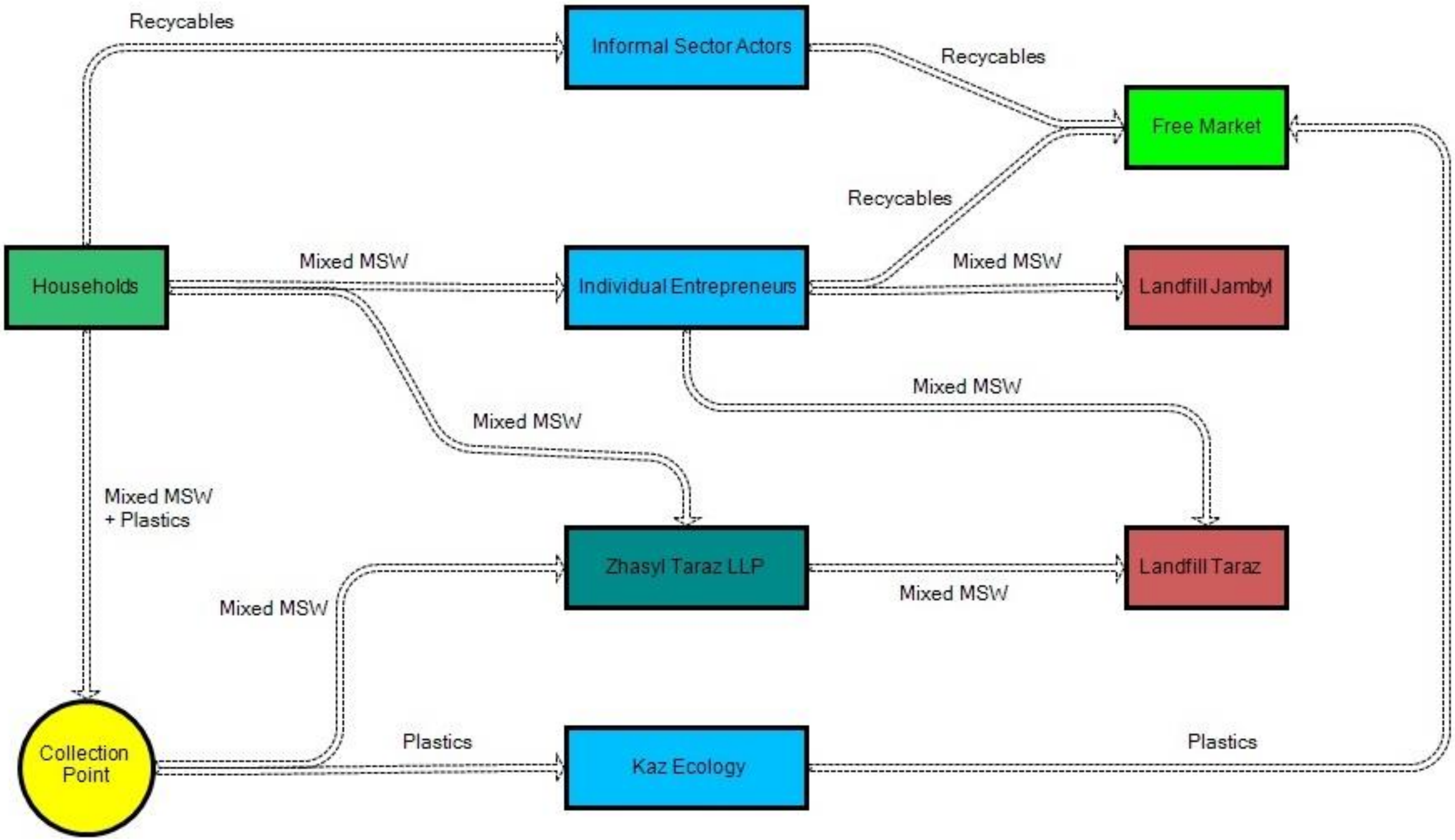

Figure 6: Current waste management system for MSW in Taraz (Own research with information from R. Mingazova 2022)

In addition to ISPs, there are individual entrepreneurs (IE) who have contracts with certain households and collect their mixed MSW and sort certain recyclables on their private commercial space out of the waste stream to sell on the free market. The rest of the mixed MSW is transported to the municipal landfill or the landfill of the Jambyl region.

A third non municipal participant is the company Kaz Ecology that deals with the plastic waste that is collected at one of the 268 collection points in the city. The Kaz Ecology collects the plastic waste and sells it on the free market. Whether it is further processed after collection is not clear.

The municipal participant is the ZhT LLP, who collects the mixed MSW from households that do not have a contract with an IE or bring their waste to the public collection points. The mixed MSW ends up in the landfill of Taraz or the landfill of the Jambyl region.

Due to insufficient separation at source the waste fractions are mixed in the waste bin and the waste truck. Especially the wet fractions like biowaste and hazardous material containing waste cause cross contaminations in the waste fractions. The recyclability of the valuable fractions decreases accordingly.

Figure 7: Prices for recyclables in the informal sector (R. Mingazova 2022)

Figure 7 shows the current prices for several recyclable materials ranging from 15 to 130 ₸ per kilo. The wholesaleprice for these materials range higher.

3.5.2 Mixed Municipal Solid Waste

As there is a separate collection system in place for a small fraction of the solid municipal waste, the authors estimated that most of the MSW is discarded in the mixed MSW bin that is collected regularly by the contracted companies from the households or central collection points for mixed MSW. Pictures that were taken during a visit on the landfill (see appendix 3) suggest that the separation at source is not done properly by the citizens of Taraz. There is still room for improvement especially concerning the organic fraction that has a high impact on the release of landfill gas during the biological rotting process in the landfill that could be used in an anaerobic digestion plant or compost plant instead.

Two key factors that have significantly influenced the development of mixed MSW volumes in Germany are the landfill ban on untreated waste from 1 June 2005 and the obligation to separate biological waste from 1 January 2015.

The landfill ban was introduced primarily to prevent further leakage of methane from German landfills, as it is up to 25 times more harmful to the climate than carbon dioxide. The ban meant that no more untreated waste with a high energy content and a high methane formation potential could be deposited. As a result, capacities for thermal recycling of waste were expanded and collection systems were refined to improve the collection of recyclable materials.

The obligation to separate biowaste ensures that the biological fraction in residual waste is reduced and less biological material reaches thermal recycling, where it loses its potential as a soil improver and supplier of biomethane. The loss of biological material also always means a loss of nutrients such as nitrogen, potassium and phosphorus for the material cycle.

3.5.3 Biowaste

With an estimated share of 54 % the biowaste fraction has the biggest share of the waste fractions in the mixed MSW waste stream of the city concerning the waste from the households only. Due to information given by the local experts the citizens of Taraz do home composting on their properties or discard the biowaste into the mixed MSW bin. A more effective way of utilizing the biowaste fraction would be to collect it separately in a biowaste bin and bring it to a modern anaerobic digestion plant. In this plant a high-quality biogas could be produced and a digestate product that could be further composted. The compost could then be sold as an organic fertilizer for farm manure substitution or hobby farmers. An alternative would be to implement a compost plant that produces high quality compost without the production of biogas. Either way the separate collection of biowaste would save space in the landfill and reduce landfill gas production, which improves climate protection. For further information on biowaste utilisation see Chapter 4.2.

3.5.4 Recyclables (Plastics, Paper and Cardboard, Glass, Metals, WEEE)

Due to its status as an upper-middle income country the number of recyclables in the waste stream auf Kazakhstan respectively Taraz is still low compared to countries with a higher income level. This will increase with growing economy and wealth in the population.

According to a report from Nurbekov (2022) the sorting rate in the Jambyl region rose considerably from 2014 until 2021. It is not clear whether it is due to a higher amount of recycling in the region or a change in the reporting system to the official parties. The development of the sorting rate in the Jambyl region can be seen in the following Figure 8.

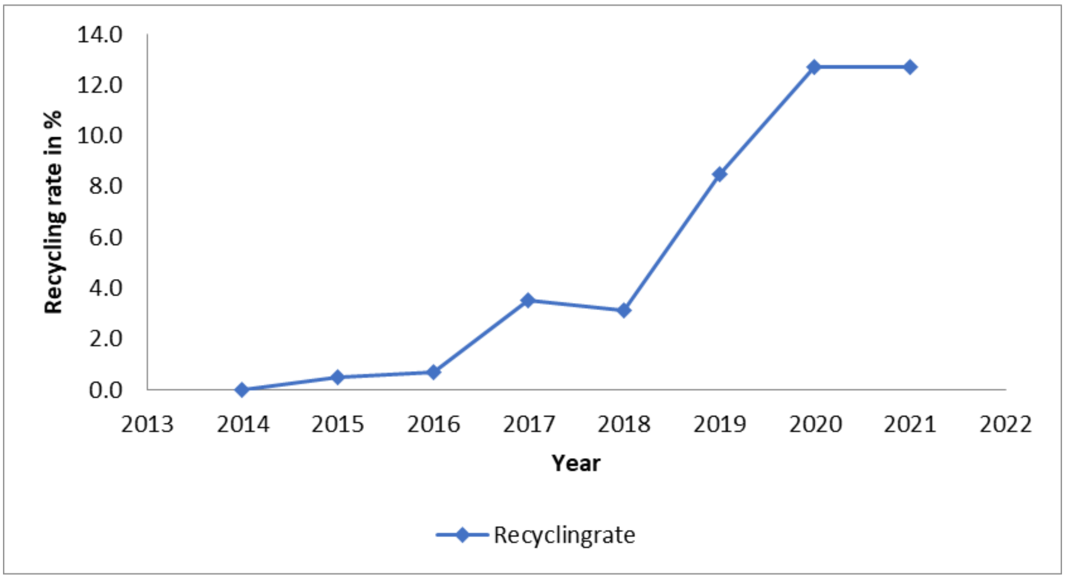

Figure 8: Sorting rate total in Jambyl region from 2013 to 2022 (adapted from Nurbekov 2022)

It is unknown to the authors how much of which fraction is recycled by which individual entrepreneur or informalsector participant. That is why it is not possible to calculate more specific values and model a material flow diagram of the city that could be an additional information to the collection system shown in Figure 6.

3.5.5 Hazardous Waste

Hazardous waste is waste that has a negative on the environment or the human health. The following wastes can be considered hazardous wastes:

- single-use batteries, rechargeable batteries or starter batteries from cars
- mineral oils and fuels
- solvents
- pesticides and herbicides
- acids and dyes
- antifreeze
- mercury containing waste

- paints and varnishes

According to local sources the city of Taraz was to set up a collection system for mercury containing lamps and other products, but did not implement it. Apart from this, it is not known of any other collection system for hazardous wastes from households. The environmental code of Kazakhstan says in Chapter 27, Article 27 Paragraph 5 “[…] Hazardous components of municipal wastes (electronic and electrical equipment, mercury-containing waste, batteries, accumulators and other hazardous components) should be collected separately and transferred for the recovery to the specialized enterprises.”

Baldé et al. (2021) report that roundabout 8.8 % of the waste of electronic and electrical equipment (WEE) is collected in Kazakhstan and 3 % is recycled. But it is not known whether a collection system for the special waste was already established or the municipality is still lacking this system. According to Baldé et al. (2021) “the Kazakhstan Waste Management Association, ‘KazWaste’, supports the creation of waste treatment and recycling industries and implements new projects to improve and optimise business processes in the field of waste management.”

3.5.6 Waste from Legal Entities

Local sources reported that roundabout 600 legal entities and companies use the service of ZhT LLP to get rid of their commercial waste that is similar to MSW.

There was no information provided how much waste was discarded of in the last years to the local landfills or recycling systems.

3.5.7 Waste from Industry

Local sources provided an overview about industrial waste in the region Jambyl. The produced MSW per industry sector for the specific year is shown in Figure 9.

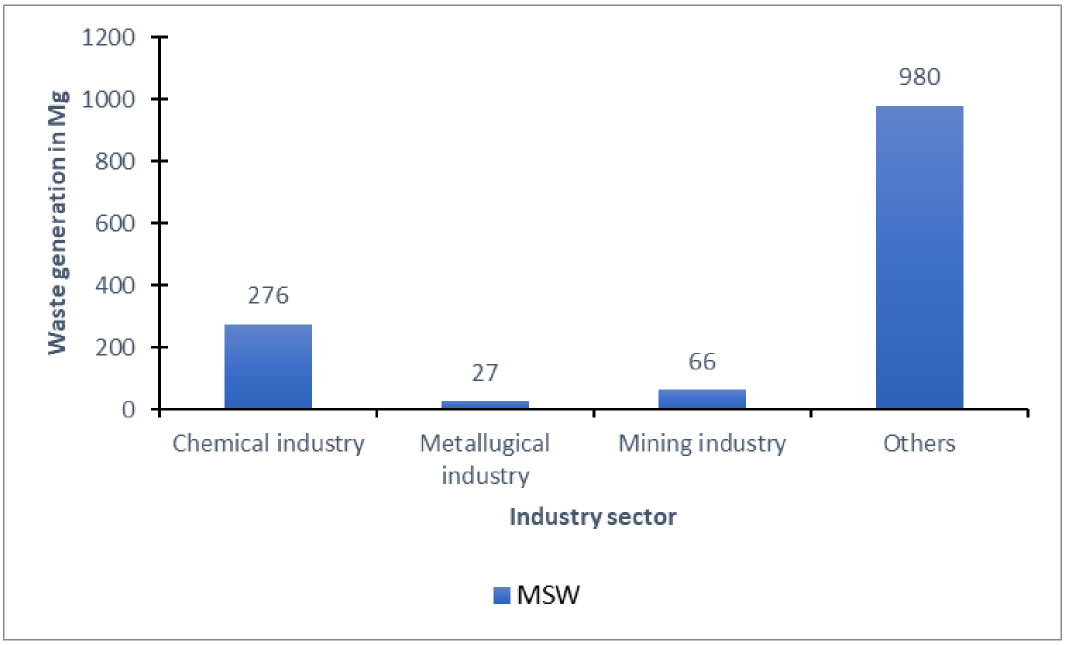

Figure 9: MSW generation per industry sector (adapted from Nurbekov 2022)

It is not clear, into which treatment facility the MSWs is going. The different industry sectors also produce plenty of toxic and harmful wastes (e. g. dust from air filtration systems) where it is unclear, how they are treated to minimize the risk of environmental pollution. An overview of the waste mentioned toxic waste fractions can be found in the Appendix 2.

3.5.8 Waste from Public Places

The ZhT LLP company is conducting a social campaign to deliver firewood from the cut of unusable trees in park areas. At the request of vulnerable segments of the population, ZhT LLP conducts targeted delivery of firewood for the heating season.

With the help of satellite photos on-demand in ZhT LLP the citizens can find out where construction waste accumulates and use it for their own need (e. g. the construction or repair of their private homes).

3.6 Waste Treatment Facilities

The main waste treatment facility of the city of Taraz is the landfill outside of the city. It was founded in 1985 and was previously owned by the company Him Prom until the municipal company ZhT LLP started renting the landfill. The entry point of the landfill is located at the following GPS-Position in the Jambyl region: 42.95072, 71.2233 in the district Kolkainar. The landfill covers an area of roundabout 30 ha (300,000 m²). Figure 10 shows a picture of the landfill site, the red line being the delimitation of the landfill area.

Figure 10: Landfill in Taraz outside of the city - delimitation of the landfill in red (Source in figure)

Every transport vehicle that enters the landfill is noted in a paper logbook by workers from the landfill. Since there is no scale at the landfill, the workers note down the estimated volume of the trucks arriving at the landfill. A pricing according to the weight of the truck is not implemented.

ZhT LLP therefore could only provide an estimated volume of waste transported to the landfill during certain times of the year, which is why the authors decided to use publicly available data already mentioned in this report. The data provided by ZhT LLP can be seen in the following Table 5. The average density of waste given, was 250 kg/m³.

Table 5: Waste volumes per season provided by ZhT LLP 2022

Value	Winter	Spring	Summer	Autumn
Volume per day in m³	500	500-600	700	600

The mixed MSW is discarded on the landfill. The authors are not aware of any registration system to track where a waste truck is unloaded. But the landfill has a territorial system in which every month another space of the landfill is filled with delivered waste.

There are regular fires on the landfill. These fires are caused by spontaneous ignition of the waste that is caused by high temperatures produced by biological activity or chemical reactions caused by highly reactive waste fractions like batteries for example. These could be damaged during transportation, compaction in the waste truck or during the unloading process.

The burning landfill causes toxic fumes that escape into the environment and could harm flora and fauna around the landfill. The next residential area "Tanty kenti" near the train station "Chaykuruk" is only 7.2 km away.

Further danger is caused by waste that gets blown over the fence in case of intense winds as there are no nets around the landfill to prevent waste particles from blowing away. Next to the landfill in roundabout 220 m distance from the border of the landfill area runs a canal that flows through the city and ends in the local river Talas. Waste particles that get blown into that canal end up in the river. The following Figure 8 shows a picture extracted from a video that was provided to the authors about the landfill (DE International Kazakhstan 2022) which shows the issues mentioned before.

Figure 11: Landfill in Taraz with fires in the background (DEinternational Kazakhstan 2022)

A second landfill in the area is the Jambyl landfill, about which the authors were not provided with information.

All participants in the waste collection system in Taraz bring the mixed MSW in one of the two landfills. Information provided to the authors suggests, that the truck drivers prefer the Jambyl landfill, as their street to get onto the landfill area has better driving conditions and the possibility of a damage to the waste truck is lower.

According to the manager of the landfill the landfill area should already been full after almost 30 years of usage as a landfill area. The initial capacity was 4,165 Mio Mg. The due date was the year 2018 but it got prolonged until 2029. Local sources estimated the filled space to be 2,450 Mio Mg, what means the capacity is filled to 58 %. The reasons for the landfill not being full yet, may be due to regular fires that minimize the volume of the waste on the landfill and or due to the fact that the street of the landfill is in such a bad condition that over the last years less and less waste was transported to the landfill.

The official sorting rate provided by Nurbekov (2022) for the Jambyl region was 12,7 % for 2021. It is estimated that the rest of the MSW is landfilled in one of the two landfills. The following Figure 12 shows the waste treatment options in the city of Taraz considering the sorting/recycling rate in Taraz being the same as the sorting rate in the Jambyl region.

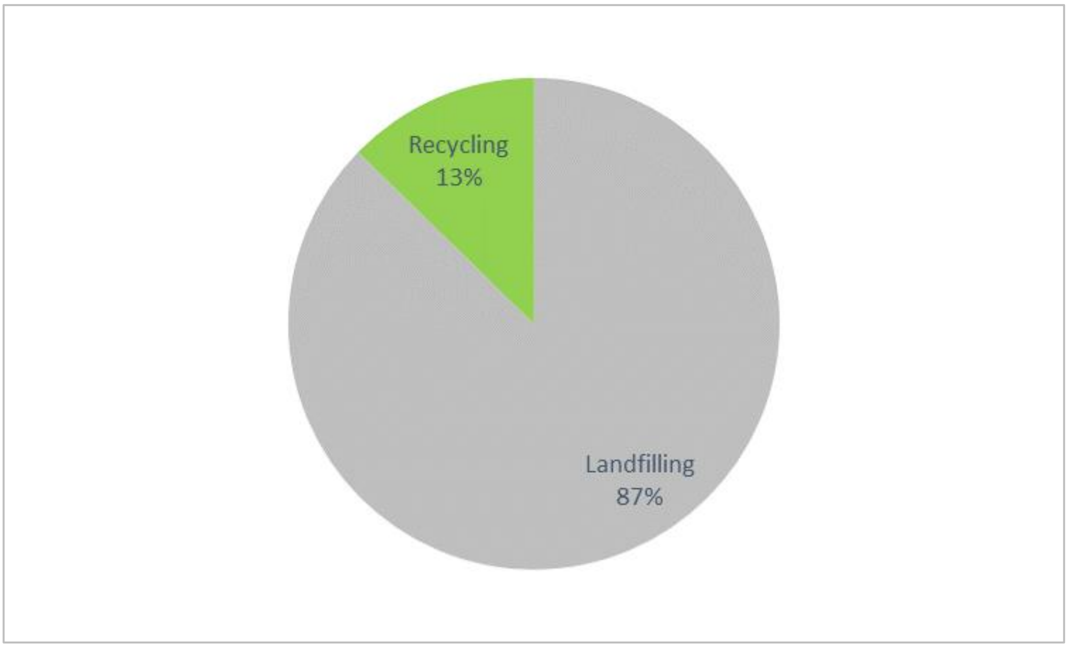

Figure 12: Waste treatment options in Taraz (Own research adapted from Nurbekov 2022)

3.7 Costs and Fees for Waste Management

In the following two chapters the authors will display the waste management cost situation in Taraz and calculations concerning the cost coverage.

3.7.1 Costs

The costs for the waste management sector were provided by the Akimat of the city of Taraz and ZhT LLP. The costs were categorized according to the following waste management cost categories:

- Administrative Costs: All costs connected to the administrative part of waste management
- Collection and Transportation: All costs related to the collection and transportation of waste in the city including repair and maintenance of vehicles.
- External Services: All costs related to the payment of subcontractors and raw materials not related to collection and transportation of waste
- Maintenance and Repair: All costs related to fixing installed assets excluding collection vehicles
- Personnel costs: All costs related to personnel including taxes, insurances, and social security payments
- Taxes, duties, insurance, license fees, other fees
- Waste Treatment Costs: All costs related to the treatment of waste

A detailed overview about the cost categorisation can be seen in the following Table 6.

Table 6: Cost items and cost categorization. (Own research adapted with Information provided by ZhT LLP 2022)

Cost item	Cost Category
Administrative expenses	Administrative Costs
Car Batteries	Collection and Transportation
Car tires	Collection and Transportation
Completed works/services	External Services
CSMI deductions	Personnel Costs
Environmental insurance	Taxes, Duties, Insurance, Licence Fees, Other Fees
Equipment rental, transport services	Collection and Transportation
Expenses for a medical examination	Personnel Costs
Fuel and lubricants	Collection and Transportation
Information Services	External Services
Maintenance and current repair of fixed assets	Maintenance and Repair
Payment for emissions into the environment	Taxes, Duties, Insurance, Licence Fees, Other Fees
Payment for the use of a land plot (landfill)	Waste Treatment Costs
Raw materials	External Services
Social benefits provided to employees (milk on coupons)	Personnel Costs
Social Security contributions	Personnel Costs
Social tax	Personnel Costs
Spare parts	Collection and Transportation
The costs of civil liability insurance for vehicle owners	Taxes, Duties, Insurance, Licence Fees, Other Fees
Worker's salary payments	Personnel Costs

According to this categorization the following two graphics show the percentagewise cost spread onto the various categories and the absolute costs starting with the year 2017. The total numbers for all years are displayed in Appendix 1.

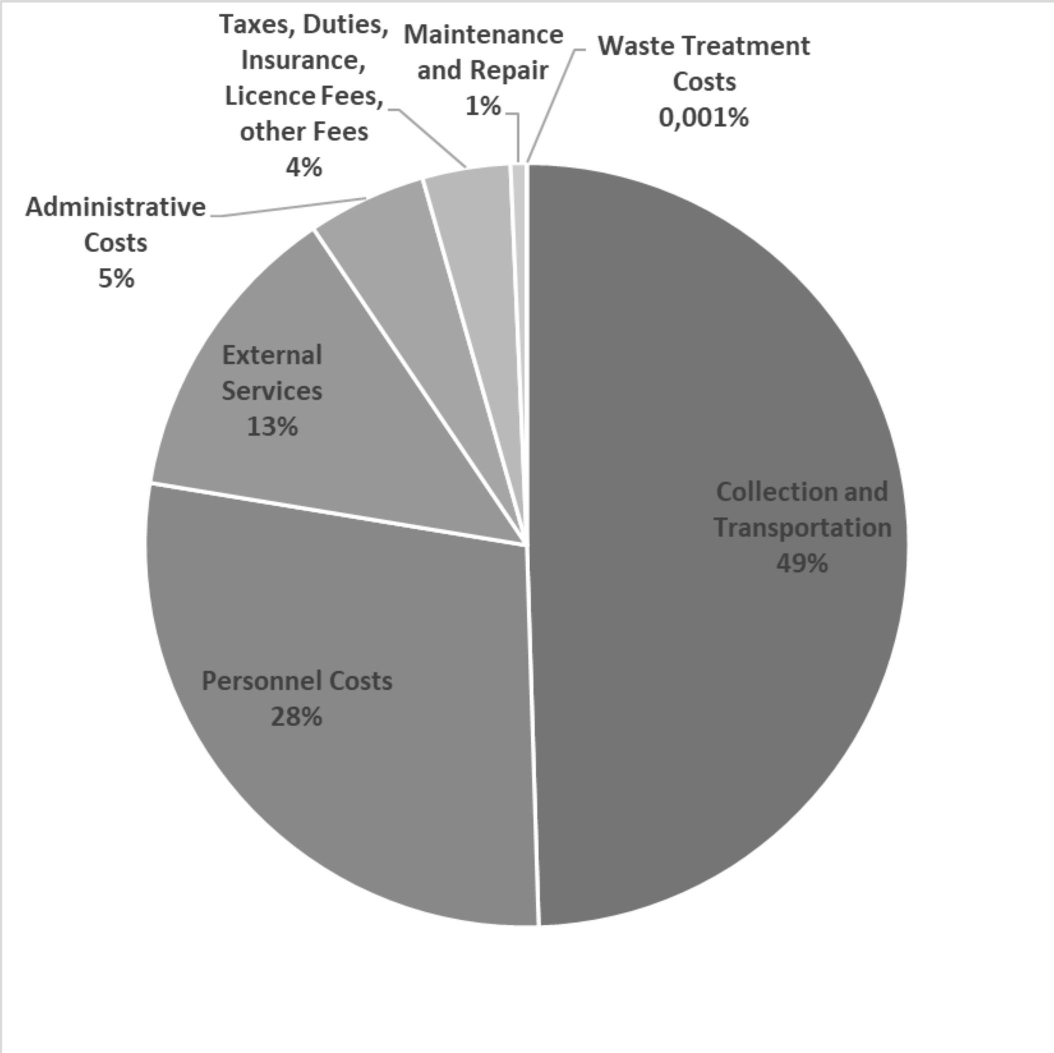

Figure 13: Cost allocation in percent in 2021 (Own research adapted from ZhT LLP 2022)

Figure 13 shows that the highest yearly costs in the waste management system in Taraz are caused by the collection and transportation, which accounts for 49 % of the annual costs. Personnel accounts for 28 % of the total costs followed by external services and others. Due to the missing waste treatment system the costs for the renting of the area of the landfill account for 0,001 % of the total costs.

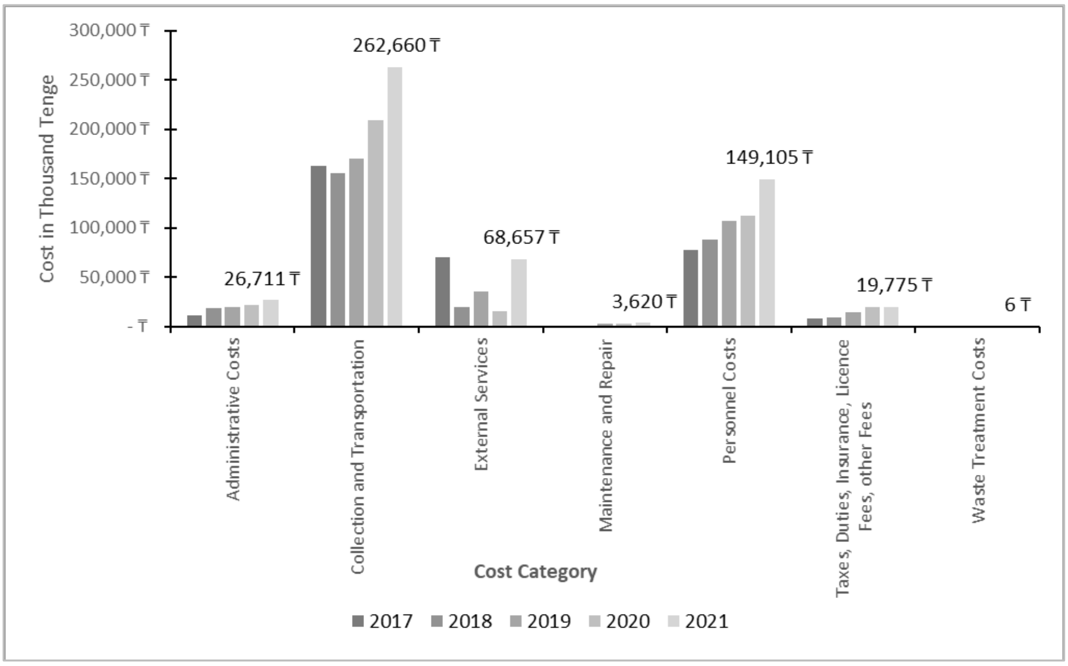

Figure 14: Absolute costs for waste management system from 2017 to 2021 (Own research adapted from ZhT LLP 2022)

Figure 14 complements Figure 13 by showing the absolute costs for the different cost categories. The total costs for the waste management in Taraz for ZhT LLP were 530,533,220 ₸ in 2021. That is an increase of 61 % in comparison to the costs of 329,796,484 ₸ in 2017. The highest being the “Collection and Transportation” category with 263 Mio. ₸ and the lowest being the “Waste Treatment” costs with 6,080 ₸. The figure shows a steady increase in almost all waste management costs since 2017. The average cost in waste management excluding the “External Services”, “Waste treatment costs” and “Maintenance and Repair” categories is 109 % (± 34 % standard deviation) in comparison to the base year 2017. The highest increase is in the waste category “Taxes, Duties, [...]” which increased by 152 % since 2017. The remaining costs “Administration Costs” increased by 129 %, “Personnel Costs” that increased by 93 % and “Collection and Transportation” costs that increased by 62 % in 5 years.

The costs to manage one ton of waste was 4.110 ₸ in 2021 considering the total costs in 2021 being 530,533,220 ₸ and the collection of 70 % waste from 90,365 Mg total. Considering 70 % of the population of Taraz were served by ZhT LLP in 2021 the costs per person to produce a 100 % cost coverage would have been 2.088 ₸ per year.

3.7.2 Fees

According to local sources the citizens of Taraz pay 98 ₸/household per adult and month for the treatment of waste. The payment for this service is done via the utility bill of the flat and can be paid through an app or per invoice. Furthermore, waste deliveries from private sector directly to the landfill can be paid in cash on receipt. One issue in collection of the fees is that the household size is often unknown due to unregulated living conditions in the city, which is why the fee often cannot be collected according to the household size. This results in an underfunding of the waste management system in Taraz (see Table 7 in Chapter 3.7.3.). Figure 15 shows the income of the municipal company from waste fees split into the income from legal entities and private households.

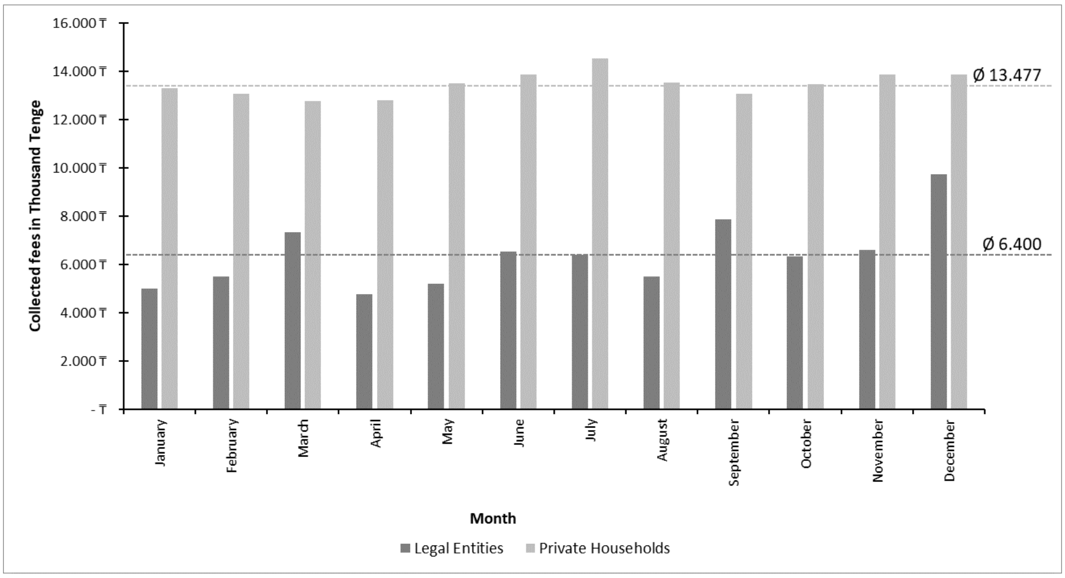

Figure 15: Income per month through fees in 2021 (Own research adapted from ZhT LLP 2022)

The Average Income from legal entities was 6.400 ₸ in and 13,477 ₸ for private households per month in 2021. Altogether the municipal company collected 238,522,800 ₸ of which 32.2 % (76.798.000 ₸) came from legal entities and 67.8 % (161.724.800 ₸) from private households.

3.7.3 Comparison of Costs and Fees

The following Table 7 shows an overview of the collected fees and the costs for the waste management in Taraz considering that ZhT LLP covers 70 % of the total waste collection in the city. The cost coverage in the municipal company was 45 % in 2021. The deficit for the municipal company was therefore 292.010.420 ₸. It remains unclear how the deficit is compensated.

To cover the costs for the waste management in the city the optimal fee per inhabitant and month would have been 174 ₸. This presumes a WM fee collection according to a known household size. Considering an average household size of 3,5 inhabitants per household the optimal WM fee would have been 609 ₸ per month.

Table 7: Comparison of waste management costs and collected fees (Own research adapted from ZhT LLP 2022)

Cost type / Fee type	Cost / Fee in Tenge (₸)	
Total WM costs for mixed MSW	- 530,533,220 ₸	
Costs per ton of mixed MSW 2021	- 4,110 ₸	
Fees from legal entities	76,798,000 ₸	(32.2 %)
Fees from private households	161,724,800 ₸	(67.8 %)
Total Fees Collected	238,522,800 ₸	
Balance	**- 292,010,420 ₸**	
Cost Coverage in %	45 %	
Optimal WM fee per inhabitant and month	174 ₸ (+78 % increase)	
Optimal WM fee per household and month ***(3,5 person per household)***	609 ₸	

3.7.4 Financing of Waste management in Germany

The local authority is responsible for the disposal of the waste. The local authority becomes the owner of the waste when its owner has disposed of it. There are two ways in which a local authority can dispose of waste in their area: through a cost-covering municipal company or through a contracted private company with a profit orientation. In the 1990s, there was an increasing privatisation of waste management because of the expectation of more cost-efficient methods of waste disposal as well as a broader use of knowledge already available in the private sector than municipal companies could have provided. In the mid-2000s, however, there was an increasing rethinking in the municipalities and a return of certain waste management tasks to municipal hands, as the market mechanisms had not worked as originally thought. In addition, the remunicipalisation of certain areas was expected to reduce costs and thus relieve the burden on citizens by lowering fees. The extent of remunicipalisation depends on the regional legal situation. This determines whether a municipality may, for example, only take over collection and street cleaning or also waste treatment through material or thermal recycling.

If a single municipality is too small to establish a municipal enterprise, there is also the possibility of inter-municipal cooperation, in which several municipalities together establish e. g. a special-purpose association for the collection and/or treatment of waste and can thus spread the costs over several shoulders. At the same time, however, competences that exist in all municipalities are bundled and administrative processes are merged (Kraemer et al. 2017).

In the case of waste, a fundamental distinction is made between valuable and non-valuable waste. Valuable waste can be sold on the open market for a fee after collection and treatment due to its value. The following are examples of valuable wastes, as they are already listed in the Closed Substance Cycle Waste Management Act as separately collected wastes:

- Waste glass
- Waste paper
- Used textiles
- Biowaste
- Ferrous metal
- High purity plastic waste
- Non-ferrous metal
- Bulky waste (high quality)

The valuable waste can be offered on the open market untreated or treated. A treatment of the waste can be, for example, a purification of the individual fractions with the help of a mechanical or optical sorting, which sorts out impurities and wrong throws from the fraction - in the case of waste glass this can be e. g. ceramics, in the case of waste paper e.g. plastic components. This increases the quality of the waste. The free market then regulates the price to be achieved per tonne of waste through supply and demand. Since a large part of the valuable waste - minus small losses during treatment - flows back into the production cycle and replaces so-called primary raw materials that were extracted from nature, the term "secondary raw material" is also used for the valuable waste.

In addition to secondary raw materials, which have a value, there is also waste to which no value can be assigned. Accordingly, they have a negative price. These wastes include, for example:

- Waste containing harmful substances (paints, varnishes, medicines, chemicals)

- Ashes (heating, wood stove)
- Hygiene products (nappies, sanitary paper)
- Waste wood (painted)
- Low-quality plastic waste
- Bulky waste of inferior quality

Since the waste management companies can no longer generate income from this waste and it cannot be returned to the production cycle, the waste producer must finance safe disposal of the waste. The remuneration for this service is regulated by the fee system in the disposal area, which can be structured differently. In waste management, a basic distinction is made between a flat-rate and a performance-based fee system (cf. Bilitewski & Härdtle 2013):

- The flat-rate fee system can be property-related, household-related, resident-related or container-related. This means that the fee to be paid by citizens for the disposal of their waste is not based on the amount of waste generated.
- The performance-based fee system, on the other hand, is based on how much waste the citizen generates. It can be based on the container volume, the frequency of emptying, the weight of the waste or the actual volume disposed of.

With the help of modern technology (chips or transponders on the waste bins), the fees can already be charged precisely according to performance. Depending on the fee model applied, certain steering effects can also be achieved in the behaviour of citizens. By setting different prices for waste disposal, the municipality can influence the separation behaviour of citizens. This works particularly well in development structures where citizens can directly see the costs saved through good separation, such as single-family home development and development structures with low population density. In apartment buildings, where waste charges are only listed in the service charges, there is often no impact at all. In addition to the possibility of collecting the waste from households, there is also the possibility that citizens deliver their waste to a recycling centre of the responsible waste disposal company and pay a fee based on the weight there (according to Bilitewski & Härdtle 2013).

In addition to the waste fees for the collection and disposal of the above-mentioned waste, the disposal of packaging in Germany is already financed when an item is purchased. The manufacturers of packaged products or those who place them on the market must register their packaging with the Central Packaging Register and are obliged to contribute to the costs of operating a collection and recycling system for this packaging. They thereby assume their product responsibility. This licensing applies to packaging made of glass, plastic, wood, paper, cardboard and composite packaging. Depending on the quantity, design and recyclability of the packaging, a fee of varying amounts is payable by the participants. This fee is then priced into the price the consumer pays for the product. Therefore, the disposal of packaging materials does not involve a fee to be paid to the municipality.

3.7.5 Cost Outlook

To show possible treatment and investment costs for waste processing technologies, the following table 7 shows average treatment costs for MSW displayed in UNEP (2015, p. 209).

Table 8: Waste treatment costs for different waste processing technologies (UNEP 2015, p. 209)

Waste Processing Technology	USD/Mg	USD million for 100.000 Mg per year capacity
Material recovery facility (MRF) for separately collected dry recyclables	45-60	8-10
Sorting of high-calorific value fractions + preparation of reuse derived fuel (RDF)	35-50	13-20
Windrow composting of separately collected biowaste	25-40	13-20
In-Vessel composting/Anaerobic digestion of separately collected biowaste	65-80	25-50
Simple mechanical biological treatment (MBT) of mixed waste prior to landfill disposal	25-40	7-13
MBT of mixed waste + aerobic/anaerobic treatment prior to landfill disposal	60-75	40-60
MBT/biodrying (partial stabilization) to produce RDF	60-75	35-45
Energy from waste (EfW) using RDF	90-115	80-100
Energy from waste using mixed waste	100-130	80-100
Sanitary landfill	20-35	12-25

Based on this data the following table shows specific costs for the waste management concept presented in chapter 6.2 for Taraz. It was estimated, that 50 % of the biowastepotential gets collected separately, 100 % of the residual waste and 70 % of the dry recyclables potential.

Table 9: Cost outlook for specific waste processing technologies per waste stream

Waste processing technology	Collected Waste Fraction in Mg	Average Treatment Cost in $/Mg	Min Investment Costs in USD	Max Investment Costs in USD	Total costs per year in USD	Costs per inhabitant per year (2017)	Costs per inhabitant per year (2017)
Windrow composting	24,399	40	3,171,822	4,879,726	975,945	1,280 ₮	107 ₮
Simple mechanical biological treatment (MBT) of mixed waste	45,889	40	3,212,263	5,965,632	1,835,579	2,408 ₮	201 ₮
Sanitary landfill		35	5,506,737	11,472,369	1,606,132	2,107 ₮	176 ₮
Material recovery facility for seperately collected dry recyclables	20.077	60	1,606,175	2,007,719	1,204,631	1,580 ₮	132 ₮

Table 8 shows an overview about possible costs that have to be considered for investment decisions and yearly cost coverage. The last two columns give an overview about the costs that could arise for inhabitants in Taraz not taking into consideration possible revenue streams from selling of recyclables , selling of compost, revenues from extended producer responsibility or crossfinancing to lower the costs for inhabitants. If the city of Taraz implements a MBT plant with sanitary landfilling the costs for residual waste disposal might rise to 377 ₸ per month not considering the costs for collection and transportation.

4 Prognosis for Waste Management

4.1 Mixed Municipal Solid Waste

The city of Taraz is a city in a growing country with a population growth rate of 1.3 % according to current data for Kazakhstan provided by the WBG (2022c) which is similar to the growth rate in the last 2 years. Additionally, the drive of people to move into cities due to better living conditions, job situations, short ways of travel and more cultural activities can further increase the population growth rate of cities (UN DEAS (2018) and WBG (2020)). So, the population growth could be supported by the increasing urbanisation rate, which is why the estimated population growth rate depicted in this chapter for the city of Taraz should be seen as a defensive estimation.

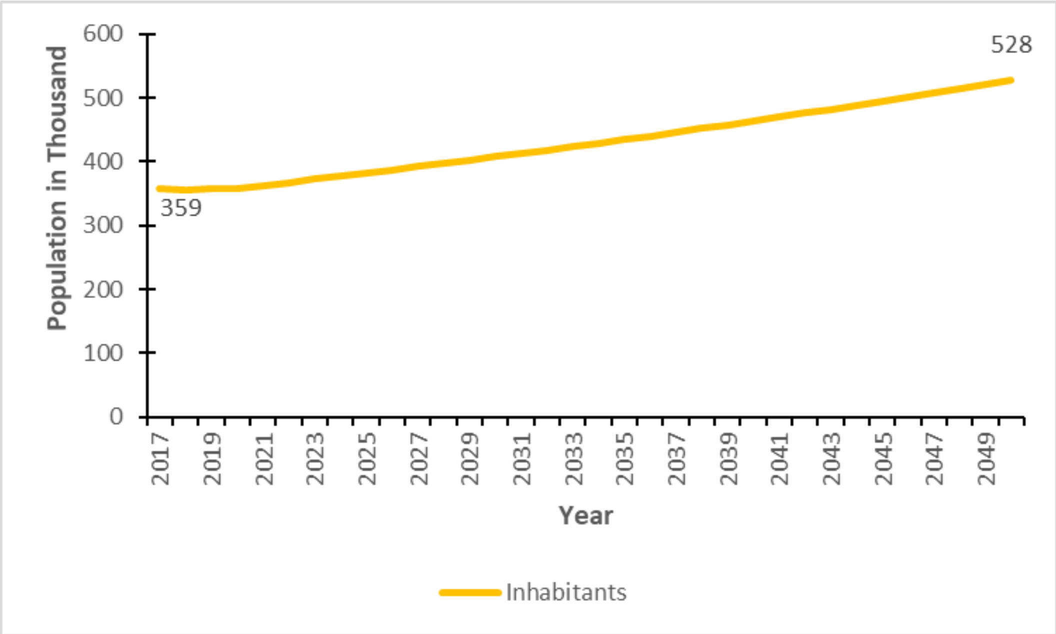

Figure 16: Population growth projection in Taraz until 2050 with an average growth rate of 1,3 % (Own research adapted from WBG 2022 and Akimat 2022)

Figure 16 shows the estimated growth curve for the population in Taraz based on the population in the year 2021 in which 362,965 inhabitants lived in the city. Until 2050 the city could have an estimated population of 528,601 inhabitants. That is an increase of 47.1 % based on 2017.

According to Kaza et al. (2018) it is possible that the specific waste generation rate per capita will increase in upper-middle income countries in the future due to economic growth and improving income situations of the inhabitants. This might lead to an increase by 0.14 kg/(capita*day) (+20 %) until 2030 and an increase by up to 0.3 kg/(capita*day) (+43 %) until 2050.

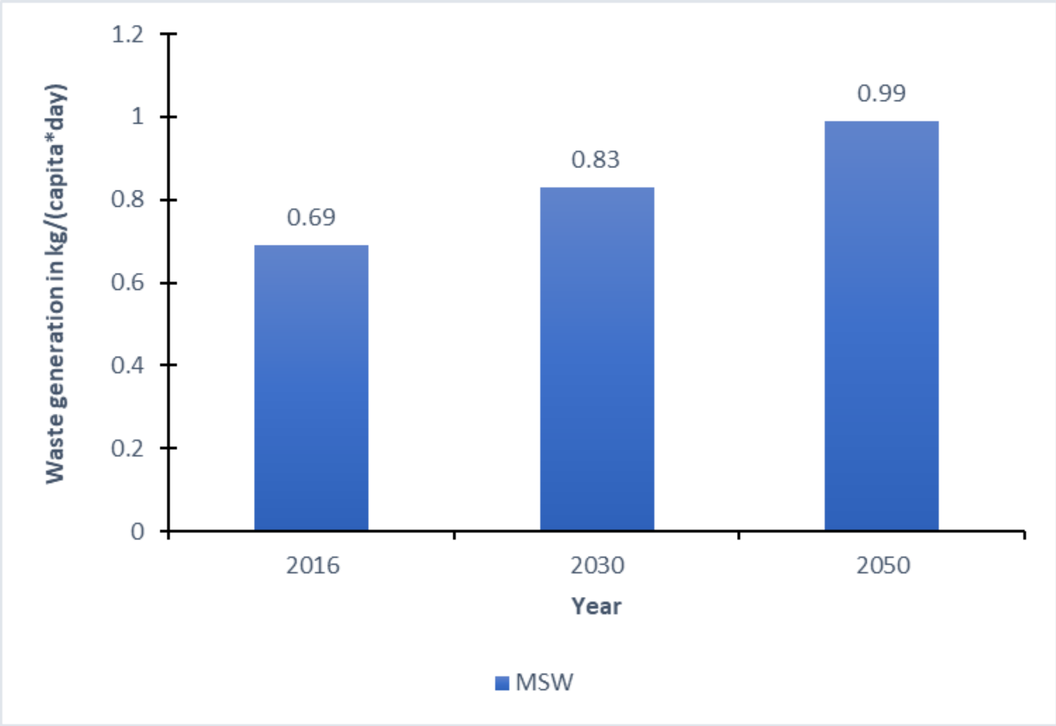

*Figure 17: Waste generation now and projected from 2016 until 2050 in kg/(capita*day)*

(Adapted from Kaza et al. 2018)

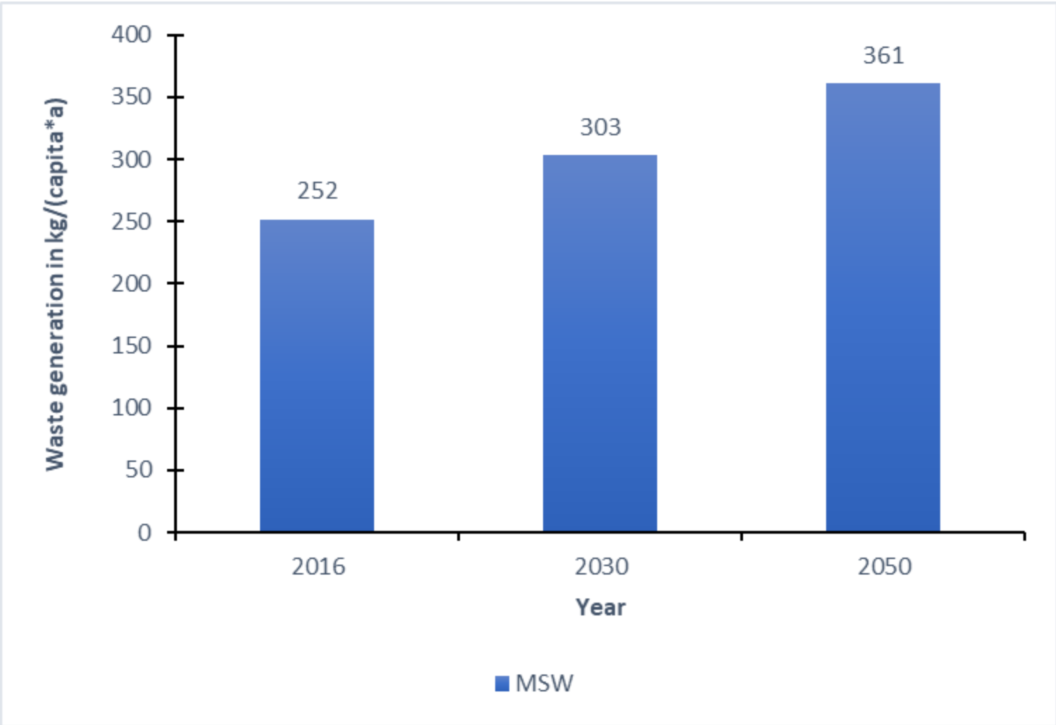

*Figure 18: Waste generation now and projected from 2016 until 2050 in kg/(capita*year)*

(Adapted from Kaza et al. 2018)

From this waste generation rate the authors calculated the following waste generation amount for the year 2017 and the years 2030 and 2050 with an annual growth rate for the urban population of 1.3 % per year. The year 2017 was chosen as a base year because it is nearest to the published waste data from Kaza et al. (2018).

The waste amounts were calculated with a steady waste generation rate (scenario 1) and an increasing waste generation rate (scenario 2) as stated by Kaza et al. (2018) and shown in Figure 17. The results are depicted in Figure 19.

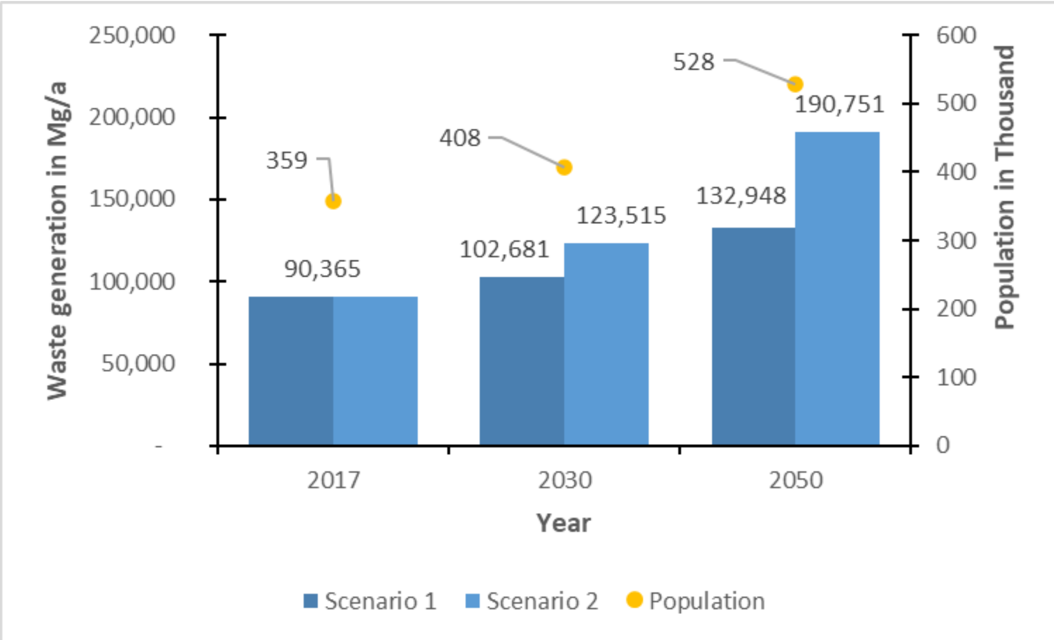

Figure 19: Current and projected waste generation per year. Scenario 1: Steady waste generation rate and growing population; Scenario 2: Increasing waste generation rate and increasing population (Own research)

Scenario one shows an increase of yearly waste generation of roundabout 13.6 % to the base year 2017 until 2030 and a 47.1 % increase until 2050. The increase of waste generation intensifies by 23.1 % to 36.7 % in scenario two until 2030 when additional to the population the waste generation increases. In 2050 Taraz would generate 111.1 % more waste than 2017, an increase by 64.0 % to scenario one in the same year. The individual waste fractions including the recyclables fraction would increase accordingly.

4.2 Biowaste Utilisation

The biowaste potential in Taraz amounted to 48,797 Mg in total relying on the waste data for 2017. To show the benefits of a separate collection of biowaste the authors built two different models. One for Compost production and one model for the production of biogas first and compost afterwards.

4.2.1 Biogas Production Model

In the scenarios used in the model for biogas production a certain percentage of the biowaste from households is collected separately. Depending on the biowaste composition and the plant technology an average biogas output between 80 and 130 Nm^3 per Mg of biowaste could be produced. For the following calculation of the biogas potential the authors estimated the criteria for the biowaste fraction shown in Table 10.

Table 10: Parameters used to calculate the biogas potential of biowaste in Taraz (Own research)

Parameter	Value
Biowaste potential 2017	48,797 Mg
Water Content (WC)	60 %
Dry Matter (DM)	40 %
Organic Dry Matter (oDM)	65 % (DM)
Operating hours	8,300 h/a
Biogas potential min.	80 Nm^3/Mg
Biogas potential max	130 Nm^3/Mg
Average methane content	55 %
Degree of efficiency thermal	43 %
Degree of efficiency electrical	39 %
Electricity ratio	0.907
Energy of Methane	9.97 kWh
Post Rotting Duration	21 d
achievable oDM reduction	0.9 % per d

A gernealized process scheme for a biogas production process can be seen in figure xyz.

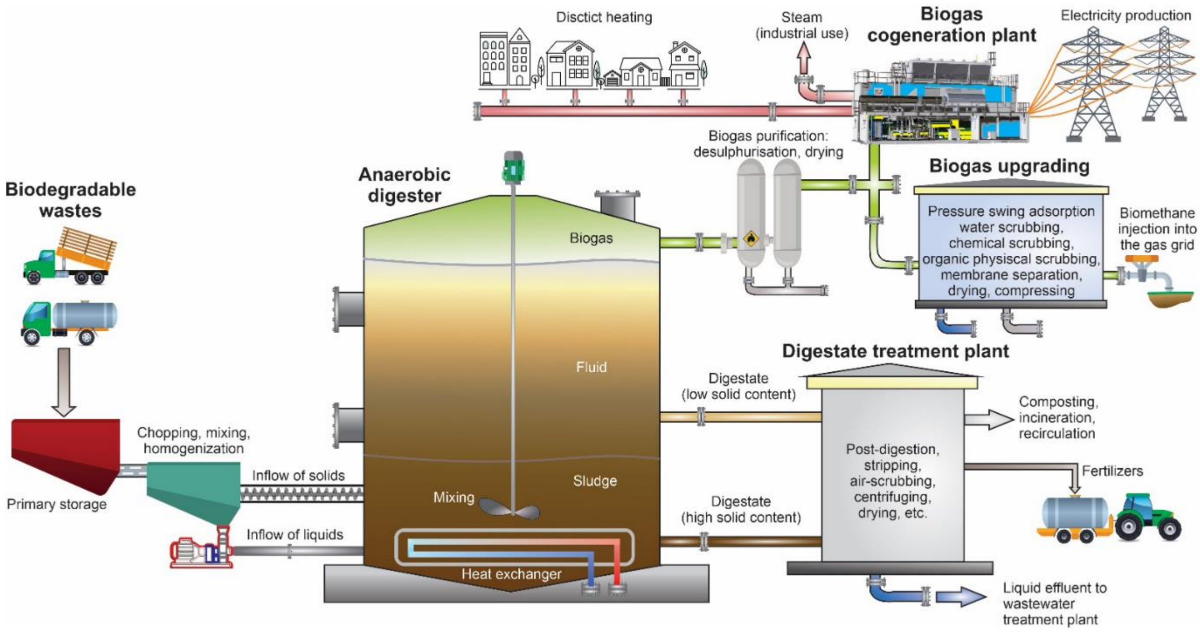

Figure 20: Generalized Biogas production process and utilisation. (Zupancic et al. 2022)

The authors built three scenarios with three different collection rates, as follows:

- Scenario 1: 30 % collection rate
- Scenario 2: 50 % collection rate
- Scenario 3: 70 % collection rate

The authors did not calculate the potential for a 100 % collection rate as it is not achievable due to diverse reasons. In Germany, for example, the separate collection of the biowaste fraction of waste has been mandatory since 2015, as far as this is technically and economically feasible for municipalities. It is done via a separate biowaste bin or direct delivery to the treatment plant, however the average content of biowaste in the mixed MSW bin is still 39.3 % according to UBA (2020). If you consider the reported waste amounts for 2019 published by UBA, an estimated 50–67 % of the biowaste potential from households in Germany actually gets collected separately. The numbers vary due to the fact that municipal green waste from parks gets collected with green waste from households in biowaste treatment plants and the actual statistics cannot be distinguished afterwards. So, the estimation of the biowaste potential in Taraz is also a defensive estimation, that could actually be higher depending on the amount of green waste the municipality collects during the seasons.

Figure 19 shows the results of a modelling process to show the potential gains of biowaste utilisation. Depending on the used anaerobic digestion method and the collection rate of the biowaste, the available energy in the form of electricity lies between 2,505 MWh and 4,070 MWh per year in Scenario 1, 4,174 MWh and 6,783 MWh per year in Scenario 2 and 5,844 MWh and 9,496 MWh per year in Scenario 3.

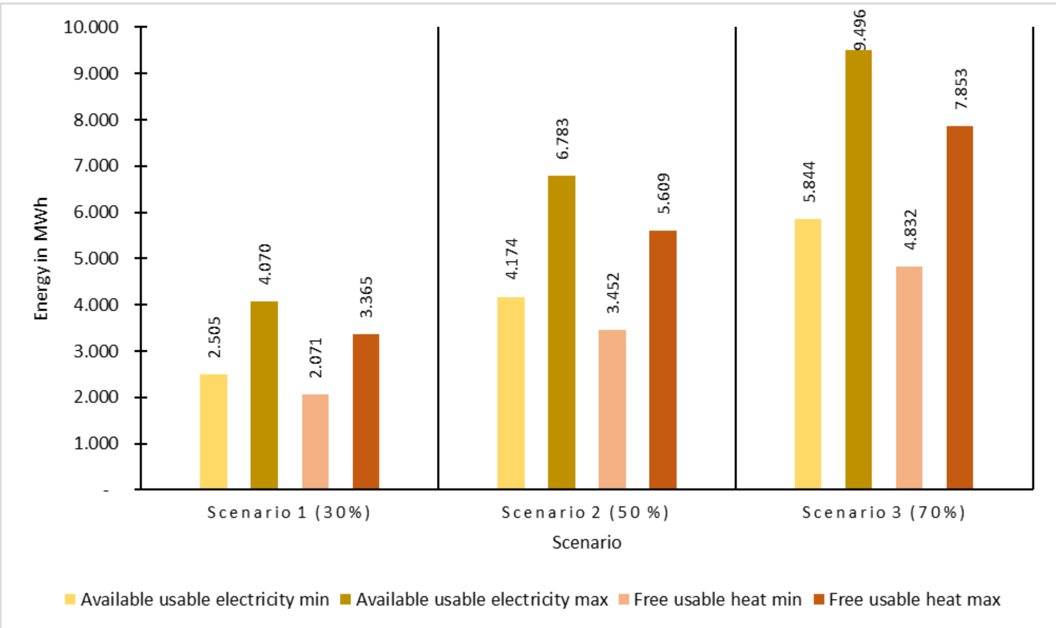

Figure 21: Results for biowaste usage in anaerobic digestion and production of electricity and heat (Own research)

The maximum available electricity lies 63 % over the calculated minimum. A survey done in 2018 among households in Kazakhstan came to the result, that the total electricity usage in the Jambyl region among 1025 households (536 rural and 489 urban) was in total 1,471,691 kWh of electricity (International Energy Agency 2022). The average household in the region thus consumed 1,436 kWh per year.

Table 11 shows the number of supplied households with electricity according to each specific scenario and the percentage of households in Taraz. The calculation is based on a given average household size of 3.5 Person per household and 358,806 inhabitants in 2017 that leads to 102,516 households in the city.

Table 11: Households supplied with electricity produced from biogas in Taraz (Own research)

Value	Households min	Households max
Scenario 1	1,744	2,835
Households in Taraz in %	1.7 %	2.8 %
Scenario 2	2,907	4,724
Households in Taraz in %	2.8 %	4.6 %
Scenario 3	4,070	6,614
Households in Taraz in %	4.0 %	6.5 %

So, the supplied households in Taraz with electricity from the anaerobic digestion plant could range between 1.7 % and 6.5 % depending on the chosen technical version and the reached collection rate in the municipality.

Table 6 shows the amount of compost produced from the collected biowaste that ranges between 5,717 Mg in scenario one and 13,340 Mg of scenario three.

Table 12: Compost masses produced in selected Scenarios (Own research)

Parameter	Scenario 1 (30 %)	Scenario 2 (50 %)	Scenario 3 (70 %)
Dry matter (60 %) in Mg	3,430	5,717	8,004
Water (40 %) in Mg	2,287	3,811	5,336
Compost mass in Mg	**5,717**	**9,529**	**13,340**

The value of the compost depends on its nutrients content that must be analysed regularly. The relevant nutrients in the compost are Nitrogen (N), Phosphate (P2O5) and Potash (K2O). Depending on the current market prices and the availability of the nutrients in the compost the compost producing company could set a price in case they want to sell it to farmers or their citizens. This also depends on the fee structure the municipality wants to implement in the waste management system.

Another option besides generating electricity directly at the biogas plant would be to further process the biogas to biomethane, which has similar qualities as natural gas and could be used for heating and transported through already existing gas pipelines. Through this method the authors estimate that between 644,124 Nm^3 and 2,442,303 Nm^3 per year could be produced. All results can be seen in Table 13. The detailed Calculation can be found in the appendix.

Table 13: Possible absolute biomethane production in Taraz in m^3 per year (Own research)

Value	Scenario 1	Scenario 2	Scenario 3
Abs. biomethane min in Nm^3/a	644,124	1,073,540	1,502,956
Revenue per year min in ₸	20,611,961	34,353,269	48,094,577
Abs. biomethane max in Nm^3/a	1,046,701	1,744,502	2,442,303
Revenue per year max in ₸	33,494,437	55,824,062	78,153,687

Considering a sales price of 32 ₸ the revenues in biomethane production could range between 20,611,961 ₸ and 78,153,687 ₸ per year.

4.2.2 Compost Production Model

In the following model the authors calculated the amount of compost production to show the benefits of composting and separate collection of the biowaste fraction. The composting plant would be divided into two Phases with a 10 day intensive composting process (Phase 1) and a 12 week maturing process (Phase2).

A scheme of a genrelaized composting process can be seen in Figure 22.

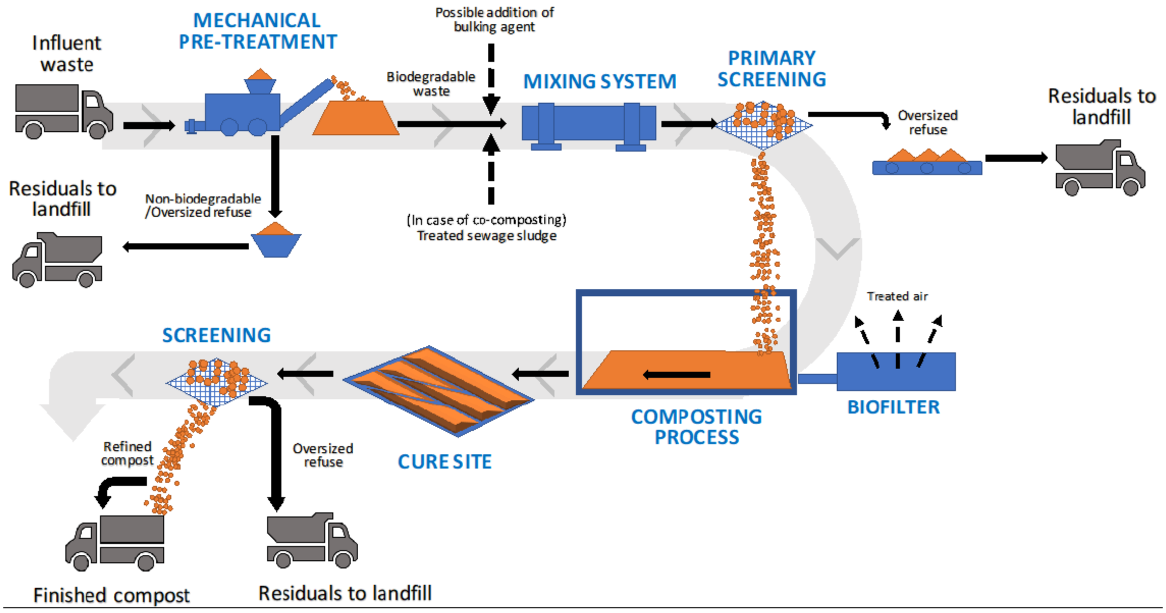

Figure 22: General flow scheme of organic waste management via composting (Bruni et al. 2020)

The chosen parameters for this model are shown in Table 14.

Table 14: Parameters used to calculate the biogas potential of biowaste in Taraz (Own research)

Parameter	Value
Biowaste potential 2017	48,797 Mg
Water Content (WC)	60 %
Dry Matter (DM)	40 %
Organic Dry Matter (oDM)	65 % (DM)
Availability of oDM for digestion	75 % (oDM)
Intensive Composting	10 days
Maturing of Compost	12 weeks
Substance turnover (Phase 1 and 2)	70 %
Compost density	0.6 Mg/m^3

Similar to the biogas production model in the previous chapter three scenarios for collection were used. To simplify the calculation and missing data, it was estimated that every month the same amount of biowaste is produced, which is not true in reality, as different seasons create different amounts of garden wastes in the region. The results of the calculation are shown in the following Figure 23: Results for biowaste usage in compost production plant (Own research) and the detailed calculation can be found in the appendix

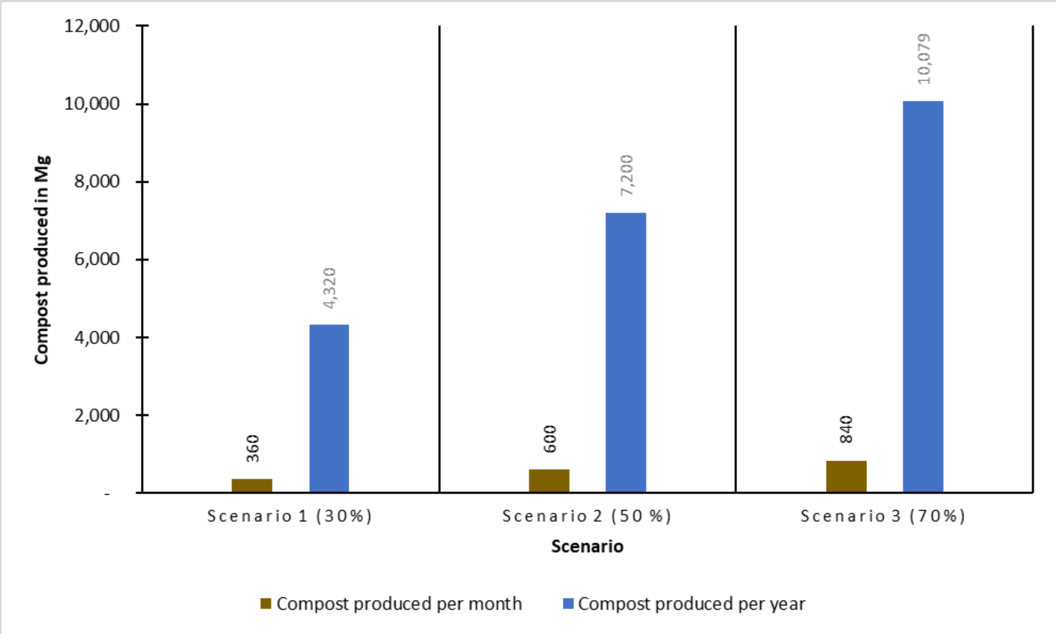

Figure 23: Results for biowaste usage in compost production plant (Own research)

The biowaste fraction of the citizens of Taraz could produce between 4,320 Mg and 10,079 Mg of high-quality compost per year depending on the collection rate and the willingness of the citizens to separate their waste at source.

4.3 Recyclables (Plastics, Paper and Cardboard, Glass, Metals, WEEE)

To show the value of the recyclable materials the authors calculated the estimated value of the waste fractions with prices provided by www.letsrecycle.com for June 2022 (see Table 12). For each waste fraction a reference material wase chosen.

Table 15: Waste fractions and price ranges according to letsrecycle.com (retrieved: June 2022)

Waste fraction	Price range
Paper and Cardboard (mixed paper)	20,206 ₸–28,865 ₸
Plastic (mixed bottles)	202,055 ₸–248,239 ₸
Glass (mixed)	8,660 ₸–12,123 ₸
WEEE (Batteries as Reference)	259,785 ₸–259,785 ₸
Metal (50 % Aluminium cans, 50 % Steel cans)	389,678 ₸–427,202 ₸

Figure 24 shows the estimated value of the recyclable materials with plastics being the highest estimated value ranging between 2,008 and 2,468 Mio ₸.

Through not separating the recyclable fraction at source the municipality is missing a possible yearly revenue between 3.6 and 4.2 billion ₸ considering a 100 % collection rate.

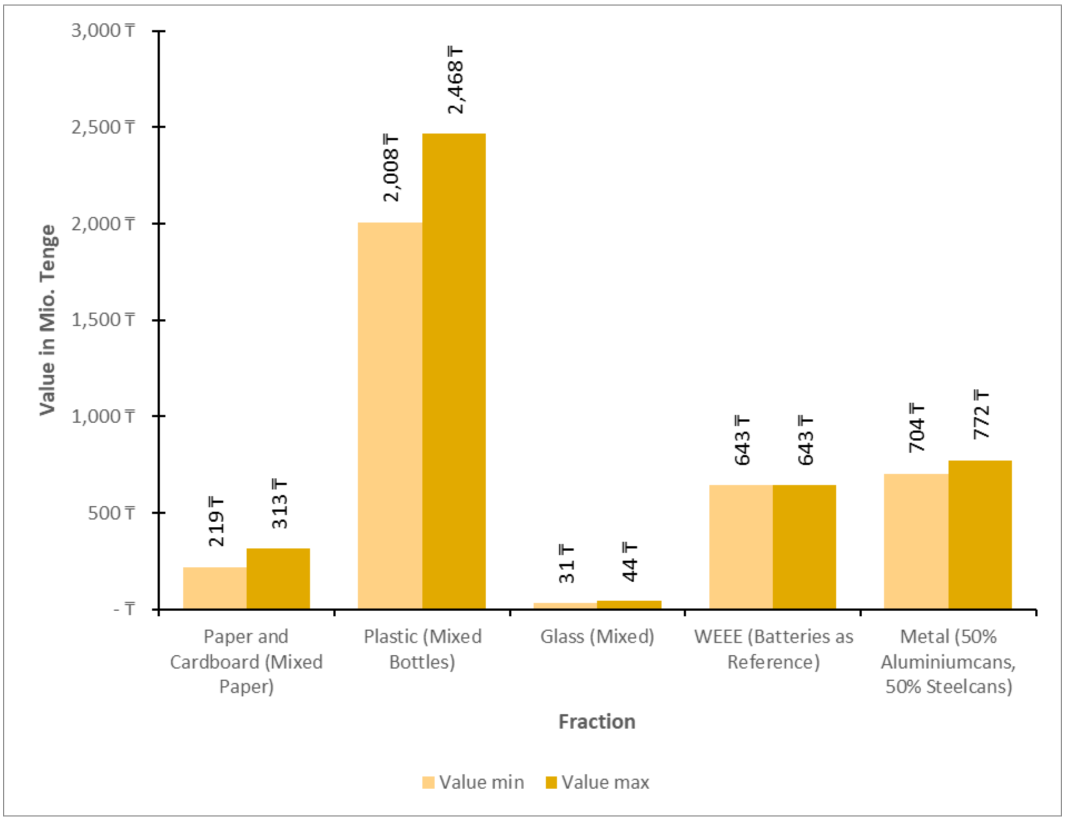

Figure 24: Estimated value of recyclable fractions according to current market prices (Own research)

5 Strength and Weakness Evaluation

5.1 Strength Evaluation

Legal Framework

The Environmental Code of Kazakhstan being the fundamental law for waste management practices has a high quality and is comparable with waste management laws of high-income countries. The waste treatment hierarchy mentioned in Article 329 leans on the foundation of waste minimisation and the least preferred option being disposal of waste or landfilling.

The rules for extended producer responsibility are in place to further improve re-use and recycling of certain valuable materials on one side and improve collection of hazardous substances containing products in Kazakhstan on the other side.

Consulting in Waste Management

The environmental courses in schools are a useful means to educate children in waste management rules and separation at source. Furthermore, it is a well-established method to show children the value of materials and natural resources. Children might also function as multipliers in societies and educate their parents about waste management rules, what might lead to better separation at source in the households.

Waste Collection and Transportation

Taraz has a collection coverage of 100 % what puts Taraz above average collection range of upper-middle income countries that lies between 45 % for rural areas and 85 % for urban areas (Kaza et al. (2018)). Furthermore, Taraz has several stakeholders in the waste collection system that already collect and sell waste as secondary resource in an economically viable way. So, the municipality has an existing infrastructure and potential partners to build on.

In the end several households already have an established collection system in which the waste gets picked up directly at their house without the necessity to bring it somewhere. For all other households, collection points are established to which the citizens can bring their MSW.

Waste Treatment

Through an increase of recycling in the greater Jambyl region, which is shown through an increasing sorting rate, the amount of waste that has to be landfilled can be reduced.

Costs and Fees

The city of Taraz has an established collection system to collect the fees from the households and legal entities concerning waste management services.

5.2 Weakness Evaluation

Legal Framework

As mentioned before Kazakhstan has a solid and well thought through environmental law that fulfils the standards of environmental laws of high-income countries. But it lacks enforcement in the Akimat of Taraz. Separation at source into wet and dry fraction is not performed and separate collection systems for hazardous wastes are missing.

A major leak in the environmental law is that it does not force municipalities to treat domestic MSW in a way it fulfils certain environmentally friendly criteria like low organic carbon content or a certain maximum heating value before landfilling it. With this rule a high impact on climate through the release of landfill gas could be reduced and the fire risk on the landfills could be reduced.

The implementation of a biological rotting process before the domestic waste is landfilled could full fill this criterion. Germany for example implemented such a law in 2005 what led to an increase in treatment facilities for mixed MSW and a decrease in environmental pollution.

The missing enforcement of the EPR causes loss of recyclables, mismanagement of waste and underfinancing of the waste management sector.

Consulting in Waste Management

Taraz has some environmental courses for schools but lacks information material for its grown-up inhabitants. Only intensive education campaigns on the risks of wrong waste management can improve the situation.

Furthermore, the municipality could improve the information for legal entities in the city to improve their waste management capacities.

Waste Collection and Transportation

Taraz has a well-established collection system but the street to the landfill is in a bad condition what causes problems for waste collection trucks and increases the possibility of damages to the trucks what causes higher costs in repair and maintenance. Overall, a well-built street could make the transportation of the mixed MSW more secure for collection vehicles and their drivers and minimize the possibility of accidents.

A separation at source is not done according to the environmental code, what causes several problems after the waste is disposed of in the waste bins:

- mixing of recyclables and hazardous wastes causes a contamination of the recyclables that decrease in value or become unrecyclable even;
- missing separation at source of biowaste causes higher amounts of leachate on the landfill that slowly seeps into the soil until it might reach ground water;
- hazardous wastes that are disposed of on the landfill increase the toxicity of the leachate and fumes;
- hazardous wastes increase the danger of fires through spontaneous combustion.

All together these points also increase the danger to health of people working in the waste management sector being it collectors, drivers, landfill workers or the local manager on the landfill.

Another negative aspect of a missing collection of biowaste at its source is that Taraz has a high population of street dogs that get attracted by the biowaste in the waste bins when they get hungry. This poses a great danger to inhabitants discarding their waste at the collection points who could get attacked by street dogs and for waste workers who try to collect the waste.

Waste Treatment

The landfill of Taraz is - besides the landfill of the greater Jambyl region - the only possible treatment option for waste. In a precise definition landfilling without pre-treatment cannot be considered as treatment in a traditional point of view. So, it could be stated that Taraz has no treatment facility for mixed MSW.

But there are other issues causing flaws in the waste management system in Taras and that is the condition of the landfill. A landfill should contain the disposed waste in a way that there is no harm for protected goods after the waste enters the landfill. But the landfilled waste causes more troubles than goods:

- missing nets on the landfill border cause waste particles to fly over the wall of the landfill and into fields and canals;
- burning waste causes toxic fumes that go into the air and could reach settlements if the wind is strong;
- burning waste causes bad smells that could cause nausea and other health issues;
- landfill gas, formed by biological activity, causes a high impact on climate change;
- landfill gas increases the danger of fires;
- missing barriers in the soil cause increased seeping of leachate into the deepest soil layers and eventually cause the formation of a contaminated site that has a high impact onto the environment for several decades.

Costs and Fees

The costs for waste management in the city of Taraz are not planned properly which is why the waste management system has a deficit of 292 Mio ₸ per year. Due to the rule that only one household member must be registered, single person households must pay the same amount of fees as families with several children and/or other family members living with them. On one side families have no incentive to reduce their generated waste as they will not pay less if they generate less waste and on the other side no one will be incentivised to produce less waste as there are no consequences for higher waste generation for the households.

Industry wastes

Taraz has several heavy industries in close proximity that produce toxic and hazardous wastes, but it seems like there is no adequate waste treatment system in place to deal with the produced wastes. So, it remains unclear if the wastes from industry are discarded properly without negative impacts on the protected goods.

Other

Since Taraz will grow as a city in the coming years, the amount of waste that is generated yearly will increase, which causes a higher pressure on waste treatment facilities and all stakeholders involved in the waste management system.

6 Goals and Tasks for the Future of Waste Management until 2027

After showing the current status of the waste management system in Taraz and analysing its strengths and weaknesses, the authors want to set up specific goals for the different topics in the waste management system of Taraz, that could be achieved in a five years time range until the year 2027.

6.1 General Management

In general, the authors recommend setting up a taskforce or working group in the Akimat that deals with waste management and cleanliness in the city and has a close connection with the municipal company ZhT LLP and other stakeholders involved.

The main task of this group would be to review the current waste management system of the city and implement improvements that lead to a sustainable waste management plan for the city, building on the results and concept provided by the authors.

Further down the road a waste management round table could be set up on which the different stakeholders can talk about needs and current problems involving the waste management of the city in a constructive environment.

The authors recommend reviewing the set goals and the waste management concept after a certain period, like every four to five years, and adapt the current waste management plan according to the PDCA-cycle used in process management and environmental management systems shown in Figure 25.

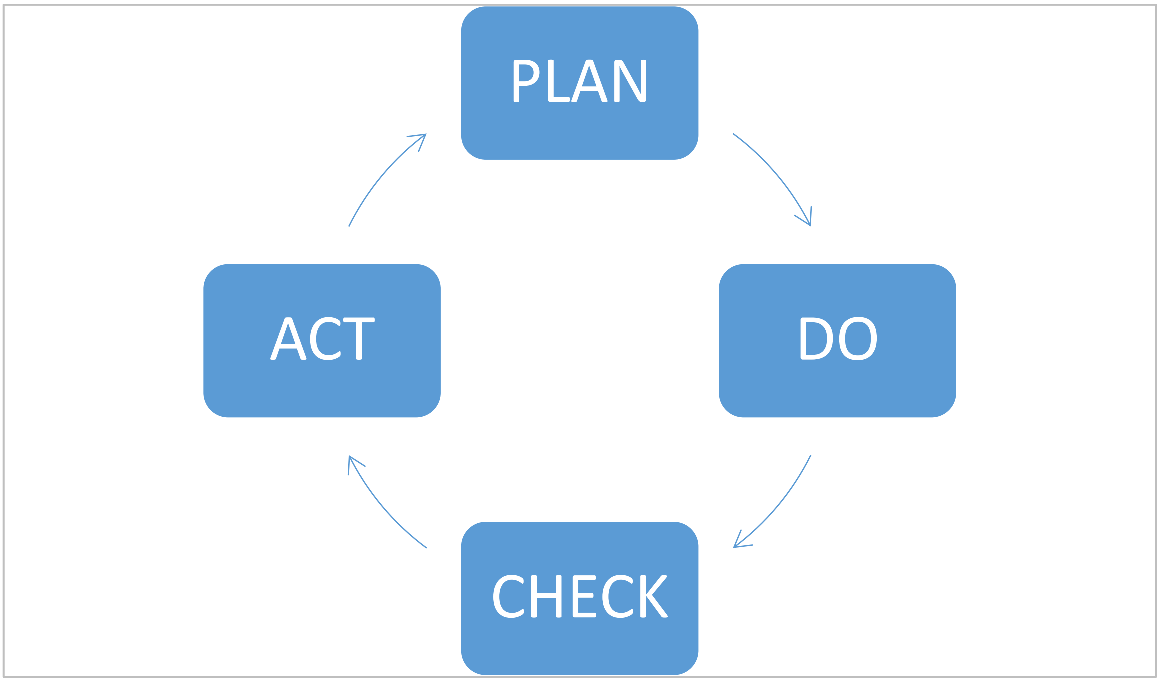

Figure 25: PDCA-cycle for waste management (Own research)

“The PDCA cycle is an iterative process for continually improving products, people, and services. It became an integral part of what is known today as Lean management. The Plan-Do-Check-Act model includes solutions testing, analysing results, and improving the process“ (Kanbanize 2022).

The United Nations Environment Programme (2015) concludes the following “Action Imperatives” for different participants in the waste management sector, that could be used as a checklist by the person in charge of waste management in Taraz:

- (Government, municipalities, stakeholders) Ensure that all sections of society have affordable access to waste management services;
- (Government, municipalities, stakeholders) Work together to establish clear strategic goals and guiding principles for waste management;

- (Government, municipalities, stakeholders) Work together to secure political commitment to those goals and their implementation, and to ensure continuity beyond political terms of office;
- (All stakeholders) Ensure public participation in decision making so that stakeholders can express their concerns, provide ideas and knowledge, and get involved and develop a sense of ‘ownership’;
- (All stakeholders) Once a new system has been agreed, ensure that waste generators know what is required of them for its implementation, and are facilitated to change their behaviour in a sustainable way;
- (Government, municipalities, other stakeholders) Establish mutually beneficial partnerships to deliver effective and sustainable waste management services. The type of partnership should be selected and tailor-made to suit local conditions;
- (Government, municipalities, other stakeholders) Ensure the inclusion of the community and informal sectors within an integrated waste and resource management system in the city.

6.2 General Concept

In Chapter 3.5.1 the authors described the status quo of the waste collection system of Taraz with all involved stakeholders shown in Figure 6. The following Figure 26 shows a new waste collection system for the city of Taraz that has the focus on separate collection at source of all recyclable fractions and hazardous wastes.

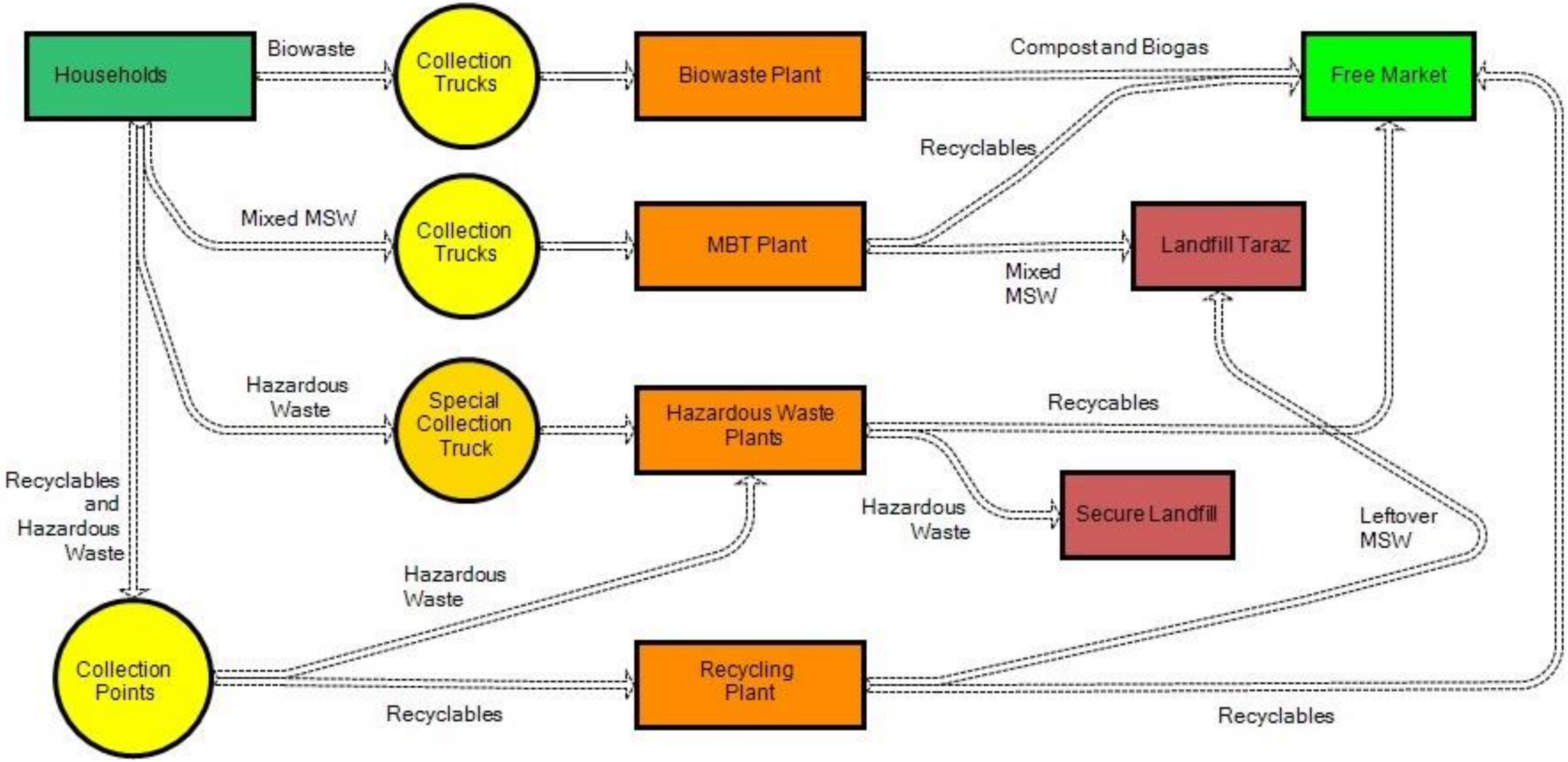

Figure 26: Future waste management system in Taraz (Own research)

The households of Taraz each get their separate waste bins for biowaste and mixed MSW. Furthermore, decentral collection points in the city should make it possible for citizens to get rid of their hazardous wastes like batteries, paints, pesticides and their recyclables like plastics, glass and paper. Alternatively, the municipality could set up a third waste bin for recyclables at the households in case the number of recyclables in the city rises in the future. legal entities should get a wastebin according to their needs and pay according to the size of the wastebin.

Besides classic waste collection trucks that collect the biowaste bin and the mixed MSW, a third truck should drive through the city on certain days in certain location in which inhabitants can get rid of their hazardous wastes for free at the truck stop.

The biowaste should go into a biowaste treatment plant that could be an anaerobic digestion plant or a compost plant. The products would be high quality biogas or compost, that could be sold on the free market.

The mixed MSW should go through a treatment process to reduce organic matter and water content before being landfilled. The system could be an MBT – Mechanical Biological Treatment plant sorting out recyclables first and reducing biological activity afterwards.

The hazardous waste should be collected as described and treated in special treatment plants designed for the hazardous waste. Of course, hazardous wastes that could be turned into secondary materials should be treated accordingly to be sold on the free market afterwards.

The recyclable fractions should be treated in a recycling plant after collection to produce high quality secondary materials that can be sold on the free market afterwards. A low amount of leftover MSW can go onto the landfill.

According to information of the local experts the city has 268 collection points for separate waste collection. Additionally, the authors recommend setting up a certain number of manned collection points on which the inhabitants of Taraz can bring their wastes. The workers at the collection points can separate the wastes into different fractions and educate the people of Taraz about the correct waste separation. This is especially necessary for bulky wastes and hazardous wastes that should not get mixed up with recyclables and wastes for the mixed MSW bin.

6.3 Waste Collection and Transportation

Concerning the door to door collection in the city, the Akimat and responsible persons should audit the collection infrastructure and identify districts in the city in which collection of waste does not work properly and set up a strategy to improve the collection of waste.

To improve the transportation situation the authors, recommend investing into the infrastructure connecting the city with the landfill of Taraz. Through an improvement of the road leading to the landfill it could be made certain that all stakeholders who want to discard waste, can reach the landfill without any troubles. The illegal dumping of waste outside of the perimeters of the landfill could be reduced significantly.

To improve separation at source the authors recommend doing a survey among the households to find out about the waste management knowledge of the citizens and set up specific information campaigns according to the outcome of this survey. Especially reasons for not separating waste (see chapter 3.5.1) should be analysed.

As Taraz already has ISPs and IE in the city that deal with waste collection and transportation it is incremental to inculde these stakeholders into the waste management system because otherwise the new waste management system would pose a danger for the livelihood of these stakeholders what might produce conflicts in the waste management system. The formation of a cooperation/association through the IE or ISPs can give the stakeholders better security in the planning of the waste management system. It would also be possible to employ all ISPs and/or IEs in the newly formed municipal company or bind them through contracts.

6.4 Mixed Municipal Solid Waste

The reduction of the biowaste fraction through separate collection and the other mentioned fractions reduces the amount of waste that goes into mechanical biological treatment and onto the landfill afterwards. This leads to less harmful emissions through waste on the landfill and a longer timeframe in which the landfill can be filled up.

6.5 Biowaste

As already mentioned, a separate collection system for biowaste for the city should be implemented. The authors recommend doing a pilot project in one district of the city and test the results and the quality of compost substrate they can generate and step by step roll out the separate collection system on the whole city. Through this step-by-step rollout, the strategy of communication of the need for separate collection can be adapted along the ways. Errors could be corrected and flaws in the system be fixed.

The fee structure for the separate collection of waste should be adapted this way that there is a financial incentive for the inhabitants to separate their waste. The easiest way would be to measure the amounts of emptying of the wastebins at the households and weigh the wastebins. The bill for the waste collection and treatment should be accordingly to the measured values. A household which produced more waste and needs a bigger waste bin or more emptying should pay more. Through the introduction of a cost free biowaste bin the weight of the residual waste bin goes down and the households save money through separate collection. Furthermore, single family homes with gardens could find an incentive in separating their biowaste thoroughly if they can get the compost after composting cheaper or even for free.

Criteria that can have an impact on the quality and quantity of biowaste collection are, according to the findings of the LfULG Saxony (2012), for example:

- Fee: Here it is shown that with a significantly lower bio-waste fee compared to the residual waste fee, the separate collection of bio-waste is encouraged. Likewise, municipalities could also introduce a free bio-waste bin or surcharges on the basic fee if there is no bio-waste bin on the property.
- Convenience: A short emptying cycle for biowaste bins leads to increased collection of biowaste.
- Level of service: A dense network of recycling centres leads to increased collection of green waste from gardens.
- Container size: Large containers lead to increased collection quantities of green waste and kitchen waste.
- Public relations work: Intensive public relations work can encourage citizens to separate better.
- Degree of connection: A regionally valid obligation to connect and use organic bins.

6.6 Recyclables (Plastics, Paper and Cardboard, Glass, Metals, WEEE)

The municipality or the company hired for treating the recyclable fractions should improve separation at source through information campaigns about waste recycling and its benefits, but also the dangers of wrong waste management. In case the responsible party builds a recycling plant in the city it could give tours through the plant for interested citizens, school classes and environmental associations.

The main reasons for missing seperation at source in households worldwide can be generalised into the following points:

- Convenience,
- Prejudices about the waste management system,
- Misinformation about the waste management system,
- Ignorance about proper separation,
- Linguistic, cultural and religious barriers,
- Savings on disposal costs,
- Belief in improved mechanical separation,
- Lack of storage facilities in the household for waste to be separated.

Use revenue of sales of recyclables to finance the waste management measures, form Public Private Partnerships or set up municipal companies to sort and sell waste. History in Germany has shown that outsourcing certain services is only beneficial until a free market exists. When single companies dominate the market, it gets more and more beneficial for municipalities to “remunicipalise” waste management services.

6.7 Hazardous Waste

As mentioned in Chapter 6.2 the municipality should establish a decentralized collection systems with easy access in the different districts of Taraz and establish a special collection truck that collects hazardous wastes in the city free of charge.

Due to Kazakh law the extended producer responsibility should be used to finance the hazardous waste collection and treatment and enforce the EPR.

6.8 Waste from Legal Entities

Legal entities are contracted with ZhT LLP at the moment, but due to missing scales and measuring equipment the fees of the legal entities seem not accordingly to the produced waste amount. In the future the legal entities should pay a fee according to the size of the container they get from the municipal company and the collection rhythm.

6.9 Waste from Industry

The authors recommend implementing an education system for responsible persons in companies to improve waste management practices and enhanced environmental protection practices during and after production. Furthermore, the municipality should audit the collection system for MSW like industrial waste and calculate the fee for these enterprises similar to the fee for the legal entities.

6.10Waste from Public Places

The information given to the collection of waste in public places was scarce, which is why the only recommendation the authors can give, is to make sure that enough public waste bins are available for the citizens, so they can discard their wastes on the go.

6.11Waste Treatment Facilities

Up to now the only known waste treatment facility is the landfill Taraz outside of the city. It is unclear for the authors for how much waste the landfill was initially designed so its not clear how long it will last. With rising waste amounts the timeframe will dwindle in the future.

In its current state the landfill is not fulfilling the task it was initially designed for – holding waste without negative impact on the protected goods. In a multibarrier concept six barriers are in place to make sure no negative effects to protected goods happen during the landfilling process. These are:

1. geological barrier
2. landfill base sealing system
3. waste pretreatment
4. landfill operation and management
5. landfill surface sealing system
6. landfill aftercare.

To the knowledge of the authors none of the known barriers is intact. The management of the landfill is doing the best they can accordingly to their possibilities, but missing information about the landfilled waste and unavailable equipment like a sealing material or a leachate drainage and treatment system makes it impossible for them to fulfil their tasks appropriately.

The authors recommend the following improvements in the next five years:

- improve the infrastructure so that waste collection vehicles can transport the waste safely,
- build a net around the landfill so the waste is not blown away by strong winds,

- improve registration for waste and adapt the fees for landfilling of waste accordingly,
- improve coverage of landfilled waste to minimize biological activity and fire risk.

In general, establishing a MBT plant for mixed MSW would also improve the multi barrier principle of the landfill and reduce methane emissions.

6.12 Fees for Waste Management

Adapt fee system to the Pay as you throw principle for companies and slight increase of fees to cover costs for waste management for households.

The optimal fee of 174 ₸ per citizens per month was calculated for the current situation with a collection coverage of 70 %. With an improved system of waste management, the fees to cover the costs will increase even more than shown in this study.

The United Nations Environmental Program (2015) proposed the following “Action Imperatives” for waste management participants concerning finances:

- (Municipalities and all waste generators) Know your costs: understand the costs that need to be paid and the revenues available;
- (Governments, municipalities, citizens) Someone has to pay for municipal solid waste management. Find the appropriate financing model;
- (Governments, municipalities and larger waste generators) Larger waste generators should assume financial responsibility for their own waste and pay the economic cost of environmentally sound management;
- (Government, municipalities and the waste industry) Ensure disposal is priced, to provide an incentive to the waste generator to reduce waste quantities;
- (Municipalities) There is no ‘right’ or ‘wrong’ financing model – each local situation requires a tailor-made solution. Select a model that is transparent and fits with the local custom and tradition and select a service that fits customer needs;
- (Municipalities) Aim to increase cost recovery gradually. Begin by making a direct charge where there is a clear demand for the service and a tangible

benefit to the service user (e.g. primary waste collection). Ensure support is available to those who cannot afford to pay;

- (Governments, municipalities and producers) Consider extended producer responsibility (EPR) as a means to transfer the costs of managing end-of-life products in municipal solid waste from the municipality to the producer and other appropriate stakeholders along the supply chain;
- (Governments, international financial institutions, commercial banks) Create financial instruments to provide access to capital for cities for investment in municipal solid waste management and infrastructure;
- (Governments, international community) Increase the flow of Official Development Finance (ODF) to help improve solid waste management in the lowest-income countries. Increase substantially the share of funding spent on improving solid waste management from the current meagre level of 0.32% of total funding.

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Appendix 1 Expenditure and Cost Overview

Expenditures	Cost category	2017	2018	2019	2020	2021
Equipment rental, transport services	Collection and Transportation	16,149,485 ₸	26,509,293 ₸	47,561,047 ₸	41,526,827 ₸	76,228,610 ₸
Completed works/services	External Services & Raw Material	15,838,678 ₸	14,937,680 ₸	25,124,075 ₸	7,732,952 ₸	49,383,856 ₸
Information Services	External Services & Raw Material	2,337,024 ₸	2,562,443 ₸	4,944,214 ₸	5,174,509 ₸	12,666,893 ₸
Maintenance and current repair of fixed assets	Maintenance and Repair	430,500 ₸	91,700 ₸	2,652,020 ₸	2,579,571 ₸	3,619,500 ₸
Expenses for a medical examination	Personnel Costs	159,500 ₸	276,500 ₸	- ₸	305,200 ₸	- ₸
Worker's salary payments	Personnel Costs	66,972,750 ₸	76,938,401 ₸	92,780,303 ₸	96,768,678 ₸	127,898,911 ₸
Payment for emissions into the environment	Taxes, Duties, Insurance, Licence Fees, other Fees	6,836,044 ₸	6,688,055 ₸	11,482,232 ₸	16,688,111 ₸	19,261,568 ₸
Payment for the use of a land plot (landfil)	Waste Treatment Costs	6,080 ₸	6,080 ₸	6,080 ₸	6,080 ₸	6,080 ₸
The costs of civil liability insurance for vehicle owners	Taxes, Duties, Insurance, Licence Fees, other Fees	213,515 ₸	543,355 ₸	83,418 ₸	635,088 ₸	- ₸
Social benefits provided to employees (milk on coupons)	Personnel Costs	1,011,710 ₸	- ₸	821,712 ₸	1,454,393 ₸	2,217,600 ₸
Social tax	Personnel Costs	6,362,411 ₸	7,309,148 ₸	8,814,130 ₸	9,193,124 ₸	12,150,397 ₸
Social Security contributions	Personnel Costs	2,344,046 ₸	2,692,844 ₸	3,247,311 ₸	3,386,904 ₸	4,476,462 ₸
CSMI deductions	Personnel Costs	378,837 ₸	1,087,346 ₸	1,388,098 ₸	1,759,860 ₸	2,361,764 ₸
Raw materials	External Services & Raw Material	51,840,364 ₸	2,125,933 ₸	5,578,345 ₸	2,844,333 ₸	6,605,854 ₸
Environmental insurance	Taxes, Duties, Insurance, Licence Fees, other Fees	811,000 ₸	1,569,163 ₸	2,951,982 ₸	1,998,854 ₸	513,553 ₸
Car tires	Collection and Transportation	- ₸	7,131,597 ₸	1,890,709 ₸	9,415,886 ₸	2,733,434 ₸
Car Batteries	Collection and Transportation	- ₸	385,616 ₸	234,472 ₸	2,671,402 ₸	1,847,545 ₸
Fuel and lubricants	Collection and Transportation	81,799,395 ₸	85,134,475 ₸	91,305,146 ₸	95,883,260 ₸	133,126,015 ₸
Spare parts	Collection and Transportation	64,657,332 ₸	36,135,530 ₸	28,905,050 ₸	59,757,222 ₸	48,724,343 ₸
Administrative expenses	Administrative Costs	11,647,813 ₸	18,906,855 ₸	20,201,294 ₸	22,034,639 ₸	26,710,835 ₸
TOTAL		**329,796,484 ₸**	**291,032,014 ₸**	**349,971,638 ₸**	**381,816,893 ₸**	**530,533,220 ₸**

Appendix 2 Industry Waste Overview

Industries	Type of waste, total / including	Educated thousand tons	used		Recycled, recycled		Placed on landfills		Transferred to third parties		Limit, thousand tons
...			thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	
Chemical industry	Granular slag	791.97							780.222		1000
	Phosphogypsum	1003.128					1090.648		6.588		1325.32
	ferrophosphorus	11.636							12.45		22
	Water-insoluble complexes of arsenic and lead sulfides	0.003			0.003						0.023
	boiler dust	19.345			9.712						26.52
	Industrial waste	0.083					0.166				1.1
	MSW	0.276									1.044
	construction waste	4.252					3.782				3.3
	tires	0.001							0.038		0.011
	Salt sludge	0.008					0.0138				0.041
	Sludge from domestic wastewater	0.0009					0.0018				0.014
	Unquenched lime grains	0.038					0.076				0.193
	Waste filter cloth	0.0036					0.0072				0.07
	Used batteries	0.002							0.002		0.0005

Industries	Type of waste, total / including	Educated thousand tons	used		Recycled, recycled		Placed on landfills		Transferred to third parties		Limit, thousand tons
...			thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	
Metallurgical industry	Slag from the production of ferrosilicomanganese	53.624					53.624				122
	Dust from electrostatic precipitators and bag filters	4.638					5.414				12.02
	cinder stone				6.965						
	lime mud				0.32						
	Fines and dust of coal	61.214	5.238						0.444		11.136
	Waste tires	0.0003							0.0003		0.002
	Construction garbage	0.02					0.04				0.04
	Nedopal	0.01					0.02				0.051
	MSW and industrial waste	0.027					0.052				0.171

Industries	Type of waste, total / including	Educated thousand tons	used		Recycled, recycled		Placed on landfills		Transferred to third parties		Limit, thousand tons
...			thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	
mining industry	overburden	14746.202	890.598		1207.968		15773.61				26811.391
	Scrap metal	0.04267							0.0652		0.05
	Waste tires	0.0097							0.0091		0.07
	Packaging container cyanite	0.00041			0.00041						0.006
	Sludge (waste)	893.85					893.856				1276.604
	Packing container	0.0113	0.01		0.0013						0.06
	used oils	0.0047							0.0052		0.009
	Used batteries	0.0003							0.0003		0.0012
	MSW	0.066							0.077		0.272
	organic screening	0.019					0.038				0.54
	constructio n waste	0.007					0.014				5
	Oiled rag	0.00022							0.00022		
	Ash and slag	0.08	0.04				0.04				1.44
	Oiled filters	0.0015							0.0015		0.0011

Industries	Type of waste, total / including	Educated thousand tons	used		Recycled, recycled		Placed on landfills		Transferred to third parties		Limit, thousand tons
…			thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	thousand tons	(%)	
others	MSW	0.098							0.098		0.107
	scrap metal	0.329							0.329		
	fell short	0.369	0.361				0.009				1.16
	Filter cake	1.717	1.7				0.022				19.331
	Slaked lime	2.686	2.645				0.051				1.239
	used oils	0.0041	0.0001						0.004		0.002
	Oiled filters	0.0002							0.0002		
	Dirty filter media	0.0015							0.0015		
	Oiled rag	0.0005							0.0005		
	Sludge treatment plant	0.006					0.009				0.011
	Waste tires	0.0003							0.0003		

Appendix 3 Biogas Production Model

	Scenario 1 (30%)	Scenario 2 (50 %)	Scenario 3 (70%)
Available Biowaste per year in Mg	14,639.2	24,398.6	34,158.1
Absolute biogas production min in Nm³	1,171,134.2	1,951,890.3	2,732,646.4
Absolute biogas production max in Nm³	1,903,093.0	3,171,821.7	4,440,550.4
Absolute biomethane production min in Nm³	644,123.8	1,073,539.7	1,502,955.5
Absolute biomethane production max in Nm³	1,046,701.2	1,744,501.9	2,442,302.7
Households supplied min	457.2	762.0	1,066.8
Households supplied max	743.0	1,238.3	1,733.6
Revenue through Biomethane sale min	20,611,961 ₸	34,353,269 ₸	48,094,577 ₸
Revenue through Biomethane sale max	33,494,437 ₸	55,824,062 ₸	78,153,687 ₸
Specific biogas production min. in Nm³/h	141.1	235.2	329.2
Specific biogas production max. in Nm³/h	229.3	382.1	535.0
Available useful electricity in kWh			
Available usable electricity min	**2,504,546.6**	**4,174,244.3**	**5,843,942.0**
Available usable electricity max	**4,069,888.1**	**6,783,146.9**	**9,496,405.7**
	0.6	**0.6**	**0.6**
Households supplied min	1,744.4	2,907.3	4,070.2
Households supplied max	2,834.6	4,724.3	6,614.0
Households supplied min %	0.0	0.0	0.0
Households supplied max %	0.0	0.0	0.1
Available useful heat in kWh			
min	2,761,352.3	4,602,253.9	6,443,155.4
max	4,487,197.5	7,478,662.5	10,470,127.5
Useful heat for fermentation			
min	- 690,338.1	- 1,150,563.5	- 1,610,788.9
max	- 1,121,799.4	- 1,869,665.6	- 2,617,531.9
Free Useful heat in kWh			
Free usable heat min	**2,071,014.2**	**3,451,690.4**	**4,832,366.6**
Free usable heat max	**3,365,398.1**	**5,608,996.9**	**7,852,595.7**
Fermentation Residue	12,882.5	21,470.8	30,059.1
Dry Matter (30 %)	3,864.7	6,441.2	9,017.7
Water (70 %)	9,017.7	15,029.6	21,041.4
Organic Dry Matter (65 %)	2,512.1	4,186.8	5,861.5
Post-Rotting duration	21.0	d	
achievable oDM reduction	0.9	%/d	
organic Dry matter reduction	434.4	724.0	1,013.6
Energy from oDM reduction	5,833.0	kWh/Mg oDM	
Energy Production from oDM reduction	2,533,814.7	4,223,024.6	5,912,234.4
Goal Water content	40.0	%	
Dry matter (60 %)	3,430.3	5,717.2	8,004.1
Water (40 %)	2,286.9	3,811.5	5,336.1
Compost mass	**5,717.2**	**9,528.7**	**13,340.2**
Water to reduce	6,730.8	11,218.1	15,705.3
Evaporation enthalpy	650.0	kWh per Mg water	
Drying efficiency	65.0	%	
required heat energy	1,000.0	kWh per Mg water	
required heat energy	6,730,833.3	11,218,055.5	15,705,277.8
Minus heat energy from oDM reduction	**4,197,018.6**	**6,995,031.0**	**9,793,043.3**

Appendix 4 Compost Production Model

	Scenario 1 (30%) in Mg	Scenario 2 (50 %) in Mg	Scenario 3 (70%) in Mg
Available Biowaste per year	14,639	24,399	34,158
Available Biowaste per month	1,220	2,033	2,847
Water Mass	732	1,220	1,708
Dry Mass	488	813	1139
Organic Drymatter	317	529	740
Organic Drymatter for Digestion	238	396	555
Inorganic Dry Matter	171	285	399
Intensive Composting (Phase 1)			
Loss of Organic Drymatter	167	278	389
Organic Drymatter left	151	251	352
Inorganic Dry Matter	171	285	399
Dry Matter left	321	536	750
Water left (no change in Water Content)	482	804	1125
Water loss	250	416	583
Compost Maturation (Phase 2)			
Loss of Organic Drymatter	105	176	246
Organic Drymatter left	45	75	105
Inorganic Dry Matter	171	285	399
Dry Matter left	216	360	504
Water loss (Goal Water Content 40%)	338	564	789
Water left	144	240	336
Compost produced per month	**360**	**600**	**840**
Compost produced per month in Nm^3	599.97	999.95	1,399.93
Compost produced per year	**4,320**	**7,200**	**10,079**

Appendix 5 Pictures from Landfill Visit

All pictures were provided by R. Mingazova and were taken during a visit to the landfill of Taraz the 19th of April 2022.


Standart
ГРУНТОВКА ГФ-02
ДЛЯ НАРУЖНЫХ И ВНУТРЕННИХ РАБОТ
AVLIN
SS SYNTHETIC EN
AMEL

x


GORKOVSKAYA
BREWERY
IPA
INDIA
PALE
ALE
ABV
OG
14,5%
IBU
55
APA
SOMERSBY