Master's Program in Humanitarian Manager: Operational Career 2017/2018

IMPROVING SOLID WASTE MANAGEMENT IN RURAL MONGOLIA THROUGH A LOCAL AND AUTONOMOUS ASSOCIATIVE APPROACH: THE CASE OF KHISHIG-UNDUR

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Paris, France

4 September 2018

EXECUTIVE SUMMARY

Over the past few decades, Mongolia has been facing increasing challenges regarding solid waste management, which appears very ineffective and insufficient throughout the whole country. While the capital city suffers many issues at every level, waste management is virtually inexistent in rural villages, where garbage is simply dumped in the steppe. Sorting is almost unknown in Mongolia and recycling and composting are still extremely limited. Facing the fact that public authorities lack resources and political will to effectively tackle the issue, especially in the countryside, this thesis aims to offer an alternative approach based on a local and autonomous handmade waste management system initiated by a non-profit activist association.

After thoroughly describing the current situation, we try to offer ideas and leads of solutions to respond step-by-step to each aspect of the issue. First of all, we suggest several options to raise awareness and improve the level of knowledge of the population regarding environmental challenges in general and waste in particular. Many activities could easily be carried out in the framework of a civic association, in order for people to change their behavior, reduce the overall waste production and sort recyclables.

We also offer leads to develop appropriate infrastructure that allow an adequate waste management at a reasonable cost. Clearing the old open dumpsite in order to make room for a proper waste management platform appears to be a necessary first step to enable effective sorting and recycling. For each of the main types of domestic waste found in Mongolian households (organic, plastic, paper, glass, textile and stove ash), we present several simple and viable options that could be locally implemented in order to reuse or recycle most of the village's waste.

Overall, this thesis tends to show that aiming towards "Zero Waste" in remote Mongolian soums at a limited cost is definitely realistic. Our findings support the idea that an associative-led approach would be particularly relevant in the absence of dedicated public or private actors, especially considering the synergies that can be found with many other aspects of local sustainable development.

ACKNOWLEDGMENT

I would first like to thank my thesis advisor Mathieu Mérino, Senior Research Fellow at Fondation pour la Recherche Stratégique (FRS, Paris). From our first meeting, he has always been very helpful and extremely responsive whenever I had any question. He made sure that this work was my work, yet gave me very clear instructions and challenged me with new perspectives. His support and direction were irreplaceable. I could not have imagined having a better advisor and mentor for my thesis work.

Besides my thesis director, I would also like to thank Pierre Guerber, my husband, without whom I could not accomplish this work. His unparalleled support, interest in my work, valuable insights were the backbone of this project. Pierre not only contributed to my work with his active feedbacks, but also dedicated all his support to me and made sure I had the right condition and possibility to continue working. I do not have enough words to thank you, my other half.

I must thank my mother Khishigsuren Tsedendorj for always being there for me, believing in me, encouraging me and helping me with whatever means she has and whenever she can. She is my real role model that I look up to in my life and I will continue my effort to become a woman like her.

Last but not least, I would like to express my most sincere gratitude to my nephew Khishigbaatar Boldbaatar for taking photos of the dumpsite from the field and conducting a short interview with the Mayor of the village, with the questions I had prepared and sent to him. As I was not physically there to accomplish these tasks, his help was extremely important to collect evidence and gather firsthand information on certain things.

PURPOSE AND LIMITS OF THE PAPER

In a global context of interdependent environmental, economic and social crises, it has become necessary to undertake a transition toward a new society based on ecological and solidarity values as well as more sustainable principles.[1] Motivated by these ideals, my husband and I are currently founding a non-profit association called Ecosoum in my country, Mongolia. Our goal is to empower rural Mongolians in order to contribute to the sustainable development of the countryside by promoting environmental protection, social equity and economic development together through this organization.

Rather than specializing on a specific issue at a large scale, we decided to primarily focus our action on only one of the 330 Mongolian villages (*soums*), using a comprehensive approach to simultaneously address its various environmental and socio-economic problems. The goal is to demonstrate the efficiency of this approach and make a "model" soum out of it in order to promote duplicating our achievements in the rest of the country. Scaling-up local successes is certainly a huge challenge[2], but we believe that it will work the best to reach all rural populations with the most efficiency.

Mongolian villages all are very isolated and independent so it is relatively easy to adequately size the project and have a comprehensive approach with a minimum of interference from outside the soum we work in. Khishig-Undur, the village where I come from, is situated in the north-central province of Bulgan province and seems perfectly adequate for testing this approach. The reason is that Khishig-Undur does not really present any particular characteristic: its structure, geo-climatic environment and socio-economic context are quite average. To succeed in turning this regular soum into a model of local and autonomous sustainable development, even though nothing particular predestines it, will help proving that such a development is possible anywhere in the country.

Our main fields of action and objectives are fivefold: raising awareness of ecology and sustainable development; promoting a more sustainable livestock breeding system and fight overgrazing; supporting agro-ecology and food sovereignty; fostering renewable energies and eco-construction; and improving local waste management. Coming from Khishig-Undur, I know the local needs personally and given the ideals that we are aiming for, I believe that these are the five main issues that need to be tackled and their solution will bring immediate positive impact.

[1] Transition Network, *What is Transition?*, 2018.
[2] Binswanger (H.P.) and al., *Scaling up Local and Community Driven Development: A Real World Guide to Its Theory and Practice*, 2009.

In order to prepare our associative activities, my husband and I have been doing some personal research and started writing (unpublished) documents on each of these topics. I decided to use the opportunity to write the thesis for my Master's degree to dedicate enough time and effort to the one pillar we had not investigated yet-waste management.

Appropriate waste management is a necessity to achieve sustainable wellbeing for all populations and the Environment. As such, I believe that it should be the full responsibility of the public authorities (or at least the private companies mandated by them). However, in relatively poor and developing countries like Mongolia, government resources and capacities are very limited, other issues are usually prioritized, and rural areas are often neglected. That is why the purpose of this thesis is not to produce recommendations for public policies; on the contrary, in line with our approach of association, we aim to identify local, autonomous and artisanal solutions that can be implemented in Khishig-Undur without necessarily needing full State support.

In order to find the best solutions, we first needed to thoroughly understand the current issues regarding waste management in Mongolia. Even though we focus on rural areas, Ulaanbaatar represents such a major part of the country that it is impossible to go around it. In any case, learning about how waste is managed in the capital city was necessary to measure the extent of the issue in Mongolia. However, while a few papers have been published on waste management in the capital, there is no research done when it comes to waste management in rural Mongolia. The lack information on the subject is what makes this thesis vital to our project, but at the same time, it is also the weakness of this paper: as I did not have the means to conduct my own extensive research, I was limited to the existing data – not to mention their reliability that was questioned sometimes. Nevertheless, given the purpose of this paper, I believe that enough information was available to synthetize a relevant overview on the current situation of waste management in Mongolia.

Beyond the current situation, the ultimate goal was to identify solutions that can be implemented in rural Mongolia and build a relevant project on waste management. Thus, the second part of the thesis was constructed less as a research per say, more as a reflection on how we could, step-by-step, design and implement a pertinent waste management system. Knowing that remarkable small-scale projects are successfully led all over the world to solve waste issues, I undertook to identify waste management technics and ideas that could be appropriate in Khishig-Undur. The purpose was to produce a document

that could be as “concrete” as possible, gathering most of the necessary information required to launch our activities in the field.

In conclusion, this paper should be regarded as a preliminary study for local solutions to improve waste management in rural areas, through artisanal ways, where conventional State infrastructures and services are inefficient or absent. The document targets Mongolia, and more specifically the soum of Khishig-Undur. However, we believe that it is – at least partially – applicable to many regions on our planet as it takes example on several inspiring projects led all around the world.

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INTRODUCTION

About Mongolia

Mongolian territory, landlocked between Russia and China, covers about 1.5 million square kilometers. It is widely constituted of mountains and hilly plateaus: the country's average altitude rises almost 1,600m above sea level, with high summits exceeding 4,000m in the Western Altai range. The climate in Mongolian is extremely continental: winters are long and very cold (down to -30°C or less) while summers are short and relatively hot (over 30°C). Each year, the country counts 265 sunny days on average, which gave Mongolia the title: "country of blue sky". Mongolian climate is considered semi-arid since annual rainfall does not exceed 220mm on average and summer droughts are frequent in many areas. The vast steppes that characterize this country extend over more than 80% of the territory.

Figure 1: Map of Mongolia *(with main cities, roads and relief)*
Source: Ezilon.com, 2009

Given these natural conditions, Mongolia has always been home to nomadic tribes and civilizations. The most famous remains The Great Mongol Empire of Chinggis Khaan and his descendants, which stretched from the Pacific Coast to Eastern Europe, on over more than 33 million square kilometers, in the thirteenth century. After dominating China, Mongolia in turn fell under Manchu rule from the mid-

seventeenth century. Independence was regained in 1911 after the Chinese Revolution. An authoritarian communist government was then established in Mongolia in 1924, under the influence of the Union of Soviet Socialist Republics (USSR). When the latter started to collapse in 1990, Mongolia went through a peaceful revolution and finally adopted a democratic and liberal regime. To this day, the country remains nonetheless widely shaped by this nomadic and communist double heritage.

Today, there are still about 230,000 nomadic households[3], which represent almost one third of the total population. With the exception of the capital city, the population of Mongolia is particularly scattered (see Box 1), with all the difficulties this situation entails. The insufficiency of transport infrastructure – less than 10% of paved roads (4800 out of 50 000 km) and a single railway – tends to isolate the rural families even further. But since the late 1990s, the trend is towards urbanization and the rural exodus is mainly directed towards Ulaanbaatar (see ***Figure 2***).

Box 1: Population and administrative divisions in Mongolia

With barely more than 3 million inhabitants scattered over its vast territory, Mongolia remains the least densely populated country in the world (2 inhabitants / km^2). About half of Mongolian population now lives in the capital city – its population has doubled over the past two decades – while the rest is spread throughout the country. Besides Ulaanbaatar and two other cities, Mongolian territory is divided into 21 *aimags* (equivalent to provinces) and 330 *soums* (equivalent to districts). Each of these soums holds a single village (called soum-center), which means that – including the capital city – the country counts in total only over 330 towns and villages. Given the distances that separate them, each soum is very independent and not much interconnected with each other. The soums themselves are then divided into *bags,* the smallest rural administrative unit. There are 1,568 bags in total in Mongolia.

The capital city has become overpopulated and is facing many challenges such as lack of infrastructure, poor community service, poverty, unemployment and the list goes on. People move to Ulaanbaatar seeking mainly economic opportunities, better education for their children, and more comfortable living condition – which they rarely find in reality once they arrive in the capital city. As the migration towards Ulaanbaatar continued with no indication to stop, Ulaanbaatar City Hall issued a special order on residing in the capital city in an effort to limit the influx. The order states that only those who own a

[3] National Statistics Information Service, 2018.

piece of land or apartments to their name and/or people who have jobs in Ulaanbaatar temporarily can obtain their right to rest in the city.[4] This order is in force until 1 January 2020 and likely to be extended.

There are intentions to develop the provincial capitals and towns near the capital city, in order to disperse the population more into rural areas, but so far, the situation in the countryside remains precarious. During the communist era, and more specifically between 1920s and 1950s, a small town (soum-center) was built in each district (soum) to introduce a more sedentary lifestyle. Each soum was given a school, a hospital, a kindergarten, a veterinary, a cultural center and a government building. Families who worked in one of those institutions settled down in the soum-centers while certain nomadic families kept their way of living – modified to the newly presented situation.

During this period, everybody worked for the communist government: the State owned everything and was responsible for public health, education and other public services.[5] The system definitely had its flaws, but in many ways, the living conditions in rural areas have deteriorated since the end of the socialist period.[6] Soums have been neglected, and remained very underdeveloped since the difficult transition to market economy began in 1990. Businesses, properties and majority of public services were brutally privatized, which led to a serious deterioration of public service due to lack of funding. At that time, because of the disorganized liberalization, the whole economy was at its weakest, unemployment increased, inequality grew, and poverty became a real struggle to many people.[7]

From 2009 to 2013, the country finally enjoyed a strong economic growth thanks to the rise in the price of raw materials, but it has diminished considerably over the past few years. Mining has emerged in recent decades as the main economic sector in the country. Natural resources such as gold, copper and coal now represent about 90% of Mongolian exports. Nevertheless, the agricultural sector – traditional livestock herding in particular – still accounts for an important part of Mongolian economy and society. While agriculture in total accounts for about 13% of GDP, the sector still employs more than 28% of the working population.[8] Today, overall Mongolian economic situation remains problematic: more than 27% of the population still lives below the poverty line – average monthly income per household was

[4] Ulaanbaatar Mayor, *Order A/17: Taking measures on ensuring the rights of citizens to live in healthy and safe environment*, 2017.
[5] Morozova (I.Y.), *Socialist Revolutions in Asia: The Social history of Mongolia in the twentieth Century*, 2009.
[6] Gardelle (L.) and Ruhlmann (S.), *La revalorisation des produits du terroir en Mongolie*, 2009.
[7] Tsolmon (T.), *Some issues of Mongolia's transition to a market economy,* 1994.
[8] World Bank, *World Bank Open Data*, 2016.

936,000 Mongolian Tugrik (MNT) in 2017, which is approximately equivalent to 330 euros – and the prevalence of under-nutrition remains close to 20%.[9]

Waste production and management issues

When the nomadic way of living was replaced with sedentary lifestyle too fast, people had to adapt their habits and behaviors as quickly as they could. With the open market, consumption habits changed dramatically and new challenges emerged. Among many issues, waste management problem grew rapidly. As people stopped moving around, they now had more space and means to keep more belongings. The free market system brought increasing quantities of variety of food and goods. People started to own more, thus started to produce more waste.

Today, everybody – including the herders – produce much more waste than they used to because of their swiftly increased consumption. Nowadays, it is estimated that Mongolia produces about 3 million tons of waste every year.[10] That means each Mongolian citizen produces in average about one ton a year, even though there is a significant disparity between rural and urban areas as well as between Apartment and Ger Districts in Ulaanbaatar (see Box 2).

Box 2: Ger District in Ulaanbaatar

The capital city is divided into two main living areas. The first one, referred to as "Apartment District", is the city center, where people live in apartments in relatively high towers. Approximately 40% of Ulaanbaatar's population is concentrated in this Apartment District. The second area, so-called "Ger District", corresponds to the sub-urban periphery surrounding the city center. There are no apartments there, only a collection of felt yurts (the traditional nomadic housing, called *ger* in Mongolian) and small wooden houses. This giant slum, that now gathers about 60% of the city's population, has been growing incredibly fast over the past two decades, while ruined rural households fled the countryside. In fact, its population is mainly constituted of former herder families who lost their livestock to a harsh winter and/or could not make a decent living in the recently opened market economy. Rural exodus was too fast for the city planning to adapt and all kinds of public infrastructures and services are severely lacking in the Ger District.

[9] Food and Agriculture Organization of the United Nations, *FAOSTAT*, 2016.
[10] Delgerbayar (B.), *Current Status of Solid Waste Management in Mongolia and Business Opportunities*, 2016.

In the capital city, solid waste management has become a major issue. The whole system, from collection to elimination, has been proving inadequate and ineffective: many people do not have their waste collected or own a container to dispose it, sorting and recycling are virtually inexistent, public services (and their private contractors) are severely understaffed and underfunded, etc. Ulaanbaatar has several main landfills that were originally meant to be waste treatment centers but these landfills do not match any of international waste treatment standards. The sites do not have any proper isolation, no fences, no soil and water protection and no resorting.

As there are not enough recycling facilities, even in the capital city, there are no incentive to sort waste to begin with, thus Mongolians do not have the habit to do so. They are not aware enough about waste management and waste production control. Overall, recycling is quite insignificant in Mongolia even though most of the waste is in fact recyclable. Even organic waste, which represents a principle category among household waste, is not separated at all for composting. The main actors of recycling have been informal: individuals, mostly unemployed people who are affected by poverty, come to the landfills and look for things that can be of any value. They collect plastic and glass bottles, old electronic parts that can be fixed or reused, old clothes that they can use, and food remnants.

In rural areas, with no surprise, there is neither proper waste treatment centers, nor proper landfills. Every soum has a dumpsite area not too far from their town center, but the standards are even worse than in the capital city. Dumpsites are just a vague area, out in the open, and there is no control over what is left there. From organic waste to toxic waste, everything is mixed and dumped at the same site. There is not a single recycling facility outside Ulaanbaatar.

Poor waste management is becoming a major problem, not only in the city but also in the countryside with terrible consequences such as environmental, soil and water pollution. Open dumpsite is also dangerous for children as they often tend play together and wander in the area. They may look for objects to play with at the dumpsite and be injured by broken glasses or metals, or even get burned by chemicals. The fact that most dumpsites are open in the field is dangerous for the livestock as well. Cattles roam inside and start to eat what they assume edible. There were many cases where herders found plastic bags and other textiles inside dead animals' stomach.

If people do not start to change their behavior towards waste and waste management, very soon their living space will be surrounded by garbage. People need to be educated on how waste is produced, how it should be treated, and on different types of waste, possibility of recycling, reuse and reducing. In

addition to raising awareness, in order to be capable of changing their habits, people need primarily a waste management system that, at last, proves effective.

Problematic and thesis plan

Then in a poor developing country such as Mongolia, that lacks resources, how can waste management systems be improved? In the capital city, studies have been done and the issue is well known but the problem keeps growing anyway. With half of the total population concentrated there, the political stakes are high and priority is given to Ulaanbaatar, but so far, public authorities were not able to improve urban waste management. Considering the level of centralization in Mongolia, what hope is left for rural areas regarding this issue? How could waste management challenges be tackled in countryside soums when the State is still struggling and concentrating its efforts only on the capital city?

In light of these interrogations, we did not want to focus this thesis on Ulaanbaatar nor on recommendations for public policies. On the contrary, we decided to focus this work on the Mongolian countryside and try to find answers to the following problematic:

How can rural waste management be improved through a local and autonomous approach?

In the first part of the paper, we will present an exhaustive introduction to the current solid waste management situation in Mongolia. First, we will try to grasp the definition of “waste”, which is not as obvious as it may seem. Then we will go through present situation of waste in Mongolia: how much is produced, where they come from and what they are composed of. After this part, we will take a brief look at the legislative framework, from the past to the present day, how waste management – including recycling – actually works throughout Mongolia. Even though this thesis insists to focus on rural areas, a significant part of this first chapter will also present the situation in Ulaanbaatar. In fact, not only the available studies concern essentially the capital city, but by fully understanding how waste management is run in Ulaanbaatar appears necessary to apprehend the overall issue and see what can be done (or not) in the countryside.

Then, based on the knowledge introduced by this state of play, the second part will attempt to offer a comprehensive perspective to improve rural waste management in Mongolia. Given the lack of public resources and priority, the focus will be given to an autonomous approach led in the framework of a local non-profit association. Examples of such small-scale projects carried out successfully in other parts

of the world will be provided to illustrate and support our recommendations. This second part will try to be as much pragmatic and applicable as possible to produce a kind of guidebook for locally improving waste management in rural Mongolia. This part will be constructed around the example of one soum that can be considered as representative of the Mongolian countryside, namely Khishig-Undur.

PART 1 – WASTE MANAGEMENT IN MONGOLIA: CURRENT SITUATION

How can we define "waste"?

Challenge to comprehensively define the concept of waste

It is necessary to start by pointing out that having a global and comprehensive definition of "waste" is particularly difficult – if not impossible. The concept of waste is indeed intrinsically relative: as Susan Strasser puts it, "*what counts as trash depends on who's counting"*.[11]

The definition of waste may in fact vary greatly depending on socio-cultural contexts, geographical zones, administrative units, family construction and personal habits. What is considered waste in one country can be seen as a useful object in another. Even within the same area, the same culture, the same people, an item can be treated differently. In many countries, including Mongolia, the same item can be considered either waste or an offering, depending on the context where people throw or give them away and their intention in that action at that very moment. Thus, solely its nature, its shape, or any other physical features cannot characterize waste.

Chemical composition can play a critical role in defining something as waste as well. However, this approach could never be sufficient: the same substances can be found in manufactured objects and in byproducts thrown away. It is needless to remind that in common language, the word "plastic" is simultaneously associated to both useful everyday life objects and environmentally unfriendly waste.

An economic reasoning could lead to consider an item as waste when it does not have any market value. Nonetheless, it seems obvious that scavengers (informal waste collectors) and professional recyclers would not look at "waste" the same way most people do. In many countries, entire communities make their living by roaming the streets and junkyards in order to find recyclable waste to sell to specialized factories.[12]

Social studies state the fact that waste can be an indicator of certain culture and society. As such, the social approach assumes the very variability of conception of waste. Moreover, such an approach can even lead towards individuals: by looking at their waste, we can collect information about the former

[11] Strasser (S.), *Waste and Want: A Social History of Trash*, 2000.
[12] Del Pilar Moreno Sanchez (R.) and Maldonado (J.H.), *Surviving from garbage: the role of informal waste-pickers in a dynamic model of solid-waste management in developing countries*, 2006.

owner, such as their social status, living space (urban or rural) and so on. Ironically, while waste cannot be easily characterized, it can seriously facilitate the characterization of some people.

Finally yet importantly, the abstract concept of waste is not even constant in time. Many items that were considered as waste in the past have now found new purposes. This remark does not refer solely to the idea of recycling old and broken objects. Many examples show how what used to be unwanted byproducts sometimes become valuable resources (as raw material for industries, fuel for energy production, etc.). This can be explained by the development of new technologies but also, in some cases, simply by an evolution of the way people traditionally look at their "waste", which can lead to new ideas and ways to use them. Following this observation, it seems fair to assume – or at least hope – that some of today's waste may also become valuable resources in the future.

A pragmatic approach that focuses on unwanted items, which need to be discarded

Considering the numerous difficulties to grasp the various aspects of waste, how do waste management legislations manage to define them? The Mongolian Law on Waste offers a definition based on the uselessness of the item in question, considering any "*article or item that the owner does not need anymore*" as "*waste*".[13] This simple definition obviously lacks imprecision and leaves space for ambiguity: what about byproducts that were never needed or wanted in the first place? What about an item that one does not simply "need" even though it is still functioning perfectly and in a good condition?

Nevertheless, a look at other countries' legislations tends to support the Mongolian prism of definition. For instance, in neighboring China, wastes are defined as "*items and substances that are generated during production activities, household activities and other activities and have lost their original values, or haven't lost their original values but are discarded or abandoned"*.[14] The current French law also considers "*any residue of a production, transformation or use process, any substance, material, product, or more generally any movable asset that is abandoned or that the owner intends to abandon*" as waste.[15] Primarily, we can see that there are more precisions about what the item can be, and secondly that the notion of "abandonment" is preferred to the more ambiguous expression "not needed".

[13] Law on Waste, Art I, § 4.1.1, Ulaanbaatar, 2017, Mongolia.
[14] Ministry of Environmental Protection of China, *Identification standards for solid wastes*, 2017.
[15] Article L.541-1-1 of the Environmental Code of France, July 15th 1975.

However, the essence of the definition remains the same: waste is seen as unwanted items of which people need to get rid.

These definitions can be debated in the light of the many variables previously introduced. The fact is that beyond the semantic aspects and the philosophical conceptualizations we could discuss, this rough definition manages to grasp, if not the many aspects it covers, at least the common acceptation of what a waste concretely is: something unnecessary that we want to make disappear. The object of this thesis is certainly not to debate words but to understand the current waste management situation in Mongolia and try to find practical solutions to improve it. Thus, in the rest of this paper, the word "waste" will be intended as previously stated, according to the official Mongolian definition regardless of its imperfection.

Different classifications of waste depending on what needs to be shown

Having said this, if we agreed that its nature, its shape or its composition could not solely define waste, certain categorizations are in fact possible. The first one is to sort waste depending on their source (households, industries, etc.), which is obviously very interesting in order to know "who" produces the most waste. For some of them, like medical or radioactive waste, it is also particularly relevant because these wastes are very specific to their respective fields and activities (and clearly characterized by them).

However, this is far from being true for most waste: many similar refuses can be produced all the same by different kinds of economic or domestic activities. More importantly, knowing where the waste comes from does not say much about how they should be managed. Besides a few exceptions (like medical or radioactive activities), knowing the origin is not enough to be able to treat them properly. Consequently, while this categorization by origin makes sense for some extent, it is surely not enough by itself. Then enters another classification that solves the issues of the first one: a threefold categorization of waste according to their level of hazardousness: hazardous waste, inert waste, and non-inert-non-hazardous waste.[16]

The expression "hazardous waste" is usually used to classify waste that contains toxic or dangerous elements that pose risks to human health and/or the environment. This category includes a wide variety

[16] French Agency for Environment and Energy Mastery (ADEME), *Nature and type of economic activities waste*, 2015.

of materials and substances, such as electronic equipment, solvents, used oils and special fluids, batteries, sprays, medical waste or even radioactive waste. Except from the last two, most can be originated from both households and economic activities. Overall, compared to inert and non-hazardous wastes, these dangerous wastes are generally produced in smaller amount but their management is usually much more complicated. Due to their high toxicity, most of them need to be treated in specialized plants. Some can be treated to lessen the toxicity and make them inert before to be reused, but the rest are supposed to end up in high security specific landfills that can prevent any exposition to the public or the environment.

On the other side of the hazard scale, the term “inert waste” is often used to refer to waste that do not decompose, burn or produce any other physical or chemical reaction to the environment. They are not biodegradable and do not break down in contact with other materials. In return, they cannot alternate other materials nor affect the environment or human health. Inert wastes are mostly mineral and essentially produced by construction and demolition activities. They include materials such as concrete, tiles, pavements or excavated rubble. Unless toxic substances have polluted them, in which case they would not be classified as “inert” anymore, these wastes are quite easily manageable. If they are intact, they can be reused more or less directly. But most of the time, they are broken down into smaller pieces and used as backfill – if possible on the same site to avoid unnecessary transportation, or on another site that needs to be leveled up before further construction (roads, buildings, etc.).

The last category, which is also the most common, exists as an opposition to the other two: the “non-hazardous wastes” are in fact the wastes that are neither inherently toxic to humans nor entirely inert. They can be produced by all types of economic activities as well as by households, in which case they are commonly referred to as “domestic waste” or simply “garbage” in everyday language. This type of waste can be made of different kinds of materials that are intrinsically non-toxic, such as plastic, paper, carton, glass, metal, wood or textiles. Since these non-hazardous wastes are the most common in everyday life, a classification by types of material can be very interesting and practical, especially if we take into account the notion of recyclability.

In fact, in good conditions and when they are not mixed up too much, most of these materials are now recyclable in many countries. On the other hand, when they are too soiled or mixed to be recycled, they are often called “ultimate wastes” and simply end up in incinerators or landfills. Biodegradable wastes

also belong to the non-hazardous category. These organic wastes usually come from the garden and food leftovers. If separated from the other materials, they can easily be “recycled” by composting.

Overall, we can see that the ways to classify waste can be different depending on the issues addressed and what we want to demonstrate. By putting together waste that share a common feature (whether its origin, toxicity, material, recyclability and so on), we can focus on the characteristics that matter the most for a specific demonstration. These different types of categorization all present advantages and disadvantages, strengths and weaknesses regarding the overall definition of “waste”. In this thesis, we will come to use one or the other depending on what we are demonstrating.

Solid waste production in Mongolia

As I have mentioned several times, waste can take many forms. More specifically, it is not always solid. For instance, many industrial activities produce liquid effluents than need to be handled carefully. Domestic wastewater is another example of liquid waste to be properly managed. Waste can even be gaseous: some activities release vaporous byproducts that could perfectly qualify as “waste”.

Nevertheless, most of liquid and gaseous wastes are very specific and fall under dedicated regulations and activities. Therefore, this thesis will only focus on solid waste, and subjects such as sanitation and air pollution will not be addressed. Consequently, from here on, our use of the word “waste” will have to be indented in the restricted sense of “solid waste”.

A waste production that grew dramatically with modernization and sedentary lifestyle

Ancient nomads did not own much as they moved around at least four times a year. The less they owned, the easier it was for them. They produced very little waste as all their refuse was essentially organic and compostable materials. The worst waste they could produce from time to time was some metal parts of their yak cart, broken stirrups, old containers in brass and copper and some jewelries.

Nomads were actually extremely good at reusing. Old clothes became covers and blankets for newborn young animals or the weakest livestock during the winter and spring. Broken parts of wooden carts were reused to build fences and shelters for the animals – or, if the parts were too small, herders used them for firewood.

It also should be noted that nothing was wasted from their animals. Livestock dung has been one of the main sources for fire fuel: dung was collected and dried during the summer for the next winter. When they killed an animal for food, no part was left as waste either: leather was used to make ropes and lassos, horns were kept to make tools such as leather working panel, awls, combs, cups and so on. The bones were left to feed the guard dogs and other animals.

However, the demographic and economic trends Mongolia experienced over the past seventy years fundamentally changed the balance of its traditionally waste-free nomadic civilization. First, as ***Figure 2*** shows, the population grew considerably: from 1950 to 2016, the number of people living in Mongolia increased from 750,000 to over 3.1 million.

During the decades of collectivist era that began in the midst of 1950's, villages were established and large portions of the population abandoned nomadic herding for sedentary lifestyle. After the end of the communist regime in 1990 and the sudden liberalization of the economy, rural exodus started to explode and urbanization increased even more. Ulaanbaatar, the capital city, absorbed most of the migrating people and now accounts for about half of the total population.

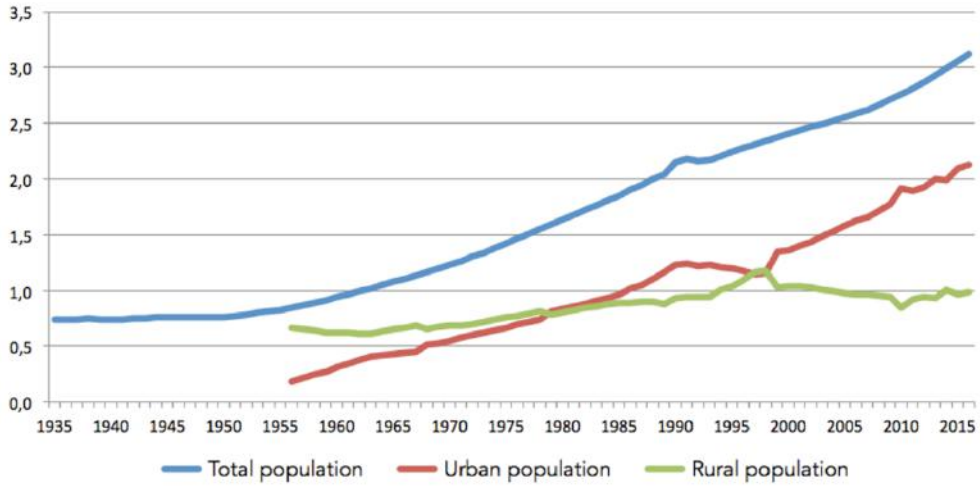

Figure 2: Evolution of the Mongolian population from 1935 to 2016 *(millions of inhabitants)*
Source: Mongolian Statistic Information Service, 2018

As people adopted sedentary lifestyle, they started changing their behaviors and habits. Not moving allowed them to own and keep more and more belongings. New non-organic objects, which did not fit in the traditional ways of waste management, suddenly appeared. For the first time in Mongolian history, garbage started to accumulate and rudimentary dumpsite appeared in the villages.

This trend then escalated and dramatically increased in the 1990's when Mongolia became an open market economy. Mongolians turned into consumers and cheap non-recyclable objects – mainly from China – found their way inside every household. The ancient balanced production and management of mainly organic waste was gone forever.

Under these socio-demographic and economic trends, waste production increased exponentially – particularly in Ulaanbaatar but also in smaller towns and villages. The fast development of mining and construction industries also contributed massively to the overall waste generation augmentation.

Origins and amount of waste produced in today's Mongolia

Unfortunately, while this massive increase of waste production is undeniable, exhaustive and detailed data about it does not really exist in Mongolia. Admittedly, it is estimated that in 2016 the country produced almost three million tons of solid waste, of which 40% were generated in the capital city.[17] According to a World Bank report, average waste production in Mongolia is about 0.7 kg/day/capita.[18] As a comparison, this report reveals that waste production is close to 1.0 kg/day/capita in both neighboring countries (China and Russia), 2 kg/capita in Western Europe and reaches over 5 kg/capita in Sri Lanka, but it comes as low as 0.1 to 0.2 kg/capital in countries such as Iran, Nepal or Mozambique. At the same time, other surveys specific to the city of Ulaanbaatar have shown that an average household produces about 0.9 kg of waste per day in the Ger district (the big slum in the outskirt of the city that contains 60% of Ulaanbaatar's population), and approximately 1.7 kg per day in the Apartment district (the city-center that represents about 40% of the capital city's population).[19]

Official statistics also show that, in Ulaanbaatar, the 2016 amount of about 1.2 million tons was 4 times higher than six years earlier, when only 290,000 tons were registered. Nevertheless, the problem is that data collection has not been comprehensive and fully reliable. For instance, it is more than likely that the registered fourfold increase of waste production since 2009 is at least partially due to the improvement of data collection itself (even though it is still insufficient) over the same period. In fact, most of the data about waste production in Ulaanbaatar is actually based on waste collection, according to the weighbridges of the three main landfills around the city. Thus, whatever does not end up there is

[17] Delgerbayar (B.), *op. cit*.
[18] Hoornweg (D.) and Perinaz (B.T.), *What a waste. A Global Review of Solid Waste Management*, 2012.
[19] Delgermaa (G.) and Matsumoto (T.), *A Study of Waste Management of Households in Ulaanbaatar Based on Questionnaire Surveys*, 2016.

not taken into account: for example, any waste illegally dumped inside or outside these landfills, any waste that stays on their production sites, or recyclable waste potentially picked up before entering the landfills, are de facto excluded from the statistics.

Moreover, how could there be any figures for the countryside, where such weighbridges do not even exist (not to mention actual landfills themselves)? How can data be accurate when the citizens themselves primarily throw waste in the dumpsites without any supervision whatsoever? With that in mind, statistics about waste in Mongolia – whether in Ulaanbaatar or in the rest of the country – should be dealt with carefully and considered more as orders of magnitude than precise figures.

As shown in ***Figure 3***, out of the 1.2 million tons of waste registered in the main three landfills of the capital city, almost 50% came from households.[20] The next main source of waste was commercial activities (restaurants, shops, services, etc.), which accounted for 28% of the total. Then came construction and demolition with 11% – the actual production of rubble is probably much more important but most of it is directly reused on construction sites, so only 130,000 tons end up in the main landfills. The rest of the registered waste mainly came from public spaces (6%), sludge (4%) and other sources (2%) – including hospitals, industries, secondary raw materials and summerhouses.

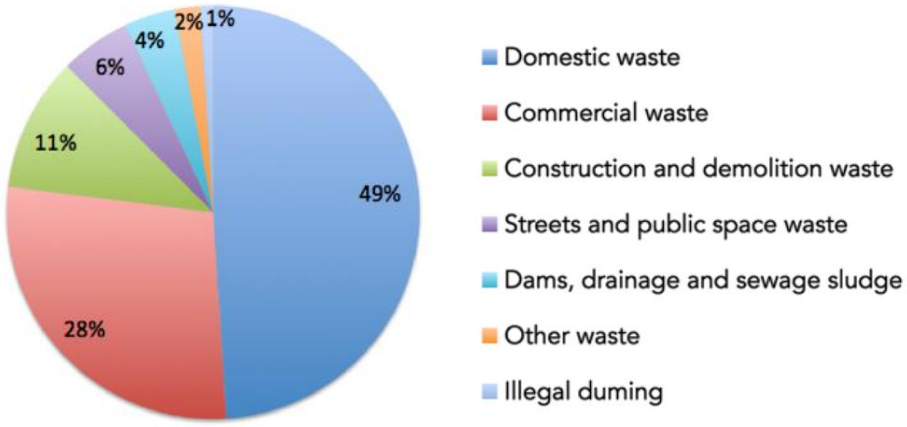

Figure 3: Waste sources in Ulaanbaatar according to the 3 main landfills' arrival weighbridge in 2015
Source: Data from Byamba (B.) and Ishikawa (M.), 2017

For the reasons previously mentioned, there is no such data for rural areas outside the capital city. Nonetheless, it is fair to assume that rural waste is also – and even more – mainly domestic since

[20] Byamba (B.) and Ishikawa (M.), *Municipal Solid Waste Management in Ulaanbaatar, Mongolia: System Analysis*, Sustainability, 2017.

economic activities (other than herding) are very limited and construction sites are quite scarce (housing being felt yurts and very small one-story houses).

Composition of Mongolian domestic waste

The composition of domestic waste can vary greatly whether people live in urban or rural areas. It can even vary significantly within these two categories. In Ulaanbaatar, we can see a real difference between the households living in the Apartment district and the ones living in the Ger district. In the same way, differences exist in the countryside between the sedentary families of the soum-centers (villages) and the nomadic herder households living out in the steppe.

Food waste represents the large majority of usual domestic waste in urban households: in the Ger district, food waste accounts for more than 40% and this share goes up to almost 80% in the apartment district (***Figure 4***). The difference probably comes from the fact that Ger district families have dogs that they can feed with their leftovers. After this organic waste, plastic is the second main category, accounting for about 20% in the Ger district and 12% in the Apartment district – which represent the same amount in absolute terms (about 0.2 kg). The rest of the households' waste is essentially composed of paper, glass and textile. Overall, virtually all of this waste is potentially recyclable with adequate facilities.

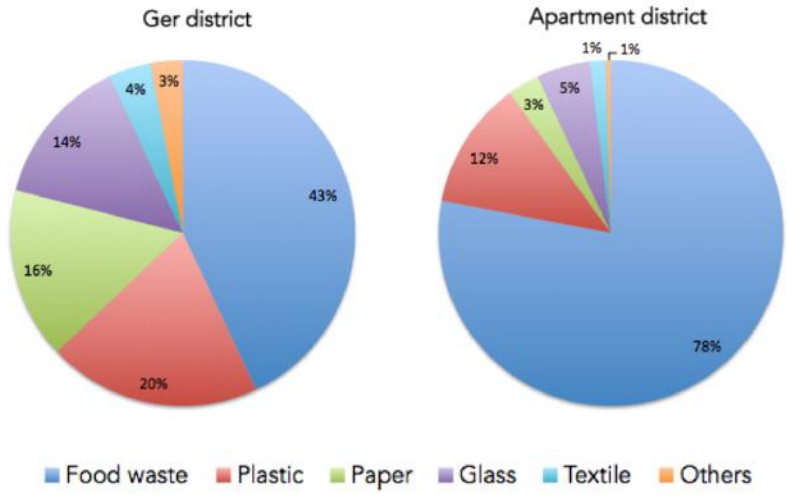

Figure 4: Composition of household waste in Ger and Apartment districts of Ulaanbaatar
Source: Data from Batkhuyag and al., 2016[21]

[21] Batkhuyag (E.U.) and al., *Characteristics of Household Waste and Coal Ash in Ulaanbaatar, Mongolia*, 2016.

In winter, the families of the Ger district also use charcoal to heat their homes (while apartments have centralized heating itself coming from charcoal-fueled plants). It should be noted that the amount of coal ash the households produce is very important – probably equivalent to the overall regular domestic waste (including food, plastic and so on) – but there are no official statistics about it. In fact, winter domestic waste statistics are even less reliable than usual, especially in the Ger district: the harsh climate conditions and slippery roads keep collection trucks from going everywhere, which means that an important part of the domestic waste cannot be collected and is excluded from the official statistics.

Unfortunately, while Ulaanbaatar solid waste situation has been the subject of several papers, studies lack dramatically when it comes to waste management in Mongolian countryside. In fact, I could not find a single source giving if only rough estimations of waste composition in rural areas. Thus, considering that people in Ulaanbaatar's Ger district have living conditions that are much closer to the ones in rural villages than to the ones in the Apartment district, we can estimate that the waste production and composition of sedentary households in the countryside are close to the ones in the urban Ger district.

By extension, we do not have a choice but to consider that the Ger district households' waste production and composition are more or less representative of today's nomadic herders. Obviously, this very imprecise approximation probably tends to overestimate their actual waste production. However, even though they still keep most of the old nomadic lifestyle, their way of living has definitely changed in contact to sedentary villages: nowadays, they most likely produce a little less waste than their contemporary sedentary fellows do, but definitely more than their nomadic ancestors did.

Nonetheless, at least one big difference remains the coal ash production in winter. Nomadic households still use dried animal dung as fuel for their stove. In the soum-centers, some people also use dung, but many favor wood, which is more expensive but more convenient and effective. Being cheaper than wood, charcoal is used more and more, but still way less than in Ulaanbaatar. Thus, if the volumes of coal ashes are certainly not negligible, the issue is evidently not as important in the countryside as it is in the city.

How is solid waste managed in Mongolia?

Mongolian Legislation on Solid Waste Management

Proper waste management regulation was first introduced in the Mongolian framework within the 1995 Environmental Protection Law. From then on, Mongolian citizens were given official rights regarding waste management services and each level of administrations were assigned specific tasks and responsibilities.[22] then, several other laws related to the issue of waste were passed over the years[23]: Law on prohibition and export of hazardous waste in 2000, Law on household and industrial waste management in 2003, Law on payment of package and case imported goods in 2005.

These evolutions took place within the densification of international standards and agreements. Mongolia notably signed the Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes in 1996, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade in 2001, and the Stockholm Convention on Persistent Organic Pollutant in 2004.

National laws and international agreements were also completed with municipal legislations, especially regarding dangerous waste in the capital city. A 2002 bylaw set rules on how to classify, collect, transport, store and treat hazardous waste in Ulaanbaatar. Additional procedures were introduced in 2006 and 2009 regarding proper disposal as well as standard labelling and containers for such hazardous waste.[24] In 2015, Ulaanbaatar's city council enacted another municipal bylaw on "Funding of waste management and transportation operations and consolidation of waste management service fees", in order to reinforce existing regulations on waste applying to household and commercial activities.[25]

In 2012, a new national Law on Waste Management was adopted by the Parliament in order to better regulate, throughout the country, all stages of the domestic and industrial waste management process – from collection and transportation to storage and landfill. This 2012 law also aimed to promote reusing and recycling, which were clearly neglected before.

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[22] Byamba (B.) and Ishikawa (M.), *op.cit*.
[23] Altantuya (D.) and al., *Municipal solid waste management of Mongolia: Analysis on the solid waste treatment of Ulaanbaatar city*, 2012.
[24] Altantuya and all, *op. cit.*
[25] Byamba (B.) and Ishikawa (M.), *op.cit*.

Finally, one final national Law on Waste Management was passed in 2017, which sets the current framework for waste management in Mongolia.[26] This law is based on the previous one, but developed further many aspects such as sorting, recycling, reuse etc. According to the new law, every citizen must sort their waste (10.2.1), report any activity that might pollute the environment to the local authority (10.2.15) and contribute to the reduction of environmental pollution (10.2.13). Different businesses and organizations are responsible to educate their employees on waste management (10.2.16), participate in public cleaning activities, and report any illegal activities related to waste. The new law forbids building a new soil-polluting toilet (the current toilet system in Mongolia is a hole in the ground, polluting soil and water sources) and any violation will be punished with a significant amount of fine both for individuals and organizations (41.3.7). The law also forbids individuals and organizations to burn any type of waste in the open-air (10.3.3), and any plastic/synthetic waste in stoves (10.3.4).

Construction of any waste management facility (restoring, recycling, incinerating, and burying) is forbidden in the following areas: green zone, water source, apartment and public area, camping areas, tourist sites and summer camps, especially or strictly protected water sources, water stations providing drinking and daily water for people, and sites confirmed to have minerals and other sites protected by different laws (16.8). If any individual or organizations dump their garbage in public space and/or green zones, their vehicle and technics are confiscated and fine the individual by 1 million MNT (about 350 euros) and the organization by 3 million MNT (43.1.19). The law gives detail on trash bin standards and put special lines for complaints in place.

Overall, if we also take into account the national action plans and strategies that Mongolia launched in 2017 regarding the improvement of waste management[27] (and sustainable development in general), the country does not lack laws and guides on the issue. Yet, unfortunately, they proved insufficient to address the increasingly complex waste situation in Mongolia effectively.

Even though legislative frameworks do exist, controlling and evaluation systems are still not operational, which makes it impossible to enforce the laws – regardless of its intrinsic imperfections and weaknesses. Furthermore, dedicated budgets remain insufficient[28] and human recourses are still scarce and underequipped. In Ulaanbaatar, authors reported in 2012 that only one officer was in charge of

[26] Mongolian Parliament, *Mongolian National Law on Waste – New Revision*, May 12th 2017.
[27] Ministry of Environment and Tourism, *National Waste Management Improvement Strategy and Action Plan 2017-2030*, 2017.
[28] Ministry of Finance, *Иргэдийн төсөв-2018. Монгол улсын батлагдсан төсөв*, 2018.

environmental policy planning, and only 15 people working for the entire environmental protection department (including air quality control).[29]

In these conditions, whether proper legislation exists or not, it simply cannot be effectively implemented. In fact, the actual waste management system in Mongolia is severely failing, whether it is in Ulaanbaatar or in rural areas.

A failing solid waste management system in the capital city

In Ulaanbaatar, the waste management system (cf. ***Figure 5***) remains very inadequate and fails to match international standards. Waste collection is done in a commingled way: there is no segregation, even in the governmental organizations.[30] Authorities appoint to each part of the city the 18 collection operators – known as "TUKs" –, which are either public (11 of them) or private (7). TUKs are in charge of collecting, removing and transporting waste to disposal sites (as well as cleaning public spaces). They use handcarts and motorized trucks: in 2016, Ulaanbaatar had 274 waste collection trucks (out of 799 nationwide).[31] Most of them are outdated and urgently need to be upgraded in order to function effectively and efficiently.

Depending on the sources, it is estimated that TUKs manage to collect between 70-85% of the urban waste[32] (against about 40% in rural areas[33]). However, the collection is actually higher in the Apartment District than in the Ger District. Indeed, even though the population is more numerous, collection services only come once or twice a month in the Ger District while they come once or twice a week in the Apartment District. This is linked to the fact that the Ger area is much wider and horizontally spread, whereas the city center is smaller, with inhabitants concentrated in high vertical towers. Thus, collection is more expensive and time consuming in the slum, even though people are poorer and less capable of paying the higher waste-collection service fees.

In addition, in the city center, households have collection containers to dispose their waste in, while in the peripheral Ger area there are no such containers. Collection is essentially made on a door-to-door

[29] Altantuya and al., *op. cit.*
[30] Altantuya and al., *op. cit.*
[31] National Statistics Information Service, 2018.
[32] Byamba (B.) and Ishikawa (M.), *op.cit.*
[33] Delgerbayar (B.), *op. cit.*

basis, but as the trucks actually do not operate much in the Ger district, garbage tends to accumulate everywhere on hills, in waterway beds and alongside roads and pathways.

As sorting is virtually inexistent, almost all of the collected waste ends up in landfills.[34] In Ulaanbaatar, there are three main landfills (Narangiin Enger, Tsagaan Davaa and Morin Davaa) as well as several small-scale informal dumpsites. All of them, including the main three, are completely outdated and poorly managed. Their operation and management standards are low and they possess no real environmental protection measures. The largest one (Narangiin Enger) is supposed to be more advanced, with some kind of leachate and gas management, but those actually do not function properly.[35]

All kinds of waste are indiscriminately dumped together in these landfills: domestic waste from Ger and Apartment districts (including coal ash); waste collected from public spaces and commercial activities; waste transported from construction and demolition sites; dam and sewage sludge; but also, some of the industrial waste, regardless of their level of toxicity and hazardousness. There is no facility to pre-treat or to prevent scattering in the wind, and leakage through soils and waters. Overall, the disposal method is simple: dumped waste is (sometimes) set on fire altogether before dirt is packed down over it.

Even medical wastes from hospitals are disposed in Narangiin Enger landfill. Ulaanbaatar's hospitals produce about 2.7 tons of waste each year, less than one third of it being actual healthcare waste (the rest being general non-hazardous waste).[36] Almost 400 kg of anatomic waste needs to be properly incinerated every year but the city does not have any specialized incinerator so everything ends up buried.[37] The only consolation is that medical waste is now confined in airtight containers before burial, in order to avoid biohazard and environmental contamination.

Nevertheless, medical wastes are the one exception to a deplorable situation: overall, except for them, there are absolutely no proper hazardous-waste management facilities in Mongolia. Everything is dumped and buried together with the rest of the inert and non-hazardous waste – without any kind of

[34] Delgermaa (G.) and Matsumoto (T.), *op.cit.*
[35] Byamba (B.) and Ishikawa (M.), *op.cit.*
[36] Delgerbayar (B.), *op. cit.*
[37] Delgerbayar (B.), *op. cit.*

protection for the environment and human health. Toxic smokes and flying ashes can spread freely over the city while hazardous substances infiltrate soils and groundwater.

Some of the hazardous wastes emitted by industries and other activities are actually stored where they are produced, but even then, secure confinement standards are inexistent. The example of Ulaanbaatar's three charcoal-fired power plants is evocative: the 900 tons of ashes they produce annually are stored on site, but even though their toxicity has been studied and demonstrated, nothing is done to ensure that pollutants do not spread and contaminate the environment.[38]

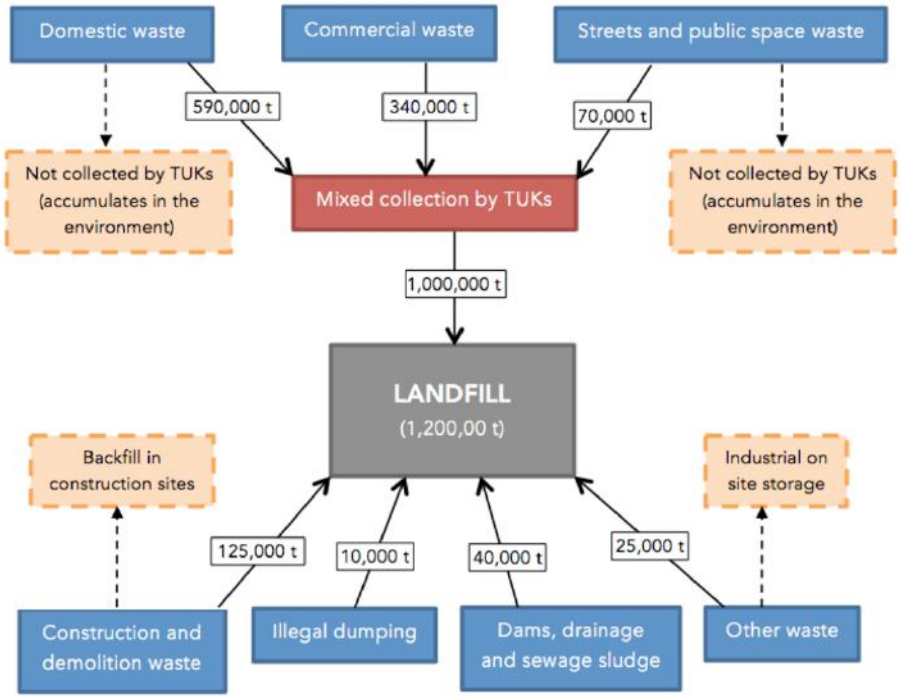

Figure 5: Schematic solid waste management system in Ulaanbaatar *(tons per year)*
Source: Narantuya Gursed, 2018

An embryonic recycling system that remains insufficient but may evolve in the near future

Up until now, there has been no widespread program or incentive to promote waste segregation at source. Mongolians who would want to sort their waste did not have any concrete solution since everything ended up in a mixed collection truck anyway. Therefore, there is virtually no at-source

[38] Batkhuyag and al., *op. cit.*

sorting in Mongolia and almost all recycled materials are extracted some posteriori from comingled general waste.

Except for some leftovers that are given to dogs in the Ger District, food waste is not separated either. This situation seems really too bad considering that this organic waste represents the majority of total household waste (which means the total amount could easily be reduced) and that organic composting does not necessary need as much means and facilities as recycling of other materials.

In winter, before collection by TUKs, Ger District households keep coal ash in a dedicated spot due to its important volume. In summer, the amount of ash is much smaller thus mixed with the rest of the domestic waste. Anyway, even in winter when ashes are collected in specific bags or drums, they end up all dumped together in the main landfills with the general waste.

Therefore, since waste sorting within households is virtually inexistent, segregation is done only after collection: it is essentially when mixed waste arrives at disposal sites that some of the recyclable materials start to be separated from the rest. This waste segregation work is performed by informal pickers: in Ulaanbaatar, around 5000-7000 of such scavengers[39] live within the dumpsites in order to collect marketable recyclables such as plastic bottles, carton, glass, metal or cans.[40]

Once they collected enough materials, these waste pickers sell whatever they gathered to waste transfer centres. Then, the recyclables are sent either to a very limited number of small recycling businesses in the city (about 12 according to some authors[41]), or mostly to big recycling factories in China. Exclusively private actors, most of whom are informal, perform this entire waste segregation and recycling system.

Overall, depending on studies, it is estimated that only about 3%[42] to 5%[43] of the total solid waste produced in Ulaanbaatar is recycled – the remaining 95 to 97% staying in the landfills. Hong Kong and San Francisco (two of the most advanced cities on that subject) already recycle about 80% of their waste. However, even if we focus on other developing countries in Asia, recycling rates appear

[39] World Bank, *Monitor Environmental Challenges in Urban Development*. 2004.
[40] Delgermaa (G.) and Matsumoto (T.), *op. cit.*
[41] Byamba (B.) and Ishikawa (M.), *op. cit.*
[42] Delgermaa (G.) and Matsumoto (T.), *op. cit.*
[43] Byamba (B.) and Ishikawa (M.), *op. cit.*

significantly higher than in Mongolia: 10% in Jakarta, 15% in Dhaka, 18% in Bishkek and even 32% in Bangalore and 35% in Lahore.[44]

In 2016, about 11,000 tons of recyclable waste were exported abroad (mainly to China) from Mongolia, including 5,000 tons of plastic and 3,500 tons of paper (the rest being mainly metal and glass bottles).[45] As a comparison, between 2012 and 2017, the United Kingdom exported about 450 000 tons of plastic waste per year to China and Hong Kong.[46]

It is worth mentioning that electric and electronic waste – commonly referred to as "e-waste" – is subject to a slightly more efficient recycling system. Like everywhere on the planet, e-waste production has been growing dramatically throughout Mongolia: estimations show that annual generation of e-waste is now about 2,000 tons (computers account for more than half of it, followed by television sets, refrigerators and washing machines).[47] E-wastes are collected in Ulaanbaatar like any other kind of waste and, when formal or informal recyclers do not recover it, it is dumped in regular landfills. Nonetheless, it is estimated that less than one third of the e-waste produced in Ulaanbaatar actually ends up and stay in landfills. About 45% of the total e-waste generation is washed and/or repaired before to be directly resold on the second-hand market, and almost half of the remaining 55% is picked up by scavengers to be dismantled and reused or sold as spare parts (or simple metal).

But even considering the efforts made regarding e-waste (and ignoring the unhealthy condition waste recyclers work in), the overall waste recycling system in Ulaanbaatar has obviously been far from sufficient to effectively recycle the city's waste. Moreover, the situation could get even worse now that China just decided (mid-2017) to stop its imports of waste from other countries, including plastic bottles and other recyclables that Mongolian waste-pickers used to sell to them.[48] With fewer options for recycling and less financial incentive to segregate, the informal recycling system could slow down even more.

Having said that, on a more optimistic point of view, this interruption of Chinese waste imports could also be the milestone leading to the development of recycling system in Mongolia. Now that there is no

[44] Greenfield (D.), *International Recycling Rate Comparison Project*, 2016.
[45] Delgerbayar (B.), *op. cit.*
[46] Laville (S.), *China ban on plastic waste imports could see UK pollution rise*, 2017.
[47] Delgerbayar (B.), *op. cit.*
[48] State Council of the People's Republic of China, *Action plan to phase out waste imports*, 2017.

other option, the government and/or some private investors will see an opportunity to build large-scale recycling factories within Mongolia and start improving the whole system, in order to solve the big issue that waste management has become in Ulaanbaatar.

In fact, some favourable projects have already been emerging. Currently, Ulaanbaatar authorities are collaborating with the Mongolian National Recycling Association (MNRA, the organization that represents most of the informal recycling sector) in order to create an "Ecopark" within each of the main two landfills (Narangiin Enger and Tsagaan Davaa).[49] These dedicated spaces (up to respectively 175 and 100 ha) would benefit from tax exemptions and other financial incentives in order to concentrate the new and existing recycling actors in this park. New recycling facilities shall be constructed to improve the efficiency of the system.

So far, the lack of financial resources is still an issue, but maybe the evolving context will bring new investors. Formalization and working conditions of informal scavengers do not seem to be the priority yet. However, having a formal dedicated platform to work on might start bringing more visibility and recognition to them.

More and more civic initiatives and local NGOs (Tehnoj, Zorig foundation-Young leadership program, Asia foundation program collaborating with local actors and local Rotaract club, etc.)[50] have started to focus on waste problem in Mongolia. They are actively working on the subject of waste management, raising awareness, behaviour change and organization of small workshops. Young generation is more and more aware about the negative impacts of single-use plastic items and call for individual responsibility. They produce short videos on the subject and post it on social media channels and the posts are circulating quite fast.

A virtually inexistent waste management system in rural areas: example of Khishig-Undur

Outside Ulaanbaatar, waste management is even more rudimentary. As resources are extremely limited, public services are scarce, especially when it comes to waste management. Actually, most of the small soum budget is usually spent on education – which itself is a good thing – but practically nothing is left for other fields and sectors. Soum administrations may have a truck or two but public waste collection

[49] Delgerbayar (B.), *op. cit.*
[50] Khogiin Khot (www.facebook.com/HogiinHot/)

does not seem to reach many families – people often still bring their waste manually to the dumpsite (using simple sacks and barrels as containers). While national legislation delegates to local administrations the responsibility to set their own waste management regulations, soum regulations are usually limited to asking people to throw their waste in a dedicated area.

The example of the average 3,000-inhabitant soum of Khishig-Undur (including about 2,000 nomadic herders), in Bulgan province, is quite representative of Mongolian countryside (cf. ***Figure 6***). Official statistics for 2017 show that only 5% of the soum households have their waste collected by public trucks. In the soum-center, almost 90% of households dispose their waste in the dedicated dumpsite while the remaining 5% throw their waste elsewhere into the environment. Out in the steppe, two third of the nomadic herder households leave their waste behind in the nature when they move to a new camp; only 31% bring their waste to the dumpsite while less than 4% are collected by public services. This is easily explained by geographical constraints: those who camp close to the village can afford to bring their waste to the dumpsite but it is much more complicated for those who live far away.

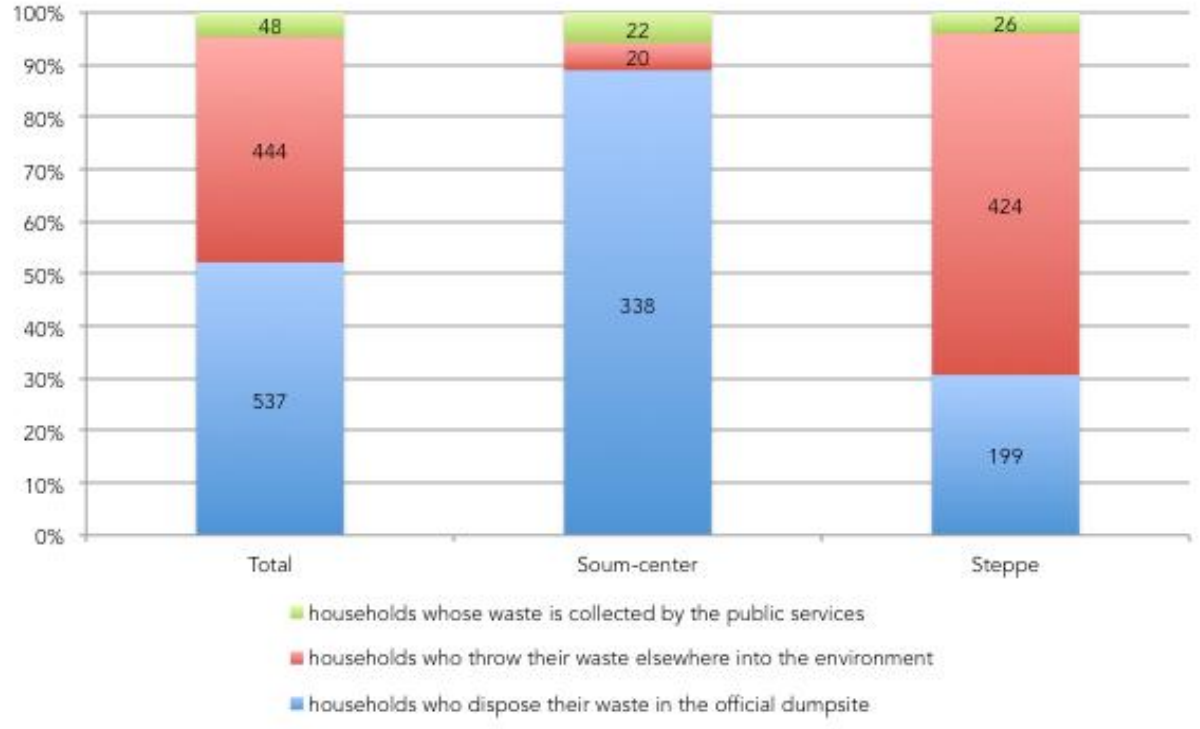

Figure 6: Waste collection and disposal in Khishig-Undur in 2017 *(number of households)*
Source: Data from National Statistics Information Service

Like in the capital city, whether waste is publicly collected or individually disposed of, all waste is mixed and dumped together without any segregation. Dumpsites do not have any protection standards or supervision of any kind. The best that can happen is that, unlike in Khishig-Undur where the area is not even physically demarcated, the dumpsite is fenced to prevent livestock to roam inside. Hazardous wastes are dumped with no specific measure with the rest of the general waste. Only medical wastes are sometimes burnt in dedicated rudimentary incinerators (low temperature stoves) but these do not match international standards and do not present any specific protection measure. In Khishig-Undur, toxic and medical waste used to be incinerated this way but now they are just buried in holes in the general dumpsite due to insufficient financing.

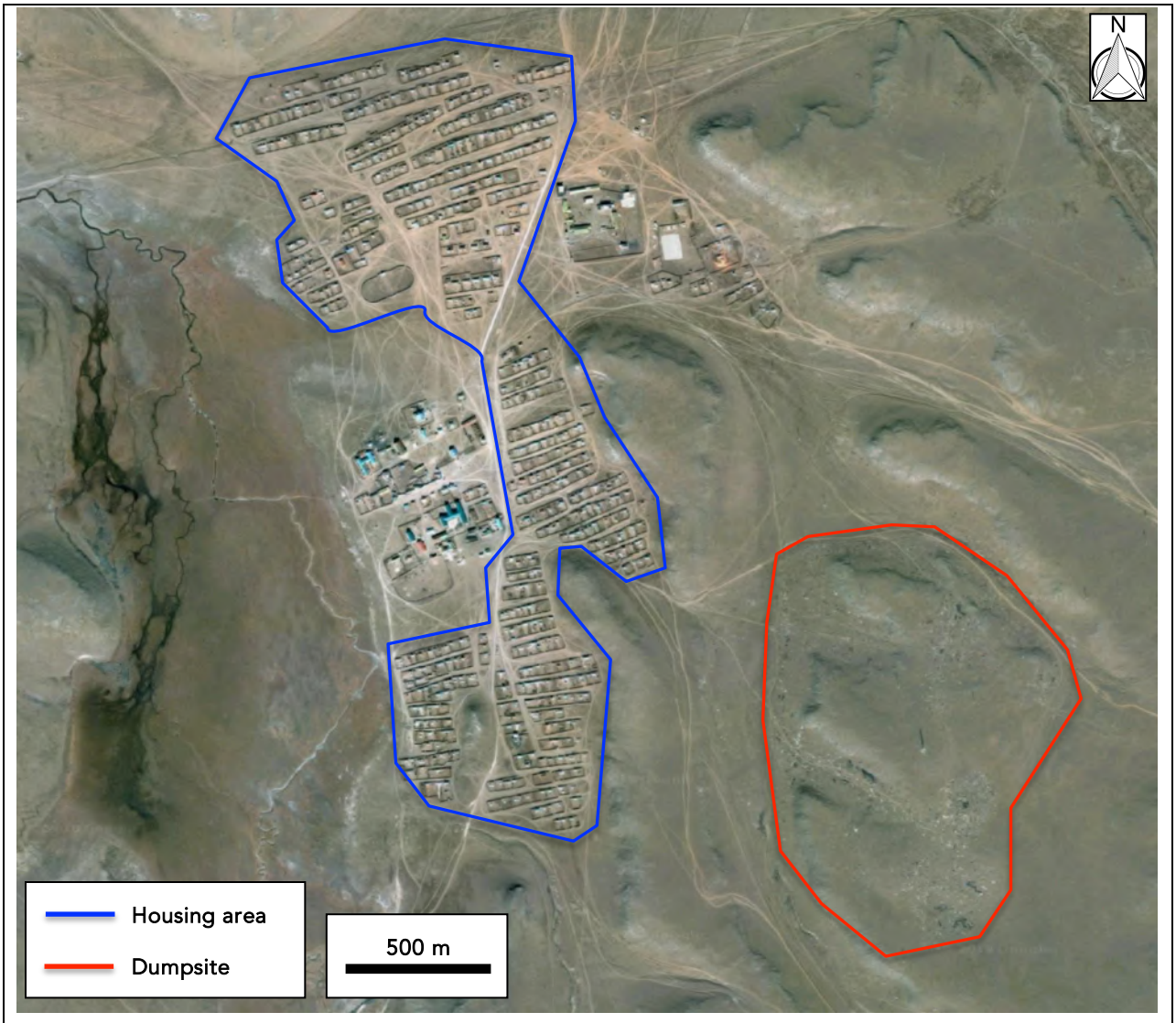

Figure 7: Dumpsite location in Khishig-Undur's soum-center
Source: Aerial photograph from Google Maps, 2018 (www.google.fr/maps)

Rural dumpsites are usually quite large. Aerial picture in ***Figure 7*** shows that the surface of Khishig-Undur's dumpsite (about 90 ha) is more than half the surface of the total housing area (about 140 ha). Throughout the country, dumpsites cover a total surface of about 125,000 ha (including Ulaanbaatar landfills).[51] This total extent appears quite large considering the small population: it represents more than 0.4 ha of dumpsite per person, to be compared with the 0.7 ha of land each Mongolian is entitled to as a free private property.

Moreover, this total surface of land occupied by waste does not even include the wild dumpsites majority of nomads informally created around their camps. Nomadic families often throw the waste they accumulate in a specific area, a few dozens or hundred meters away from their camp. These informal dumpsites are usually a natural depression, a hole or a hidden space between rocks, which give the impression of making waste disappear while (ineffectively) preventing wind dispersion.

[51] Delgerbayar (B.), *op. cit*.

PART 2 – A LOCAL AUTONOMOUS APPROACH AS A PATHWAY TO IMPROVE WASTE MANAGEMENT IN RURAL MONGOLIA

Raising awareness in order to reduce waste production in the first place

Why prioritize a local and autonomous approach?

The current situation presented in Part 1 shows that waste management suffers from many major issues both in urban and rural areas. Many recommendations could be produced for different actors to develop public policies in order to improve the whole system; in fact, many have already been issued in various studies.[52] Given this context, the following points should be the most important aspects in order to improve waste management in Mongolia:

First, overall data collection needs to be significantly improved in order to have reliable information, on which to build an andequate waste management system.

Second, the legal framework should be reinforced both nationally and locally in order to better regulate waste management and introduce higher safety requirements that match international standards. The reality of its failing implementation should be taken into account to improve it in light of current and future trends. Effective sanction mechanisms should also be reinforced to make sure that every stakeholder, at every stage of the process, manages waste properly and holds responsibility to their actions.

Third, since the whole system is understaffed, from policy makers in the designated offices to waste workers on the field, human resource capacities need to be reinforced. Cooperation between all stakeholders, including government entities, foreign projects and public and private field workers should be improved. Informal actors, who represent most of the recycling sector, should be better integrated into the formal waste management sector.

Forth, public awareness and education regarding waste issues should be reinforced. There are some public awareness raising campaigns and educational programs put in place by the Ministry of Environment and the Ministry of Education, but they need to be widened and multiplied so that all Mongolian rapidly adapt their behaviours and reduce their waste production.

[52] Altantuya and all, *op. cit.*

Fifth, obsolete equipment needs to be upgraded or replaced – or simply be introduced where it lacks. Up-to-date facilities, including proper landfills with actual environmental and human health protection measures should be put in place. Large-scale recycling plants must be built shortly, not only for plastic but also for all other types of recyclable waste.

Sixth, the waste-collection fee system needs to be revised: not only it currently does not generate enough money to finance waste collection, but also it is fundamentally unjust. Sure, collecting waste in remote parts of the Ger District or in the wilderness of the steppe – where people are horizontally spread – costs more than doing so in city-centres where they are vertically concentrated. However, the households in questions (unemployed slum families and poor herders) cannot afford to pay the higher fees that collection services bring on them. In these conditions, there is higher waste prevalence in the poorest areas.

Obviously, all of these recommendations are essential to improve waste management in Mongolia. On the other hand, pragmatically, it is just as obvious that the lack of financial resources represents a tremendous constrain in tackling all these challenges nationwide – not to mention the lack of technology and political will. While we can only support such an improvement of public policies and services, it seems very unlikely that problems are going to be solved promptly if no additional initiative is pushed. This is particularly true for rural areas, where resources (the total budget of the soum is almost all allocated to education and health, which leaves virtually nothing for waste related issues) and political priority are the lowest.

That is why we believe that local association initiatives such as ZeroWaste[53] in several countries around the world must emerge. Their goals should not be to replace the failing public services completely but to fill the gaps and catalyse dynamics to help and build together an effective system. This is actually true not only for waste management but for all other types of local challenges. The improvement of waste management needs to be addressed not as a separate and independent issue but as a part of the general sustainable development approach at local scale.

The context of rural Mongolia lends itself particularly well to such a holistic associative approach of local and autonomous sustainable development. Because of the low population density, communities are far from each other, clearly identifiable and not interdependent. Each soum comprises a central village of

[53] Zero Waste France, *Towards a zero waste society,* 2018.

sedentary inhabitants, surrounded by nomadic families (who administratively belong to the village) spread in the steppes. The interactions between different soums are thus very limited because of the isolation and distance between. In addition, the soum population – nomads comprised – is generally limited to a few thousand inhabitants only, a particularly relevant and convenient scale for implementing local development projects. In any case, each soum is so independent and remote that it needs to find an effective way to deal locally with its own waste.

Thus, in the rest of this thesis, we will leave the urban waste management problems and the national public policies aside in order to focus only on the possibilities to implement such a local and autonomous approach in rural Mongolia. Given the failure of institutional waste management, we will try to imagine a civic approach that Mongolian citizens could develop and implement themselves in their soums, working hand in hand with the local administration.

The low-cost initiatives we will recommend are intended to be initiated, supported and/or run within the scale of a small association comprised of motivated member residents willing to bring positive changes in their village.[54] The case of Khishig-Undur will serve as a base in order to be as precise as possible, but the solutions that will be suggested should be completely transposable to other soums.

Before to try imagining better ways to manage the produced waste, it seems essential to start by trying to reduce the amount of waste we produce. Nonetheless, profound and lifelong behaviour change can be achieved only through proper education and strong awareness. This means that raising awareness must be prioritized in order to solve waste management problems in Khishig-Undur (like everywhere else).

Raising awareness regarding global sustainable development issues

One of the reasons waste and other environmental issues such as pollution and environmental degradation in general have become such major problems worldwide is because people at large are not aware enough of those issues, their deep root causes, their long-term consequences and how everyone could contribute to fixing them.[55] This is particularly the case in developing countries such as Mongolia

[54] As explained in the "Purpose and limits of the paper" section, such an association (called "Ecosoum") is being created in Khishig-Undur in order to carry out this associative approach, for waste management and other issues.
[55] Ajaps (S.) and McLellan (R.), *''We do not know enough": Environmental education and pro-environmental behaviour perceptions*, 2015.

because populations in these countries face many more short-term challenges in their everyday life. In fact, who could blame people who struggle to feed and make a decent living for not focusing primarily on environmental issues?

Nonetheless, difficult living conditions do not necessarily have to lead to eco-unfriendly behaviours. Actually, on many levels, adopting a more environmentally responsible lifestyle can lead to better economic situation and living conditions.[56] Therefore, the challenge is not to make people do something they do not want to do but to make them realize that it is in their best interest to change their usual behaviour and adopt new habits.

It seems like integrating the subject of waste into global environmental issues gives a better perspective and a durable effect on explaining why address the problem. Indeed, proper waste management is actually just one of the many aspects of true sustainable development. Improving waste management alone is not enough and should not be the only purpose by itself: it is only one of the paths to reach the ultimate goal to protect the environment and improve people's living conditions. Therefore, awareness raising actions regarding waste problems should be undertaken as part of a more comprehensive ongoing awareness raising campaign addressing environmental challenges as a whole.

In addition, given the close links between ecological, social and economic issues, both locally and globally, all three spheres of sustainable development should be part of the awareness raising campaign: indeed, numerous organizations and authors have shown the links between capitalism and market economy on one side and environmental degradation and social crises on the other.[57] In their own way, enthusiasts of "minimalism" – which, concisely, refers to a simple way of life implying little consumption and little waste production – show that stepping aside from the compulsory consumption pattern that goes with our economy and model of society allows significantly reducing waste production.[58] Reducing our overall ecological footprint definitely suggests to question the Western way of life – as the root cause it is – instead of just trying to fix its consequences one by one.

In any case, at the very least, sustainable development and ecology have to become part of people's main preoccupations in order for things to really change in a conclusive way. Only when people are properly informed and placed in an adequate state of mind can they willingly adapt their behaviour and

[56] Development Studies Network, *Environmental sustainability and poverty reduction: Pacific issues*, 2002.
[57] Bell (K.), *Can the capitalist economic system deliver environmental justice?*, 2015.
[58] Fields Millburn (J.) and Nicodemus (R.), *Everything That Remains: A Memoir by The Minimalists*, 2014.

translate that overall eco-friendly consciousness into practical actions – one of these actions being the establishment of a better waste management system.

To that end, targeting children form the youngest age appears to be a good investment for the future. In addition, children are undeniably a fundamental means of sensitization for their families and communities as a whole[59], which is why they shall be at the heart of the awareness raising activities. Evidently, the best way to do so is to work within schools and start from the youngest age. This way, children are educated about comprehensive sustainable development state of mind. Given the fact that almost one third of Khishig-Undur's population are under 19 year-old and that most of them are enrolled,[60] targeting school is definitely the best way to effectively trigger changes.

The first step should be to strengthen the school and the teachers' capacities. Specific needs shall be identified with the teachers' participation in order to mobilize them around the problem and build relevant educational projects based on the current curricula. If necessary, explicit presentations on various subjects can be organized for the teachers to make sure that they fully comprehend the subject as a whole and are capable of teaching about sustainable development for years to come. Partnerships with specialized associations or with foreign schools that already teach the topic are necessary to establish in order to get their feedback, access up-to-date data and produce proper teaching materials.

After training the teachers, associative members could keep taking part in educational activities at school by regularly setting up various concrete projects illustrating some key issues in a playful way. Children can participate in the realization of these small projects in many forms (scientific, artistic, etc.). Additional activities also need to be carried out outside the school by forming an extracurricular educational group dedicated to sustainable development and eco-friendly projects (the model of scouting movements can be applied here). In fact, it seems essential that children are not only introduced to environmental protection, but also they really build a strong personal link with Nature by discovering ecosystems first hand.[61]

In addition to children who have an essential role to play, adults should be included in the target population. Associative events, gathering as many participants as possible, shall be frequently organized

[59] Damerell (P.) and all., *Child-oriented environmental education influences adult knowledge and household behavior*, 2012.
[60] National Statistics Information Service, 2018.
[61] Nair (S.M.), *Creating environmental awareness among children*, 1992.

to promote sustainable development[62]. In particular, documentary films about waste, ecology and sustainable development could be publically screened and serve as a base to group discussions. For instance, 2012 British documentary "*Trashed*" (by C. Brady) successfully displayed how waste has become a worldwide challenge. Other movies such as 2015 French documentary "*Demain"* (by M. Laurent and C. Dion), that was translated and screened in many countries have also proved very effective to raise awareness and give people plenty of motivation to start taking actions.[63] Many other carefully selected movies on the subject could be screened in order to inspire people and encourage debates and sensitization.

This digression regarding global sustainable development awareness raising may seem ineffective or aside the point in the framework of the present thesis. Nevertheless, I believe that it is indispensable if people are to change the way they look at waste and the way they translate their concerns into actions. We should see that this overall eco-consciousness actually is the essential foundation stone on which an effective waste management can be built.

Therefore, we can see that from this very first stage of general awareness raising, the local, autonomous, associative approach that we promote appears particularly relevant. Considering the constant field mobilisation and enthusiasm that it requires, no national policies or local administration incentive alone could lead such an approach. Such local associative engagement appears to us like the best – and probably the only – way to establish sustainable development-based projects in Khishig-Undur, to raise people's awareness regarding environmental issues, and to catalyse social dynamics that are essential to change behaviour and habits extensively among the population.

Raising awareness of waste issues in order to encourage behaviour change

Within the framework of this general sustainable development awareness raising, waste issues must be addressed specifically. Whether it is at school, during public events, through flyer distribution, social and conventional media publications or any other way, the worldwide waste problem needs to be presented as a base for people to understand why it has to be tackled there too, in the little soum of Khishig-Undur.

[62] Laura Masiulienė and al., *The key features of successful awareness raising campaigns*, 2015.
[63] The movie's official website opened a dedicated page were hundreds of people already told about the local projects they started implementing after watching *Demain* (https://www.demain-lefilm.com/apres-demain/les-projets).

People need to realize that over 1.3 billion tons of municipal solid waste is produced worldwide each year, and that this amount could reach 4 billion a year by 2100.[64] Presenting the terrible situation that Ulaanbaatar has reached – as shown in Part 1 – could help them to project this global reality into their own country. Images from the capital city and other parts of the world that show the overwhelming negative impact waste produces should be shown so that people can comprehend what is ahead of them if they do not change their habits soon.

The dangers and consequences of waste proliferation should be clearly explained as well, so it does not remain an abstract concept. People need to understand that unsafe waste disposal can let pollutants penetrate soils and run into groundwater – the very water they drink directly from their wells in the village. They need to know that since the 1950s, over 8 billion tons of plastic have been produced worldwide, of which only 9% has been recycled[65]. Moreover, up to 12 million tons of land-produced plastic end up every year – through rivers – in the oceans,[66] meticulously decimating wildlife, forming giant garbage islands, and even ending up on people's plates in the meat of the fish they eat.[67] They need to face the fact that burning waste produces toxic smokes, which affect their health, and that letting livestock and scavengers roam in dumpsites increases the risks of disease transmission between animals and humans. No specific data is available about rural Mongolia, but the impact of poor waste management on human health has already been demonstrated in many parts of the world.[68]

Certainly, despite the fact more and more waste is carelessly dumped, the situation is not that bad yet in rural Mongolia. Nevertheless, just as it was necessary to explain that waste management is only one issue among other sustainable development aspects, it is important to stress that local waste challenges are part of a global challenge. The message should be clear that everyone in the world is concerned and that Mongolian soums are on the verge of experiencing the same difficulties if their inhabitants do not quickly change their behaviour and adapt their habits.

At that point, Khishig-Undur population – or at least the first group of motivated persons – should be ready to access solutions and behaviour adaptation suggestions. In order to modify the common

[64] Hoornweg (D.) and Bhada-Tata (P.), *op.cit.*
[65] Geyer (R.) and al., *Production, use and fate of all plastic ever made*, 2017.
[66] Jambeck (J.R.) and al., *Plastic waste inputs from land into the ocean*, 2015.
[67] Greenpeace, *The Ocean Plastic* Crisis, 2017.
[68] Ziraba (A.K.) and al., *A review and framework for understanding the potential impact of poor solid waste management on health in developing countries*, 2016.

"consumption – waste production – waste disposal" pattern progressively, a graduated approach has been used around the world for many years. Usually referred to as the "3 R's rule"[69], this waste-hierarchy-based method aims to guide people through a systematic and progressive reflexion process that leads to reducing waste production at source.

Over time, the "3 R's rule" evolved to integrate new Rs (words and number of Rs now vary greatly depending on sources) such as "Respect", "Refuse", "Replenish", "Replace", "Recover", "Repair", "Repurpose", "Rot" and so on. The new Rs, which can be slightly redundant with one another, seem to have appeared in order to precise and detail the original three. Nonetheless, the main idea remains unchanged and can be summed up as follows with the 3 Rs from the origins:

- **Reduce**: the first step of the process consists in *reducing* the amount of waste produced by reducing consumption altogether. It requires refusing items that are not necessary in the first place and buy or accept only products that respect sustainable development, environmental and ethical standards (introducing the idea of *respect*). Overall, the idea is to reduce the use of waste generating items as much as possible, especially plastic objects, and try to consume less in general;
- **Reuse**: the second step is to make sure that the items we do get are *reusable*. We should *replace* disposable single-use objects such as plastic bags, bottles and cups in particular by reusable ones. This step also includes notions such as *repurposing* (when an item has stopped being useful, we should try to find a new purpose for it) or *repairing* (to make sure a broken object is fixed instead of being replaced);
- **Recycle**: finally, if we really have to get rid of an item, the third step insists on making sure it finds its way into the recycling process (instead of throwing it to disposal as an ultimate waste). *Rotting*, or composting, belongs to that stage when it is organic waste.

This "3 Rs rule" should be hummed home as a mantra until it becomes part of everyone's personal habit – just like the World Health Organization (WHO) "5 fruits and vegetables a day" slogan (aiming to encourage us eat at least 400 g per day) has become part of our everyday life over the past 15 years.[70]

[69] United Nations Centre for Regional Development, *Reduce, Reuse and Recycle (the 3 Rs) and Resources Efficiency as the basis for Sustainable Waste Management,* 2011.
[70] World Health Organization, *WHO and FAO announce global initiative to promote consumption of fruit and vegetables*, 2003.

Posters should be displayed extensively in public spaces and checklist reminders, such as the one (that actually includes 6 Rs) created by Green Cross Australia (see Annex 1), could be distributed to Khishig-Undur inhabitants until they get used to the concept.

Anyone who lives by the "3 R's rule" could testify that it is not as constraining a rule as it may seem. In fact, once past the first few days or weeks of adaptation, following this process becomes a very stimulating personal playful challenge. I have learnt this from my personal experience and people from my entourage testified to have lived the same experience. This is why we are very confident that launching the process will prove successful in Khishig-Undur, even if not all inhabitants participate from the beginning. A snowball effect will certainly enrol more and more people as soon as positive feedback is shared among the community.

Teaching this progressive daily life 3 Rs approach to the population should also be completed with additional one-time actions in order to reinforce the message and mobilize people. For example, an interesting annual event entitled *Plastic Free July,* was born in Australia in 2011 and now registers the participation of over one million people from 159 countries.[71] The concept consists in trying not to use any single-use plastic item for the whole month of July. A one-page guideline/check-list is made to clarify the challenge, give good tips and precise the impact of each action (see Annex 2). Obviously, there will be no one there to control whether people respect their promises or not as it is not the main point. Beyond just reducing plastic waste production for single month a year, this approach is meant to make people realize how much plastic is present everywhere in our daily lives and how much plastic waste we produce without even paying attention. This interesting and effective awareness raising method could be introduced easily in Khishig-Undur.

Furthermore, a so-called *Waste Bucket Challenge* has emerged in several countries over the past few years.[72] The goal is, for a limited period of at least 7 days, to reduce personal waste production as much as possible and keep the waste that is generated in a specific bucket. At the end of the period, the challenger is supposed to post a video on social media showing how much waste he or she generated, and then challenge three new people to do the same thing. Like *Plastic Free July*, the main goal of this action is not to reduce waste production for a few days, but to help realize how much waste we usually generate as well as how easy it can be to reduce the amount with just a little good will and motivation.

[71] Plastic Free July (http://www.plasticfreejuly.org)
[72] The Sustainable Tree, *What is doing the Waste Bucket Challenge like?*, 2017.

While *Plastic Free July* and *Waste Bucket Challenge* are meant to be personal challenges (whether they are shared or not on social media), collective events can also be organised to raise people's awareness. For instance, local associative activists could organise, occasionally, waste picking events in Khishig-Undur. Motivated people would join for a few hours or a whole day. Goodies such as event-related t-shirts or useful reusable items (bags, cups and so on) could be distributed as a reward to encourage people. Not only this type of event could clear public spaces of accumulating waste but also it would show the entire community that some people are already tackling the local waste issue and that everyone should join the movement. Such events have been organized a lot around the world, especially on beaches (for example through the program *Ocean Initiatives* of Surfrider Foundation Europe, which also aims to collect data for advocacy).[73]

Finally, besides these different types of general population awareness raising, actions can also be led towards private businesses as well as public administrations. For example, Cambodian NGO Plastic Free Cambodia[74] – that was created in Siem Reap after the success of the first *Free Plastic July* event in the country – has been organizing workshops, trainings and consultancy within small and big companies. The association aims to sensitize those regarding waste issues and offer them eco-friendly solutions. This approach towards private businesses and public institutions seems particularly relevant in addition to people's sensitization in order to address all waste producers within Khishig-Undur soum.

Sorting waste and developing appropriate infrastructures to enable recycling

Introducing waste sorting and finding ways to support and enforce this activity

As people will be more aware of the issue and try to follow the "3 Rs rule", they will start *reducing* and *reusing*, leading overall waste production to decrease. However, evidently, waste is not going to disappear at once so it will still be necessary to find ways to manage all the waste that is produced properly. In order to give people a chance to respect the third R (*recycling*) of the "3 Rs"– and keep reducing the amount of ultimate waste – it will be essential to introduce a notion that is still virtually inexistent in rural Mongolia: waste sorting.

[73] Surfrider Foundation Europe (https://www.initiativesoceanes.org)
[74] Plastic Free Cambodia (https://plasticfreecambodia.com)

As part of the awareness raising measures previously described, it will be useful to explain and describe the content of typical Mongolian waste (as presented in Part 1).[75] Regardless of the proportions, which can vary from Apartment District to Ger district and rural areas, it is certain that most of household wastes – organic, some types of plastic, paper, glass and so on – are recyclables. Therefore, the population should realize that sorting waste at source would lead to enable recycling, which would considerably reduce ultimate waste disposal.

Once more, informing adults should not be neglected but children remain the most accessible and most effective target for such sensitization. By introducing educational courses and activities at school addressing this specific issue, children could rapidly learn and start to sort waste. Educational materials on the topic already exist and could easily be translated and adapted to Mongolian schools in the countryside. For instance, the "Solidarity Comity" of Canadian city Trois-Rivières has set up a youth-dedicated "*Réseau In-Terre-Actif*" that offers lots of online interactive educational materials for teachers to implement at school, including about waste sorting.[76]

In addition to just having teachers sensitize children through interactive courses, school could become a concrete and inspiring example of how sorting should work. The leading activist association could provide the school with adequate bins and make sure everybody, including all adult staff, sorts their waste. Inspired by this daily waste sorting experience at school, children would then apply their new habit at home and encourage their family members to do the same.

In a way, children will be given the gratifying and empowering responsibility to act as an informal "waste police" at home. A strategy that has already proved effective in other contexts: for example, as Israel implemented long lasting plans to reduce national water consumption dramatically, mass communication campaigns placed children at their core, voluntarily putting them in a position of "water police".[77] This strategy proved very efficient to reduce water consumption in Israel, and should prove just as successful for introducing and enforcing waste sorting in Mongolia.

In fact, we should not talk about "introducing" waste sorting because it has not been completely inexistent in recent times. Numerous Mongolians have been sorting at source for one specific kind of

[75] An additional field study in Khishig-Undur could be useful to determine, beyond the studies conducted in the capital city, what really is the composition of waste in the village.
[76] Réseau In-Terre-Actif, *Tout savoir sur le recyclage,* 2015.
[77] De Féligonde (V.), *Israël, orfèvre de l'eau*, La Croix, 2016.

waste, namely plastic bottles. The main reason is not necessarily environmental preoccupation but the fact that they were able to make a little money out by selling them to Chinese recycling factories (like Ulaanbaatar scavengers mentioned in Part 1, through various intermediaries). Now that Chinese new legislation has made this option disappear for Mongolians and the rest of the world, there is a real risk of people stop sorting plastic bottles and dispose them with the rest of their waste. We should nonetheless note the small-scale efforts of responsible individuals sorting their waste in Ulaanbaatar: they share their experience on the social media and call for others to join and start sorting. The young generation is quite open to adopt such habits if there is slightly more facility to do so.

In any case, this experience of at-source plastic bottle sorting proves that, with a little incentive, people are perfectly capable of, and interested in sorting waste even in the most remote Mongolian soums. Thus, in addition to awareness raising activities that will allow some people to sort waste to conform to their newfound civic and environmental consciousness, it seems essential to introduce complementary incentives in order to encourage them and inspire more people to start sorting. As mentioned regarding plastic bottles, personal interest definitely is a powerful – and legitimate – motivator.

As we will discuss later, local waste recyclers should be set up in the soum. Whether they are run by public services, a non-profit civic association or small private businesses, these new recyclers could pay people to bring some of their recyclables – just as Chinese big factories have been paying up until now. The amount does not need to be high. Just a few hundred *tugriks* for each kilogram of recyclable should lead many residents to start sorting (for example, some recycling companies have been paying about 400 MNT/kg of plastic waste or up to 250 MNT per glass bottle). Selling new objects that the recyclers produce out of "recyclable raw materials" they bought would recuperate the money they paid. Alternatively, in a non-monetary-based barter system, people who bring enough recyclables could be "rewarded" with useful items made out of recyclable waste. We will come back on recycling in detail later, but the point here is that people should probably be given a personal interest – whether financial or not – to sort their waste.

With environmental consciousness and personal interest, public authorities should also push people to sort waste. Stricter legislation that would make sorting mandatory, with an effective fining system to penalize people who do not, can certainly be an option. Such kind of measure has proved very effective in Japanese village of Kamikatsu, where people now sort their waste into 45 different categories in order

to facilitate waste management for public services and enable full recycling (the village has been aiming towards zero waste by 2020).[78]

It seems unlikely for political reasons that Khishig-Undur administration would take the initiative to introduce such changes officially before they are actually adopted by a significant number of residents. Realistically, enforcing such fines would be virtually impossible given the current lack of means and administrative staff. Even if it was possible, starting by forcing people to sort their waste through coercive measures may not send the right message and would probably go against the overall positive, civic dynamic we call for. Nevertheless, even if the introduction of a fining system may not be the most appropriate approach at first, non-mandatory waste-sorting recommendations should be integrated into the local waste management regulations in order to give legitimacy to the different actors who do take sorting and recycling actions.

Moreover, without having to take any active coercive measure, public services could still indirectly push people to sort their waste. For reluctant people – who believe that sorting waste is too much trouble – to change their mind, the idea would be to make sorting more convenient than not sorting. For example, public waste collectors could decree that henceforth they will only collect sorted waste and no more mixed waste. Then people who do not sort their waste would have to take their waste themselves all the way to the surrounding dumpsite, thus, it will be simpler if they just sort their waste.

In short, whether they rely on ethical values, personal interest or public services adaptation, several actions could be taken in order to make people sort their waste. We cannot really anticipate which of the measures would work better, but it is certain that combining all of them carefully and properly will eventually lead to entrench waste sorting into people's new habits.

Developing appropriate public waste management infrastructures

Now, for people to start sorting and for a proper waste management system to emerge, the soum will need a completely new set of appropriate infrastructures. Public spaces must be an example: separate bins should be installed in the main streets so that people can sort their waste even out of their homes. There should be at least three kinds of bins with obvious different colours and clear signs: one for recyclables (i.e. blue), one for organics (green), and one for the rest (red).

[78] Garfield (L.), *The simple way this Japanese town has become nearly zero-waste*, 2017.

Inevitably, these public trash bins will suffer – at least at first – from involuntary mistakes or even intentional careless blending. However, their role will go beyond the basic purpose of collecting/sorting: by being set all over public places, the coloured recycling bins will be a constant visible reminder of the changes that are being implemented in the village. Sure, some people may not use the recycling bins properly at first, but everyone will be constantly reminded that they should. In this manner, these bins will also serve as an awareness-raising tool.

Besides these street bins, the main challenge will reside in transforming the current open dumpsite into a proper operational waste management platform. Considering the limited resources, aiming for a state of the art fully equipped platform with environmental protection features respecting international standards does not seem realistic. Nevertheless, it is conceivable to imagine basic infrastructures that allow proper waste management including a minimum of environment considerations in line with this new approach. Collaborating with specialized actors could help find relevant technical solutions.

In order to minimize the natural space lost to waste, the new waste management platform should be set within the premises of the current open dumpsite.[79] Therefore, the first challenge will be to clear the site off the garbage currently spread all over it, in order to make way for the new platform and start the new waste management system on a "clean slate". The goal would be to regroup all existing waste in a limited and confined part of the site. As we can see in ***Figure 8***, Khishig-Undur's dumpsite is covered with big amount of widely spread indiscriminate waste. The surface occupied by garbage at this site is very large, but most is not piled up (the ground is still visible everywhere) so the total volume remains relatively manageable.

Thus, the best solution would be to collect the garbage laying on the ground manually in order not to just pile it up but to try to sort it as much as possible. There is a lot of paper, plastic and other recyclables that can easily be collected and sorted separately. This way, the volume of existing waste will reduce significantly. Even though this task seems tremendous and may require a long time to finish, we believe that the situation in Khishig-Undur – where the total volume of waste is not dreadfully overwhelming yet – allows aiming for such solution. With enough people involved, it seems realistic to

[79] Unless field investigation shows that, the site was poorly chosen in the first place: for instance, if the dumpsite is located upstream from drinking water wells in the village, risks of groundwater contamination from waste may require relocating the waste management platform in a more suitable area.

plan a quasi-total clearing of the dumpsite through successive waste picking campaigns, which can be part of the awareness raising activities previously explained.

Figure 8: Pictures of the open dumpsite in Khishig-Undur
Source: Narantuya Gursed, 2017

Nonetheless, in addition to the easily collectable individual pieces of garbage disposed on the ground, some of the waste has also been mixed with soil over the years in some places, filling the existing or purposely dug holes. For these piles of soil-mixed waste, manual collection will not be possible. Two options will then be conceivable: the first option will be to use machines such as mechanical shovels to excavate and gather up all the soil/waste piles into a single big pile that can be managed afterwards. If the various piles are not too deep and huge in amount, this option would lead to clear the dumpsite of all waste (except for the new big pile) and let the areas that is not used for the future waste management platform go back to nature.

If gathering all soil/waste piles into a single pile proves too complicated, the second option would be to cover each of them with a clean layer of soil definitively. That way, we would at least prevent from further wind scattering or animal scavenging and let the zone go back to nature, as a minimum on the surface. This solution clearly is not satisfying from an environmental point of view, but it may be the only possible choice from a realistic point of view. While letting grass grow back and erase visible traces of the past dumpsite, physical signs (flags, cairns, etc.) could be arranged in order to enable future cleaning if/when new means or better solutions are found in the future.

Once all these waste-collecting actions have cleared enough space in the dumpsite, the new waste management platform shall be established within its premises. Depending on the amount of available financial resources, the site should include several types of infrastructures and equipment to facilitate and reinforce the waste management system. If there is not enough initial investment, waste management activities could start with whatever is at disposal before additional infrastructures and equipment installed progressively when it is affordable and/or accessible.

Box 3: Conceptual example of waste management platform

For instance, the waste management platform (basically inspired by Western waste disposal sites like French "*déchetteries*") should be fenced to clearly delimit the area and keep livestock and children away. It could also be partially paved to limit the risks of soil contamination and leakage into groundwater. Pavement will also help providing a clean and professional working area on which waste management activities are carried out properly. Some parts of the platform would also benefit from a roof to protect workers and key areas from rain and snow. Actual rudimentary buildings could be constructed to offer appropriate working spaces for recycling activities, especially for winter months. Containers should be installed to facilitate sorting, and provide temporary storage for recyclables.

The overall layout could be imagined in different ways, but some basics will have to be respected for the platform to be efficient. A schematic representation of how the platform could be organized is presented in ***Figure 9***. First, different areas should be organized for people and/or collection services to drop off the waste they bring into the designated areas depending on what they bring and the need to be sorted.

If people bring already sorted waste (i.e. plastic, paper and so on), they could bring it directly to dedicated containers close to the recycling facilities (represented in purple in ***Figure 9***), and have their contribution registered and/or rewarded according to the previously discussed specifications. We can consider having at least one container for each principle type of waste as identified in Part 1.

The recyclables that brought separated from general waste but not from each other would be dropped off in a preliminary larger area (represented in blue) where the platform staff would sort them and place them in the right containers. Food waste and other organic waste would also be disposed in designated areas (represented in green) so they can be composted afterwards. The composting area could be set up within the premises of the waste management platform (as represented in ***Figure 9***), or biodegradable waste could be brought directly to existing composters from nearby associative gardens and/or local farms.[80]

All waste that is brought unsorted will be temporarily disposed in a specific area (represented in orange) where the staff will try to recover as many recyclable as possible. Whatever they cannot keep for recycling shall be definitively dumped in the ultimate waste area (represented in red). Only the platform staff will now be allowed to dispose waste in this final dumpsite in order to make sure that no recyclable is lost due to inappropriate drop off by careless people. This area is also, where the ancient soil/waste piles that are excavated should be regrouped and disposed as mentioned earlier.

[80] As previously explained, the associative waste management activities that are discussed in this thesis are intended to be part of a broader sustainable development association. As mentioned in the "Purpose and limits of the paper" section, an agricultural project is also planned: an associative garden comprising a composter will be set up, therefore it should be able to receive at least some of the food waste collected in the waste management platform.

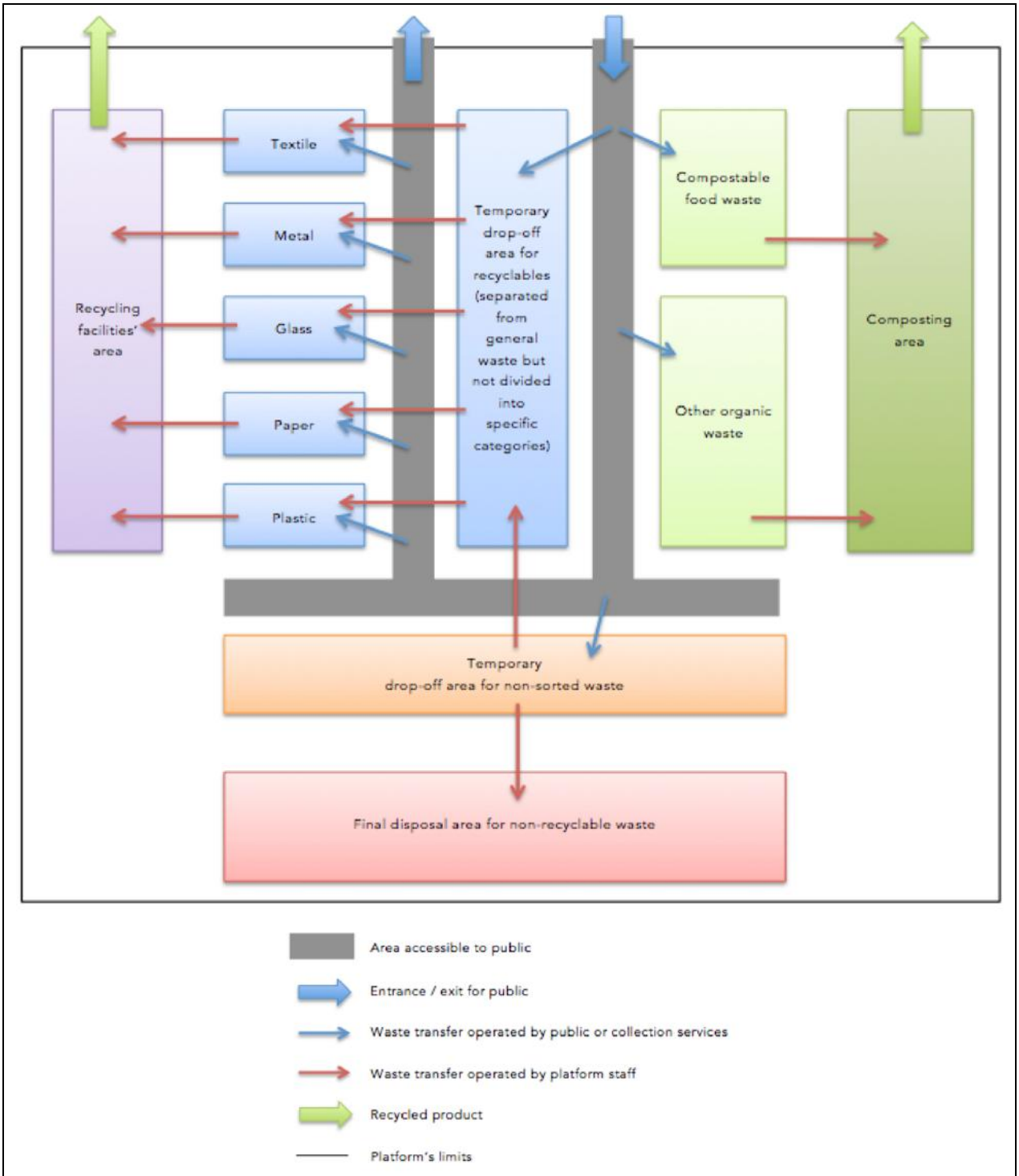

Figure 9: Schematic representation of the future waste management platform in Khishig-Undur
Source: Narantuya Gursed, 2018 (not at scale)

Ideally, this final disposal area should be arranged to become a proper landfill.[81] Concisely, a waterproof liner (made of plastic or packed clay or both) should be installed in the bottom of the hole to prevent leachate to run to groundwater. The leachate shall be collected thanks to appropriate drainage system and pipes and be cleaned in a proper water treatment plant. Methane produced by anaerobic degradation of organic compounds should also be collected to prevent air pollution. Disposed waste should frequently (if possible daily) be covered to prevent scattering in the wind.

With that being said, it is obvious that such measures and infrastructures require huge investments (and management costs) that will not be available in Khishig-Undur in short or medium term. Most likely, until better solutions are found in the long term, there will be no other option but to dispose ultimate waste as it used to be, in a big unprotected pile. Clearly, this pragmatic solution is not fully satisfying. However, the overall new waste management system will still be a significant improvement since the volume of new ultimate waste to dump on that pile will be reduced dramatically thanks to all the other sorting and recycling measures. The only alternative to that final disposal would be to burn the remaining waste, but proper incineration actually requires even more investment and goes itself with important environmental problems (mainly air pollution) so it does not appear to be an interesting solution here.[82]

In summary, in the context of Khishig-Undur, our small-scale association driven approach of waste management cannot offer any satisfying solution to the non-recyclable ultimate waste issue. That is precisely the reason why the global reduction/sorting/recycling process has to be developed and reinforced as far as possible, in order to tend to zero ultimate waste.

How to manage the waste from nomadic families?

Before finally investigating how waste can be efficiently recycled in Khishig-Undur, we need to address one more question that, contrarily to the rest of what we wrote so far, is very specific to Mongolian countryside: how to deal with the waste produced by nomadic families. Indeed, considering the distance that separates them from the soum centre facilities, usual sedentary waste management systems are not very adapted to these remote isolated households. In fact, as we showed earlier in ***Figure 6***, official statistics estimate that the two third (65%) of nomadic households (who themselves represent two third

[81] Advance Disposal, *Learn about Landfills,* 2018.
[82] Sharma (R.) and al., *The impact of incinerators on human health and environment,* 2013.

of the soum's 1,000 households) in Khishig-Undur dispose their waste out in the steppe, in completely informal open dumps. This phenomenon requires a specific thinking dedicated to their case, by going back over the different measures we previously suggested in order to make sure we offer an adequate response to this category of the population.

First, we need to make sure that our awareness raising activities reach them effectively. In fact, almost all of their children go to school in the soum-center. Therefore, educational activities carried out at school, as we previously described, will effectively benefit to the nomadic families when the children go back to live with their parents during the holidays. In contrast, nomadic adults will not be able to attend most of the public awareness raising events organised in the village. That means some activities will have to be brought directly to them in the steppe.

It seems hardly conceivable for awareness raising activists to visit door-to-door each of the over 600 nomadic households of Khishig-Undur. However, it could be effective to target the most influential households. By convincing the most respected herders to start paying more attention to waste related issues, words could rapidly spread throughout the entire community. Thanks to a snowball effect, all nomadic households could be reached indirectly.

In addition, it is important to notice that all herders gather a few times a year in their *bag-center.*[83] These scheduled reunions could be an opportunity to address all of them directly and frequently in order to discuss about waste management, to screen documentaries and so on. Moreover, within the framework of this associative approach, other matters and projects will lead the activists to be in regular contact with the herders (especially for projects aiming to reduce overgrazing). Even if waste management is not the sole issue they discuss, the subject could be addressed and reminded on several occasions.

Through these various means, herders too will progressively become aware of waste related issues and be encouraged to sort waste and stop littering wilderness. In order to help them sort, the association could provide them with some basic equipment like big bags or boxes for each type of waste (plastic,

[83] A *bag* is the smallest administrative division of Mongolian countryside, corresponding to the old communist subdivision of State farms and cooperatives. Beside the soum-center (which is officially the fifth *bag*), Khishig-Undur's steppe is divided into 4 *bags*. Each of these *bags* has a rudimentary center, usually a single house where nomads gather to hold meetings, to vote and to organize small events etc.

glass and so on). This way it would be relatively easy for them to start sorting and store their waste before it is moved to the central waste management platform.

The question is then: how can their sorted waste be brought back to the soum-center to be processed correctly. Even when they will be willing to sort their waste, many herder households will not have the means (no car, no money, etc.) to bring it to the waste management platform. Collection will therefore be the key issue for them.

A first solution could be to provide more affordable (or even free) public services door-to-door collection, even with a relatively low frequency such as once a month. In 2017, only 22 herder households had their waste collected by public services.[84] The main problem remains the cost, which many families cannot afford: today, the administration charges 100,000 MNT (about 30 euros, which is about 10% of the average monthly household income) to send a truck to collect the waste.[85] By coordinating neighbouring families to collect their waste at the same time, price per household could be reduced. As experimentation, and to encourage nomadic households to start sorting waste, the activist association could (at least temporarily) cover some or all of the collection costs.

Another solution could be to install simple but adequate infrastructures in the four *bag-centers* and ask nomads to drop their sorted waste in these dedicated areas. Collection trucks would then have to go only to these four places to collect waste from several families. This solution appears quite complementary to the first one. Actually, we can imagine three types of collection for Khishig-Undur's nomadic households:

- Families who live close enough to the soum-center or go there often enough could bring their waste to the platform by themselves. In 2016, official statistics show that there were already about 200 (or almost one third of nomadic households) to do so (see ***Figure 6***);
- Families who live far from the soum-center but close to their bag-center could drop their sorted waste there for a collection truck to collect it, in line with the second solution mentioned above. We can estimate that another third of the nomadic population would fall under this category;
- Finally, the remaining third of herder families, who live far from both soum-center and bag-center, would have their waste directly collected by a truck sent to their camp. Truck collection

[84] National Statistics Information Service, 2018.
[85] According to Khishig-Undur's administration contacted on April 11th 2018.

schedule shall be organized with neighbouring families to share costs. We can even imagine a system where trucks go to the camps bringing some cargo that the herders need in order to avoid empty trips and reduce the cost even more.

This conceptual organization will have to be further discussed with the herders themselves in order to match their needs at best and maybe to adapt the previously mentioned incentives (money, useful items, etc.) to their specific interests. However, we can see that waste collection does not seem overly complicated even for remote families who live 20 or 30 km from the soum-center. Then, if collection and transportation to the soum-centre platform is executed properly, we go back to the general issue of proper waste management we addressed earlier.

The last issue specific to nomadic families' waste would be what to do with the existing informal open dumpsites they have been creating and filling over time. Indeed, just as we plan to clear the soum-centre's dumpsite from its old comingled waste; it would be advisable to recover existing garbage in the steppe in order to restore the wilderness in the steppe. Considering how scattered and unregistered these small individual dumpsites are, the operation will be complicated if it is carried out at once solely by the association volunteers or the public services. The best solution would probably be to wait for nomadic families to progressively convert to sorting. Once a household will have definitely given up open dumping and sort their waste completely, clearing their old dumpsite can be done with their help for the last time.

How to recycle Khishig-Undur's waste locally?

At that point, all measures and actions previously taken according to our recommendations should lead to reduce the overall waste production and to bring and sort more and more recyclables within the waste-management platform premises. The last step is to find a way to recycle (or reuse, repurpose, and so on) them efficiently as locally as possible in a simple way. In this section, we will go over each domestic waste category as identified in Part 1 and try to describe realistic solutions for each one. The leads and ideas will remain as simple and pragmatic as possible: overcomplicated and expensive techniques (for either investment or management costs) will not be considered here.

It should also be noted that we will not discuss about who specifically should be carrying out the recycling activities (nor the actual management of the previously described platform). Maybe local authorities will find a way to allocate more resources and public services will implement everything.

Maybe some private businesses will emerge as they see a potential source of profit. Maybe the activist association itself will take care of recycling on a sustainable non-profit basis. Alternatively, maybe all three will collaborate or switch position over time. In any case, all possible stakeholders have limited resources so the only relevant point here is to try to identify inexpensive and simple recycling solutions that either of them could implement effectively and pragmatically.

As previously mentioned, quantitative data about waste production is not available for Khishig-Undur or any other rural soum. When asked, local authorities claimed that annual waste production in the whole soum is about 500 to 700 tons, but since there is actually now way for the administration to measure waste production and since it is not specified what type of waste is included or not in this alleged total (hospital waste, economic activities waste, ashes, etc.), this figure should be treated with considerable caution. Nonetheless, *Table 1* bellow presents an estimation for each type of household waste in Khishig-Undur, based on this total of 500 tons and the percentages shown in Part 1 for Ulaanbaatar's Ger District (***Figure 4***) – which is considered roughly representative of rural families.

Type of waste	**Weight** (tons)	**Proportion** (%)
Total	500	100%
Organic	215	43%
Plastic	100	20%
Paper	80	16%
Glass	70	14%
Textile	20	4%
Others	15	3%

Table 1: Waste production estimations for Khishig-Undur

Organic waste

Considering that statistics showing food waste to be the largest part of domestic waste (see Part 1), it seems that properly managing it will help decrease the total amount of ultimate waste enormously. Composting, which refers to a controlled method of using microorganisms to decompose organic waste, has proved to be a very relevant and effective way of managing "green" waste – in rich and developing countries.[86] This technique is fairly simple and inexpensive to implement anywhere in the world, including rural Mongolia.

[86] Taiwo (A.M.), *Composting as A Sustainable Waste Management Technique in Developing Countries*, 2011.

Composting organic waste as much as possible while eliminating waste and producing natural fertilisers at the same time can be profitable to the community through agricultural fields and pasture lands.[87] As mentioned earlier, either local farmers or the waste-management platform staff (or both) could carry out this green waste composting activity.

Being an extremely well known and widely spread technique, it seems useless to describe how composting works in details in this paper. It should only be mentioned that proper organic waste composting requires the right balance of "green" waste (i.e. vegetable peels) that are rich in nitrogen and "brown" waste (i.e. straw or saw dust) that are rich in carbon. In Mongolia, the lack of usual "brown" sources of carbon may complicate composting activities, but we will see later that pertinent alternatives can be found (see "Paper" section).

It should be noted that all organic wastes are not vegetables, and therefore not as easily compostable. While peels and such green organics degrade very rapidly, other common organic wastes are usually not composted together because they need more time to degrade, because they produce bad smells and/or because they tend to attract pests. This is essentially the case for animal products such as bones and other meat leftover. In rural areas of Mongolia, these meaty leftovers are often given to dogs so they do not end up in dumpsites. As such, they do not represent a major issue in the framework of this thesis. However, Mongolian rural context raises a much bigger challenge regarding animal waste: what should be done with carcasses of dead animals in big amount, considering the scale of herding activities?

Usually, when they lose a livestock, nomadic herders tend to abandon the carcass on the ground where it fell. Time and scavenging wild animals then take care of the rest. However, the ancient herders did not do the same. They had a dedicated spot for dropping of carcasses in order to reduce the risk of contamination, disease transfer, bad smells, exposure to children and other animals and many other reasons. The carcasses were buried or burnt if they suspected that it died due to sickness. Unfortunately, this very logical and neat tradition is lost with growing number of animals and herder households. In sedentary villages, where people also have livestock (although in more limited number compared to nomads in the steppe), carcasses are usually brought to dumpsites where they are openly disposed together with the general waste. As we can see on the pictures in ***Figure 10***, this is also the case in Khishig-Undur where we can see numerous carcasses lying around.

[87] Sullivan (D.M.) and al., *Food Waste Compost Effects on Fertilizer Nitrogen Efficiency, Available Nitrogen, and Tall Fescue Yield*, 2000.

Figure 10: Pictures of animal carcasses in the open dumpsite in Khishig-Undur
Source: Narantuya Gursed, 2017

Such a concentration of exposed animal carcasses can raise health problems.[88] Decomposing carcasses produce bacteria and other organisms such as salmonella that can affect human and livestock health through living parasites like flies and ticks. That is why specialised services are offered (and often mandatory) when a situation requires dealing with a dead animal in rich countries. Such services do not exist in rural Mongolia so it will be necessary to find other ways to manage the dead livestock safely.

Several techniques exist when it comes to dealing with a dead animal.[89] Composting actually is possible, and sometimes considered the best option in adequate contexts. However, the number of animals to deal with and the lack of sawdust, straw or any other necessary carbon source that we previously mentioned makes this solution very difficult to implement in small soums. Burning the carcase can also be an option, but it requires very high temperatures to disintegrate the body fully, which means lots of fuel. Therefore, incineration is often not considered a viable economic option, especially when resources are limited like in Khishig-Undur.

Burial thus appears like the most viable option left and a specific zone could be dedicated to that end in a remote part of the current dumpsite (out of the new platform to avoid unnecessary risks). Nevertheless, if this solves the issue of direct contamination of humans and animals, one problem remains if groundwater is close to the surface, it can be contaminated by pathogens leaching from the decomposing carcase, especially if many are buried in the same area.[90] As mentioned previously regarding the waste-management platform, basic investigations are necessary to make sure both the platform and the potential burial site are not located upstream from the public drinking water wells.

In remote areas, we could encourage herders to adapt the ancient method to dispose animal carcasses in a specifically dedicated area far from their livestock' grazing areas. This way, animal carcasses do not pose any threat to human and animal health, and are eaten by natural scavengers such as vultures, wolves, etc.

Paper waste

Due to their extremely low toxicity, (only inks can pose a problem) and fast biodegradability, most paper wastes – like food wastes – are not really polluting by themselves, so dealing with paper waste is a

[88] Syracuse University, *Dead Animal Hazards*, 2018.
[89] Rahman (S.) and Berg (M.), *Animal Carcass Disposal Options : Rendering, Incineration, Burial, Composting*, 2017.
[90] Freedman (R.) and Fleming (R.), *Water Quality Impacts of Burying Livestock Mortalities*, 2003.

minor issue in comparison with other types of waste. Yet, paper wastes represent about 16% of the total domestic waste (according to statistics show in Part 1 for Ulaanbaatar's Ger District). Therefore, it should not continue to be thrown into the wild as it is in Khishig-Undur, which means that it is necessary to find a way to manage it anyways.

Nowadays, paper can be recycled relatively easily thanks to long developed techniques.[91] In summary, the process is usually as follows: after paper is crushed, turned into flakes and mixed with water, filtration of the mixture eliminates foreign bodies (like staple, plastic and so on) before ink is removed through chemical and thermal processes. At the end of the process, the obtained paste is dried and packaged for shipment to a paper mill. This way, old paper is used as a raw material to make new pieces of paper instead of requiring more wood which is the principle raw material to make paper.

This worldwide-used technique appears rather simple but it does require a minimum of specialized infrastructures to be able to recycle paper efficiently. This is why it appears difficult to implement in rural Mongolia. On one hand, resources are too limited in small villages to invest in large plants. On the other hand, if enough financing were available to build small and affordable infrastructures, the loss of economies of scale would most likely make the process not economically viable. In addition, even if recycling paper locally through this technique were possible and relevant, there would still be no local paper mill to sell the recycled paper to, having to send it all to paper mills in Ulaanbaatar would definitely make the overall cost and ecological footprint higher. In summary, considering the current level of resources and capacities, aiming to create a paper recycling facility in Khishig-Undur does not seem realistic – at least on the short term.

Today, at least one large paper recycling plant does exist in the capital city so it could be considered to send all sorted paper waste there to be recycled. Then again, frequent six-hour journeys from Khishig-Undur would consume a significant amount of fossil fuel that would defeat the purpose of trying to reduce the ecological footprint of waste, especially for a type of waste like paper that is not intrinsically dangerous for the environment. That is why it seems better to find a local solution to manage paper waste.

[91] European Paper Recycling Council, *The Recycling Process,* 2017.

Life Cycle Analysis (LCA)-based studies have clearly shown that recycling paper usually consumes overall less energy and produces less greenhouse gases than incinerating paper,[92] which is why this technique is usually favored. However, placed in the context of rural Mongolia, these studies may probably show different results. As we just explained, the gas emissions from truck transportation to Ulaanbaatar must be taken into account in the LCA calculations, which would lessen the advantage of recycling compared to incineration.

Moreover, as we mentioned earlier, more and more people use coal as fuel for their stoves. Obviously, paper does not have the same combustible power as coal (or wood) and cannot replace them completely. However, if paper is locally burnt in stoves instead of coal, the amount of greenhouse gases emitted by paper combustion should be roughly compensated by the avoided gas emission that coal incineration would have produced. Finally, taking the impacts of coal extraction and transportation into account– while waste paper is a combustible that is locally available anyway – would most likely invert (or at least balance) the conclusion of the previously mentioned Life Cycle Analysis studies.

Overall, considering these factors and ignoring the existing negative environmental impacts, encouraging a useful (it would contribute to produce necessary energy for cooking or heating houses) local incineration of paper waste may in fact appear as a valid solution, especially if the process leads to reduction of overall combustion of environment-unfriendly coal and precious wood.

The very fact that a significant amount of paper waste still ends up in landfills and dumpsites shows that Mongolians do not systematically use this simple and beneficial method of eliminating waste paper. This may seem surprising considering the fact that these families pay for the wood or coal they use, when they could fuel their stoves free with the paper waste they produce. This probably has to do with the fact that fire and fireplace is sacred for many Mongolians who believe that it should not be “polluted” with waste. Nevertheless, if a simple paper incineration were to be recommended, there would probably be many other places that could use paper waste as fuel (starting with the large stoves that are used to heat municipal buildings like the school, hospital, city hall etc.).

Even though energy-producing incineration can appear as a simple, effective and legitimate way to eliminate paper waste in the absence of conventional recycling solutions, paper may still prove itself an

[92] Finnveden (G.) and Ekvall (T.), *Life-cycle assessment as a decision-support tool—the case of recycling versus incineration of paper*, 1998.

even more valuable resource through other techniques. Being essentially composed of carbon, paper can be very useful in processes such as composting or dry toilets.

Indeed, as mentioned earlier, composting is to be encouraged, not only to eliminate food waste but also to produce valuable fertilizers for crops. But the limited resources of sawdust, straw and other "brown" organic waste – that are necessary to balance the composting process – can be a problem in rural Mongolia. In these conditions, paper and carton (at least the ones that do not contain too much ink, glues and other potentially toxic substances) can be used as this essential carbon source.[93]

In the same way, paper could be used instead of the regular sawdust necessary to operate dry toilets. Today, Mongolian toilets are usually simple holes in the ground, so developing proper dry toilets would be very welcome.[94] To that end, valorizing paper waste for that purpose appears to open interesting possibilities.

In summary, it seems like despite the difficulty to recycle waste paper conventionally in a small Mongolian village, possibilities exist indeed to use this type of waste as a resource, either to fuel stoves or facilitate composting and improve sanitation infrastructures. Further field research could help determinate which technique is the most suited, but a combination of all three seems perfectly appropriate: papers that are clean enough should be dedicated to composting and dry toilet while the ones that contain substances that may risk to contaminate should be incinerated to produce energy.

Plastic waste

Unlike organic and paper waste, plastic is characterised by a very low biodegradability: it can take hundreds of years for plastic to be fully degraded in the nature.[95] Considering the tremendous volume of plastic waste produced every year (as reminded above), that is why recycling plastic waste properly is perhaps the most important challenge regarding waste management in Khishig-Undur just like in the rest of the world.

[93] Vinje (E.), *Composting Paper. How to use cardboard and newspaper in your compost pile*, 2013.
[94] Developing eco-construction, renewable energy and dry toilets are actually one of the topics our association in Khishig-Undur aims for.
[95] 4Ocean, *How Long Does it Take Trash to Decompose*, 2017.

As mentioned in Part 1, less than 10% of the plastic ever produced around the world has been recycled so far. The recycling techniques can vary from one plant to the other but the basics usually remain the same[96]: after being sorted and collected, plastic is washed and resized into small particles. Then, each different type of plastic is separated and finally melted into new items (or pellets that will be used later to produce new items).

Once again, establishing a state-of-the-art plastic recycling plant requires huge investments that are very unrealistic considering Khishig-Undur's means. Ulaanbaatar now has a few plastic recycling facilities but, like most plants, they accept only a limited number of types of plastic items. Moreover, as we previously discussed, multiplying fossil-fuelled transportations to bring Khishig-Undur's waste to the capital city, in order to manage there, is not a solution we can recommend especially if this logic is applied to all 330 rural soums of Mongolia. Local recycling options must be developed additionally.

In fact, many handmade initiatives have emerged around the world to recycle some plastic waste locally: the Internet is rich in articles and videos presenting ideas on how to reuse, to repurpose or to recycle plastic materials with extremely limited means, like for instance simples techniques to turn plastic bottles into brooms.[97] Such artisanal techniques may seem anecdotal: they are clearly not enough by themselves and they definitely do not compete with industrial recycling. However, in the context of poor rural villages, they may help provide some complementary livelihood unemployed people, while slightly contributing to reduce plastic waste dumping.

More advanced techniques have also been emerging in order to repurpose plastic waste and turn it into a valuable resource. For instance, studies have shown that plastic waste can be used when mixed with bitumen to build roads.[98] This technique has already proved very effective – especially in India – to enhance the road resistance while dramatically reducing the cost of their construction.[99] More broadly, construction seems to be a field that will bring many opportunities to use plastic waste as a building material. In fact, whether it is for roads (that are insufficient and easily damaged by harsh winter climatic conditions) or houses (that lack efficiency, especially energy-wise), rural Mongolia is in great need of improvements for construction techniques so such prospects are more than welcome.

[96] Greentumble, *How Is Plastic Recycled: Step by Step,* 2018.
[97] TopDreamer, *How to Make a Plastic Bottle Broom in Less Than 3 Min,* 2017.
[98] Kwabena Appiah (J.) and al., *Use of waste plastic materials for road construction in Ghana*, 2017.
[99] MBA Polymers, *Introducing Indias' ''plastic roads''*, 2016.

Some inspiring techniques could prove very useful; especially the technologies that make it possible to create bricks out of plastic waste. In Colombia, a company called *Conceptos Plasticos* is building inexpensive modular houses for underprivileged people using such a technique.[100] Another company called ByFusion uses a comparable technology in New-Zealand.[101]

Research is still in progress and this kind of approach in the construction field will definitely bring major opportunities around the world.[102] Unfortunately, such actors have not emerged yet in Mongolia and developing or importing similar technologies require large investments that are not available in (or around) Khishig-Undur. On the same note – and without ruling these options out for the future (on the contrary) – finding more affordable and accessible ways to reuse/recycle plastic is thus necessary for Mongolian soums.

Figure 11: Picture of a construction brick made of plastic waste
Source: ByFusion, 2018 (www.byfusion.com)

In the construction field, there actually are more rudimentary ways to reuse plastic waste especially plastic bottles. Having been developed for decades in the United States of America as well as in many

[100] Conceptos Plasticos (http://conceptosplasticos.com)
[101] ByFusion (http://www.byfusion.com)
[102] Kamaruddin (M.A.) and al., *Potential use of Plastic Waste as Construction Materials: Recent Progress and Future Prospect*, 2017.

parts of the world, "*Earthship*" construction has been proving the possibility of using old plastic bottles (as well as tires, aluminium cans, glass bottles, etc.) directly as building materials[103] (see picture in ***Figure 12***). Other stakeholders, like the Colombian non-profit organisation Organizmo, promote similar techniques.[104] Beyond using plastic as a valuable resource, this kind of construction would more broadly be very relevant for other points of views such as energy efficiency.[105]

Nonetheless, even if enough people decided to build such unconventional houses, these rudimentary uses of plastic waste in construction could only bring, at best, a solution to the issue of bottles. Obviously, there are many other types of plastic wastes that would still need to be managed – the very types that cannot be recycled by formal recycling industries. Additional recycling techniques are therefore necessary to bring a more comprehensive response to the plastic waste issue.

Figure 12: Picture of an Earthship house construction using plastic bottles and other types of waste
Source: Writinglikeastoner, 2013 (https://writinglikeastoner.wordpress.com/tag/earthship/)

It turns out that a simplified version of plastic-recycling plant machines has been developed over the past few years, enabling to recycle virtually any kind of plastic waste. Since 2013, Dutch designer Dave

[103] Earthship Biotecture (https://www.earthshipglobal.com)
[104] Organizmo (www.organizmo.org)
[105] Grindley (P.C.) and Hutchinson (M.), *The thermal behaviours of an Earthship,* 1996.

Hakkens has been creating small plastic recycling machines within the framework of a project called *Precious Plastic*.[106] He has been offering the open-source designs as well as detailed tutorials online so that anyone could reproduce them and start plastic recycling activities on their own. His initiative has rapidly grown to become a worldwide community of low budget recyclers that keep improving the machines and recycle more and more plastic waste. So much so, that Precious Plastic won the Grand Prize at the Famae Challenge 2018, which rewards the best innovative solutions to reduce or recycle waste.[107]

According to Precious Plastic information, the machines are inexpensive to build (about 200 US dollars each) and can be handmade anywhere without difficulty, from most parts from basic materials that can be found everywhere around the world (including Mongolia). This approach seems extremely interesting for any community and village in developing countries, Khishig-Undur included. Considering the prospects and possibilities offered by these machines, it seems interesting to present Precious Plastic's technique more thoroughly in this section.[108]

As of 2018, Precious Plastic has created its third version of the plastic-recycling machine and now provides a whole package of blueprints as well as step-by-step informative manuals, video tutorials, and even advices for workspace and business plan to guide new recyclers through the whole process for free. As we already explained earlier, Precious Plastic logically insists on the importance of collecting and sorting plastic properly in the first place. I found out that some of the recyclers pay around 10 cents/1kg of plastic (an amount that can vary from country to country) to the people who bring it to them. It demonstrates that handmade recycling machine can find an economically viable model while rewarding people who sort and bring their plastic waste to the recyclers (confirming what we discussed above in this thesis).

Precious Plastic precises that plastic waste should be sorted by category, according to the ASTM International Resin Identification Coding System[109] that usually appears on the items:

1. PET (polyethylene terephthalate);
2. HDPE (high-density polyethylene);

[106] Precious Plastic (https://preciousplastic.com)
[107] Famae (https://famae.earth/en)
[108] The following information all comes from the project's website or its informative manual that can be downloaded directly.
[109] ASTM International, *Standard Practice for coding plastic manufactured articles for resin identification*, 2018.

3. PVC (polyvinyl chloride);
4. LDPE (low-density polyethylene);
5. PP (polypropylene);
6. PS (polystyrene);
7. All other plastics.

Each type of plastic has its own physical features and can be identified through different basic techniques even if the ASTM code is not visible (see Annex 3). It is better to recycle each kind separately for at least three reasons. First, all plastics do not melt at the same temperature so recycling them together may greatly complicate the process. Second, because of their different characteristics, mixing different types of plastic tends to decrease the resistance of the final product. Third, mixing plastics would make the new item very difficult to recycle again in the future.

At that point, sorted plastic waste shall be resized thanks to the first machine: the shredder (see pictures in ***Figure 13***). Shredding plastic waste into small plastic flakes is an important part of the process because it facilitates the next steps of washing, storing, and – more importantly – melting. This kind of shredder is usually made out of recovered parts (motor, structure, etc.) as well as specifically laser-cut metal parts (blades etc.), which remains simple enough thus inexpensive. Once the machine is assembled, the motor will simply put the blades into motion so large plastic waste can be crushed and shredded.

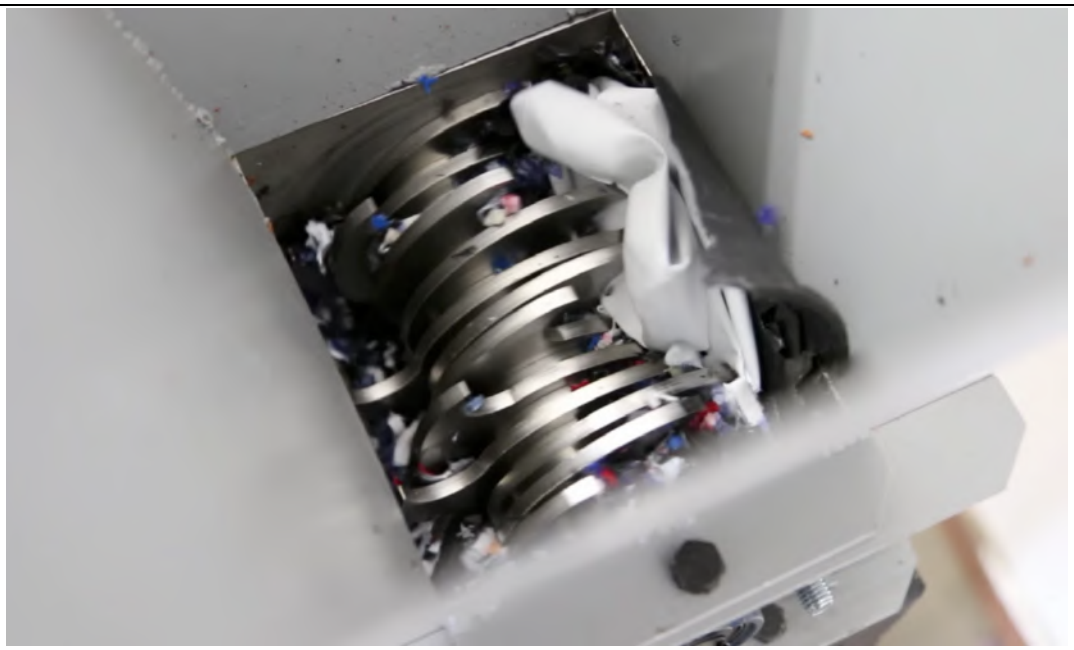

Figure 13: Pictures of Precious Plastic's shredder
Source: Precious Plastic, 2018 (https://preciousplastic.com/en/machines.html)

Once plastic waste is shredded, it should be washed from dust, dirt and impurities do not compromise the machines or the quality of the final product. Obviously, it is simpler if plastic is brought clean in the first place to the sorting area. Nevertheless, the most efficient way might be to wash it once it is shredded, by immersing the flakes into a tank of water. Afterwards, the plastic flakes should be dried before being stored by category until they are melted thanks to one of the three recycling machines Precious Plastic offers (see drawings in ***Figure 14***).

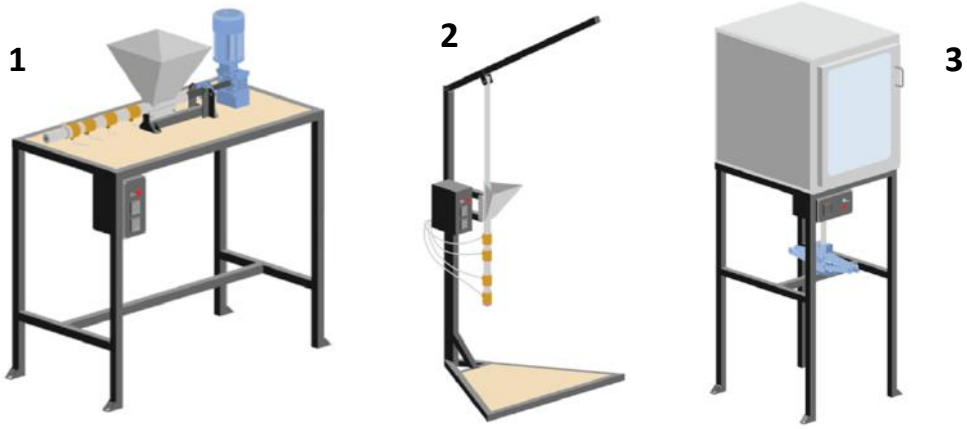

Figure 14: Drawings of Precious Plastic's extrusion (1), injection (2) and compression (3) machines
Source: Precious Plastic, 2018 (https://preciousplastic.com/en/machines.html)

These three machines all work according to the same principles: plastic is melted with heat before being shaped or pressed into a mould. When plastic cools down, the recycled item may need some final touch (usually quick sanding) and it is a new product ready to use. The main difference between each machine is the way plastic is shaped:

- With the extrusion machine, plastic is continuously melted (as long as there are flakes in the hopper) and extruded into a line of plastic, which can be used to make spools of plastic filament that will serve as raw material for plastic industries or 3D printing. Alternatively, you can directly create objects by shaping the filament while it is still hot.
- With the injection machine, melted plastic is injected into a mould by manually activating a lever. With this technique, a precise final item can easily be reproduced as many times as necessary. All that is needed is to first create or buy a mould.
- With the compression machine, the principle is the same as the injection machine except that plastic flakes are heated in an oven in a mould that is compressed by a car jack. This process takes more time than the previous ones, but it allows making bigger items.

Overall, no matter which machine is preferred, the handmade process Precious Plastic offers is particularly adapted to Khishig-Undur's context. It requires a very limited investment and virtually no specific knowledge or particular skill (except basic repairperson abilities to build the machines). Such machines could thus be easily constructed (if needed with the help of a local mechanic) to start recycling plastic, even before a comprehensive waste management system is fully implemented.

Of course, this technique has a very low productivity compared to large scale recycling factories. A standard Precious Plastic shredder seems to have a shredding rate of only one to two kilograms per hour depending on its motor power or the size of the hopper and mesh. Recycling at a large scale (ultimately for the whole village) would also require a significant amount of working force.

However, it should be noted that these machines are modular so they can easily be adapted to match the needs. In addition, being relatively cheap, it would be easy to build several of them if necessary. As for labour, many people in Khishig-Undur (like most poor rural villages) are unemployed (partially or totally) and may be interested in working in the field if it provides them with an income source – however small it is.[110]

[110] Official statistics of unemployment are not available at Khishig-Undur's scale. At national level, unemployment was over 9% of the active population in 2017, but this rate is much higher among sedentary people of rural villages (National Statistics Information Service).

In summary, Precious Plastic's technique offers what seems to be an adequate approach to Khishig-Undur's plastic recycling issue. Without knowing exactly how much plastic is produced in the village; the exact recycling rate of the machines; and the amount of people required to operate them, it is impossible to make an estimation about the costs and the long-term economic viability of this approach (especially if it was to be eventually scaled up to the whole soum). Yes, considering the amount of artisanal recyclers that have emerged around the world thanks to Precious Plastic,[111] we can assume that the concept offers real opportunities and adequate answers to the issue.

It appears that building a first set of machines in Khishig-Undur would allow experimenting the technique firsthand, start recycling plastic and collect valuable data. As people start sorting more and more in the village and as the need for recycling machines increases, the economic viability of the approach can be assessed precisely and new sets of machines can be built to progressively match the evolving needs.

A field study should be conducted to determine which kind of items would be the most relevant to create with these recycling machines. These items should be simple enough to create with basic moulds, but more importantly, they should be useful for the population in their everyday life. Only then can the items really motivate people to sort and bring their waste to recyclers. It could be for example bowls or other kitchen items, for which Precious Plastic already provides blueprints. Their website also offers the design of simple tiles that could be used to pave some public areas. Creating trash bins to give to the population would also be very useful as a way to facilitate sorting and enhance the speed and impact of the overall waste management system.

Glass waste

In industrialized countries, glass is relatively easy to recycle in large-scale specialized factories: after crushing contaminants are removed and glass is melted in a furnace before to be moulded or blown into new items (usually new bottles or jars, but not exclusively). Some aspects must be taken into account (colour of the glass, quality etc.), but the process is rather simple and widely developed. In addition, since glass does not undergo any degradation under the right conditions, it can theoretically be recycled

[111] Precious Plastic Community (https://preciousplastic.com/en/community.html)

indefinitely.[112] Nowadays, some countries like Switzerland or Finland already recycle more than 90% of their glass waste.[113]

However, like for plastic, the lack of recycling industries in developing countries makes it very difficult to reach such high recycling rates (which, for that matter, many riche countries still have not achieved yet[114]). This kind of large glass recycling plants have recently been emerging in Ulaanbaatar, but the problem of the distance to remote villages like Khishig-Undur remains the same as we discussed for plastic. Having said that, since these recycling factories pay a significant amount of money for some specific kinds of bottles and good quality glass, it may be interesting to consider sending at least these types of glass waste to the capital city for state-of-the-art recycling facilities. The overall volume of glass waste remains lower than plastic waste, so the total greenhouse gases emissions due to transportation could remain acceptable, especially if the logistics is planned efficiently.

For the rest of the glass waste, and in order to keep the logic of local recycling, other solutions implementable in Khishig-Undur itself are explored. Small-scale local glass recycling, using the same principle of fusion and moulding/blowing, is of course possible and exists in other countries.[115] However, in the context of a small village in Mongolia, this kind of recycling seems complicated, and it would face several challenges. First, the volume of glass to be recycled in a single village would be too small to invest in automatized equipment, and neighbouring villages are too far to coordinate investment and recycling management.

Individual handmade glass manufacturing would also be difficult to develop because it requires specific skills that are not found in rural Mongolia. Very high temperature that is needed to melt glass would also be an issue, as it would require lots of fuel that is either lacking or pollutant. Moreover, such artisanal manufacturing would require a significant local outlet that is not sufficient in the village, especially since the production costs would be high compared to the local standard of living.

Fortunately, glass waste does not necessarily need to be melted in order to become a useful resource. Primarily, a used glass item like an empty bottle should not be regarded as waste: glass properties make

[112] Stanford Recycling Land, Buildings and Real Estate, *Frequently Asked Questions: Glass Recycling*, 2018.
[113] Recyclenow, *Glass Bottles*, 2018.
[114] The United Kingdom recycles about 50% of its glass waste. In the United States of America, this rates falls down to 25 to 30%.
[115] Bertolini (G.), *Recyclage du calcin (verre cassé), recheche de debouchés alternatifs*, 1999.

it long lasting so glass items can easily be reused. Bottles and jars are particularly useful as storing containers for herders that produce a lot of milk and dairy. Supporting glass items reuse – through a better coordination between producers, shops and consumers – could thus reduce the production of glass "waste". In the process, by reducing the need for plastic containers, this could also help reducing plastic waste production.

If it cannot be reused as a container, glass waste can be used for other purposes. Besides decorative handicraft – for which the prospects appear anecdotal in the context of our study – glass waste can be useful in construction field. For instance, like plastic bottles, unbroken glass bottles are used as a precious construction material in houses like *Earthships* to build walls (see ***Figure 15***).

Figure 15: Picture of an Earthship glass wall, classic in this type of building
Source: Pinterest, 2018 (www.pinterest.com/pin/513621532494748884/)

Glass waste, especially if it is broken – and thus not reusable as a food/beverage container or an Earthship "brick" –, can also be useful in construction to make concrete. Many studies have already been conducted to demonstrate the feasibility of using glass waste as an aggregate in concrete mixes.[116,117] To some extent, this also appears to be the case for plastic waste.[118] More broadly, glass

[116] Chen (G.) and al., *Glass recycling in cement production – An innovative approach*, 2002.
[117] Bum Park (S.) and al., *Studies on mechanical properties of concrete containing waste glass aggregate*, 2004.
[118] Batayeh (M.) and al., *Use of selected waste materials in concrete mixes*, 2007.

aggregate is considered durable, strong, and convenient to compact.[119] As such, this material can prove useful for many other construction applications, such as backfill, drainage medium and so on.

Khishig-Undur may not have the technical knowledge and skills to implement such applications for now, but it is always possible to temporarily store the glass waste the village produces in a dedicated area of the waste management platform until a skilled stakeholder shows interest in it (for instance to build a road or any type of construction nearby). From this pragmatic standpoint, the sorted and carefully stored glass debris will stop being "waste" but a useful resource waiting to be used.

Textile waste

In comparison with the previous four types of waste (organic, paper, plastic and glass), which represent 93% to 98% of Mongolian domestic waste (see Part 1), textile waste is clearly not the most important issue. Their level of toxicity or direct impact on wildlife is relatively low and the overall textile waste remains limited in the village. Nonetheless, studies have shown that textile reuse and recycling do lead to positive environmental impact (mostly due to avoided production).[120] Most of these studies also stress that reusing provides more benefits than recycling.

In fact, as we previously mentioned, Mongolian herders have long been reusing their textile waste in order to protect their newborn or weak livestock from the cold winter. It should be mentioned that Mongolian winters are particularly harsh and livestock frequently die in large numbers during the most difficult winters (see Box 4).

Based on these observations, one simple recommendation can be made: whatever textile waste that is not reused yet and still ends up at the dumpsite in Khishig-Undur should be systematically recovered and transformed into valuable covers and blankets for livestock. If the amount of textile waste to transform into clothing items turns out to be important, the activity may even create jobs in the process.

The overall operation should be economically viable and sustainable for the different stakeholders involved, considering the "win-win" situation it will create. On one hand, the raw material (textile waste) will be free so clothes makers could earn some "easy" money while selling their production for a low price. On the other hand, there should always be a demand because herders will most likely be willing to

[119] CWC, *Developing Specifications for Recycled Glass Agregate*, 1996.
[120] Sandin (G.) and Peters (G.M.), *Environmental impact of textile reuse and recycling – A review*, 2018.

pay a small amount of money for livestock clothing if it can protect their precious animals from the high risk of death by harsh winters.

Box 4: Extremely harsh winters called "dzuds" that decimate Mongolian livestock

Over the past couple of decades, overgrazing has been intensifying a long feared phenomenon. While livestock numbers increase year after year, forage availability decreases, so much so that animals struggle to find enough food to constitute the fat stocks they need to face cold winters. As long as these winters are not too extreme, most animals manage to survive. However, as soon as a particularly harsh winter arrives – which is actually quite frequent – livestock start dying in mass. That is a phenomenon Mongolians refer to as "dzud" which is formally defined by the Mongolian Language Vocabulary Dictionary as a "*very severe food insecurity situation for both humans and animals caused by climatic factors during the winter*".[121]

Over the past twenty years, two major events (and several smaller ones) struck Mongolia, in 1999-2002 and 2009-2010: each killed about 10 million animals (which represented one third of the total national herd of the time).[122] After these devastating dzuds, thousands of nomadic herder families, who lost their entire flocks, were devastated and forced to flee towards Ulaanbaatar slums.

The impact of dzuds is unequal among herders: the ones who suffer the most are those who do not have access to good winter pastures, more precisely to grasslands that are naturally protected from the cold winds by hills or forests. For them, but also to a lesser extent for the rest of the herders, finding another way to keep their animals warm enough is an absolute necessity. Building shelters and amassing stocks of emergency forage is obviously a primary solution, but it requires money and time most do not have. However imperfect it may be, having access affordable animal clothing may thus be a life-saving option for many herders.

Stove ashes

As explained in Part 1, domestic stoves produce an important volume of ashes, which come from the combustion of either cow dungs, wood or charcoal. Estimations mentioned before show that, in winter,

[121] Leary (N.), *Climate Change and Vulnerability*, 2008.
[122] National Statistics Information Service, 2018.

the weight of these ashes could represent as much as the total amount of five types of domestic waste previously discussed together. Therefore, it seems particularly important to briefly examine this case and try to identify solutions – or at least potential leads and ideas – for its management.

The slash-and-burn agriculture – which consists in burning down a portion of forest to enrich the land with nutrients before to cultivate it – is a technique that has been used for thousands of years to sustainably fertilize soils[123]. Non-treated wood ashes from stoves might also play a role in soils fertilization. In fact, numerous studies have been carried out on the subject and many have shown that, when properly used, they really can improve the fertility of soils.[124]

The studies point out that the composition of ashes depend on many parameters, such as the type of wood that is burnt or the temperature of the combustion. In the same way, they stress that the benefits that can come from spreading wood ash also depend on bio-climatic conditions, such as atmosphere temperature and precipitations. Finally, beyond bringing some nutrients, wood ash is primarily a liming agent: it is very useful on acid soils but does not have much interest on basic ones.[125]

Without further field investigation and good knowledge of the soil characteristics in Khishig-Undur, it is thus difficult to conclude with certainty if wood ash from domestic stoves should be widely used to fertilize surrounding fields and pastures. Nonetheless, given that this method is considered safe, simple and economical[126], land application seems to offer interesting possibilities to dispose large quantities of wood ash. It thus deserves to be considered as a credible solution to ash management and to be investigated further in Khishig-Undur.

In addition, studies have shown that wood ash can have other interesting uses. For instance, tests and analyses have shown that it can significantly improve the quality and performances of compost.[127] Moreover, wood ash has also been used for millennia as an efficient insecticide.[128] Thanks to the hydroxides of potassium, sodium and calcium it contains, ash can be used as a detergent: it is

[123] Kleinman (P.J.A.) and al., *The ecological sustainability of slash-and-burn agriculture,* 1995.
[124] Demeyer (A.) and al., *Characteristics of wood ash and influence on soil properties and nutrient uptake: an overview*, 2001.
[125] Ohno (T.) and Susan Erich (M.), *Effect of wood ash application on soil pH and soil test nutrient levels*, 1990.
[126] Campbell (A.G.), *Recycling and disposing of wood ash*, 1990.
[127] Kuba (T.) and al., *Wood ash admixture to organic wastes improves compost and its performance*, 2008.
[128] Hakbijl (T.), *The Traditional, Historical and Prehistoric Use of Ashes as an Insecticide, with an Experimental Study on the Insecticidal Efficacy of Washed Ash*, 2013.

particularly effective to wash dishes when embedded dirt needs to be removed[129], and it can be used for laundry as well after making washing liquid out of the ash.[130] It has also disinfectant properties that make it a valid substitute for hand-washing soap in low-income communities.[131] In summary, in light of this non-exhaustive list of services and benefits that ash can provide, it seems clear that it should be considered as a valuable resource. Maybe all these justifications will change people's mind and stop throwing wood ash away in the dumpsite with other types of waste.

Studies on dung ash are unfortunately not as numerous as about wood ash thus, I could not find relevant information in academic papers. However, even though we cannot be sure about their reliability, it is worth mentioning that traditional practices involving dung ash for their beneficial properties are presented in different press articles, blogs and websites on the Internet. It is for instance the case on several Indian sites that mention the exact same properties as we previously described about wood ash.[132] Insect repellent and antiseptic properties of dung ash are also mentioned in a press article about South Soudan.[133] Another Indian website also stresses the seed preservation and pest repellent aptitude of dung ash[134]. Overall, these unsurprising findings tend to suggest that dung ash management in Khishig-Undur could basically be undertaken the same way as for wood ash.

It seems that coal ash is also widely used as a soil fertilizer, contributing like wood ash to neutralizing soil acidity and bring some useful nutrients.[135] This finding was more surprising considering that coal ash usually contains significant levels of toxic substances, mainly arsenic and heavy metals that can contaminate – and have contaminated – the environment.[136] While the practice of spreading coal ash over fields raises more and more critics[137], it seems dubious to recommend such a suspicious option for Khishig-Undur. It seems that coal ash may also find uses in other fields (like concrete)[138], but it requires specific technologies that is not available in the village.

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[129] Vasquez (G.), *Domestic Uses for Wood Ash*, 2012.
[130] Culture Acre, *How to Make Liquid Laundry Soap from Ash in 10 Easy Steps*, 2016.
[131] Bloomfield (S.F.) and Jyoti Nath (K.), *Use of ash and mud for handwashing in low-income communities*, 2009.
[132] Goseva, *Glories of Dung Ash,* 2018.
[133] Pemberton (B.), *The fascinating tribe that uses cow-urine showers and ash from dung fires smeared on the skin to fight infection*, MailOnline, 2016.
[134] Natural Farmers Kerala, *Effective application of ash in rural and farmers life*, 2013.
[135] Adriano (D.C.) and al., *Utilization and Disposal of Fly Ash and Other Coal Residues in Terrestrial Ecosystems: A Review*, 1979.
[136] Cherry (D.S.) and Guthrie (R.K.), *Toxic metals in surface waters from coal ash*, 1977.
[137] Cimitile (M.), *Is Coal Ash in Soil a Good Idea?,* 2009.
[138] Manz (O.E.), *Worldwide production of coal ash and utilization in concrete and other products,* 1997.

Since there is no sure, safe and accessible way of disposing coal ash in Khishig-Undur – and considering that, its combustion pollutes the atmosphere while its extraction contaminates groundwater[139] (which obviously go against our overall sustainable development goal) – we can only recommend that fossil charcoal use, as a fuel for stoves should be limited. Otherwise, it would be impossible to tend towards zero ultimate waste effectively. On the same note, given that Mongolia does not have much forest and deforestation is already preoccupying[140], it would be reckless to recommend using more wood instead of coal only to serve the sole purpose of facilitating stove ash management. In the end, this digression raises the question of how to produce energy for rural Mongolians that both produces manageable amount of ash and is generally consistent with sustainable development. Working on stove and houses insulation efficiency as well as developing cleaner sources of energy are probably leads to investigate, but this would go beyond the framework of the present study.

[139] Tiwary (R.K.), *Environmental Impact of Coal Mining in Water Regime and its Management*, 2001.
[140] Tsogtbaatar (J.), *Deforestation and reforestation needs in Mongolia*, 2004.

CONCLUSION

With the adoption of a more sedentary lifestyle, the switch to a market economy, the changes in consumption habits and the growth of the population, Mongolia has been facing increasing challenges regarding solid waste management. The waste production rate does not appear significantly higher when compared to many other countries, but the lack of infrastructures, organization and resources have led to a very unsatisfying reality.

Indeed, poor data collection makes it difficult to evaluate the amount of waste produced, disposed and recycled precisely but it appears that solid waste management is very ineffective and insufficient throughout the whole country. While the capital city suffers many challenges at every level and struggles to implement a relevant waste management system, the latter is practically inexistent in rural villages, where garbage is simply dumped in a large, vaguely delimited area out in the steppe. Sorting is almost unknown in Mongolia while recycling and composting are still extremely limited.

As evidenced by the recent ban of certain type of single use plastic bags and the efforts to develop an "Ecopark" in order to support recycling initiatives in Ulaanbaatar, public authorities are aware of the problem. Nonetheless, the lack of resources and the fact that priority is given to other major issues leaves Mongolia insufficiently armed to face the waste management challenge, especially in the countryside soums.

As almost no budget available for public waste management in rural villages, it seems particularly important to call for alternative initiatives there. In addition, considering the relatively limited population and the distance between each village, it seems unrealistic to plan – in short or medium term – the creation of conventional large recycling facilities, as the ones that we see in richer countries. That is why, in the light of all these constrains, more hope can probably be put for now in the development of a local and autonomous handmade waste management system initiated by a non-profit activist association.

Beyond the lack of means and infrastructures, the problems first come from the lack of knowledge among the population. For that reason, it seems extremely important to raise Mongolian people's awareness about environmental issues and sustainable development, in order to build a general eco-consciousness that will allow behavior change regarding waste management. Many activities – such as

film projections, group discussions, waste picking campaigns, or personal challenges like *Plastic Free July and Waste Bucket Challenge* – could easily be carried out in the framework of a civic association.

The goal would be for people to realize why and how they should start paying more attention to waste production and management at an individual level. Only once people will have really integrated the "3 R's rule" (*reducing*, *reusing* and *recycling)* will adequate waste management be possible at community level. To that end, placing children at the heart of the awareness raising campaign – at school but also thanks to extracurricular activities connecting them to nature – will probably be the best way to see changes both in short and long term.

Besides trying to reduce waste production in the first place by raising awareness, it will obviously be just as essential to develop appropriate infrastructure that allow an adequate management of whatever waste is still produced. Clearing the old open dumpsite in order to make room for a proper waste management platform appears to be a necessary first step. At the very least, there should be several containers dedicated to each main type of domestic waste to enable sorting and recycling effectively.

Composting (and dry toilets) should be developed in order to turn food waste and some carton and paper waste into valuable fertilizer. The papers that contain important quantity of potentially toxic inks and glue probably should not be used for composting to avoid all risks to human health. However, they could easily be eliminated if they were used more as fuel for fire stoves.

Stove ashes could also be used widely for soil fertilization, if local field studies confirm the adequacy between ash composition and soil needs. Other interesting usages – such as detergent, insecticide etc. – have been identified, which tends to confirm that stove ash could be turned into a valuable resource from a useless waste. Only coal ash may be more difficult to use given the toxic substances it may contain.

Under the right logistics and assuming a financial benefit, it may be interesting to send some of the glass waste to Ulaanbaatar for conventional recycling. Glass could also be used locally, especially in construction whether as a "brick" for specific houses like Earthship or crushed and mixed in concrete or as backfill. In parallel, textile waste could very easily be used to make cheap and extremely welcome animal clothing for herders to protect their weakest livestock in winter.

At the end, given their important volume and their impact on the environment, plastics seem to be the most important issue in Mongolian villages just like everywhere in the world. Nonetheless, several

interesting uses were identified that could turn plastic waste into a valuable resource even in remote soums like Khishig-Undur. Not only plastic bottles could be used in several ways in construction (both for buildings and roads), but it could also be recycled through a more conventional way thanks to small-scale "Precious Plastic" machines that are easy and inexpensive to build.

Overall, this thesis shows that many local and handmade solutions do exist to reuse or recycle virtually all of rural domestic waste. Considering how basic most of these techniques are, the cost of such adequate waste management would definitely be relatively limited – but additional field investigation should be conducted to estimate these costs precisely.

In any case, it appears that an associative-led approach would be particularly relevant in the absence of dedicated public or private actors: in a context of scarce public resources and limited short-term profit potential for businesses, motivated and passionate activists are probably the most relevant stakeholders to initiate the necessary changes.

In addition, it appears that synergies can be found with many other aspects of local sustainable development. Food and paper waste, like stove ashes, can have a major role to play in the development of a much needed local agro-ecology. Textile waste can help herders to cope with the harshest winter they have to face. As for glass and plastic waste, they can become resources to build new types of roads and houses that are more suited to Mongolian climate than the current ones.

In conclusion, it is clear that initiating and developing all the measures highlighted in this paper would face many obstacles and require time. It is not easy to change people's habits and behaviors that they developed over long period. In fact, the inhabitants of Kamikatsu, the small Japanese village that is approaching Zero waste, were also reluctant to change at first.[141] Nevertheless, with enough effort and time invested, the local leaders have managed to convert them to the idea and everyone is now very proud of their achievement.

[141] Fleuri (J.), *Un village japonais Zéro déchets*, 2017.

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ANNEX 1: GREEN CROSS AUSTRALIA 6RS' CHECKLIST

(1 page)

Source: www.greenlanediary.org/media/9915396/gld_6rs_checklist.pdf

The 6Rs

Reduce, reuse, recycle, refuse, respect and replenish

The 6 Rs are a great way to track your environmental impact. Use this checklist to ask yourself, what else could you be doing to help protect our wonderful environment?

☐ **reduce**

Can you reduce the amount of rubbish or waste you are using?

☐ **reuse**

Before you throw it out, can you reduce or reuse your item?

☐ **recycle**

Could recycled materials be used for your activity?

☐ **refuse**

Only accept things that are the best option for the environment. For example, is the packaging really needed?

☐ **respect**

Think twice about our great planet. Is there a better way to solve this problem that is less damaging to the environment?

☐ **replenish**

Walk the talk! Are you replacing what you use so there are enough of the world's resources for everyone?

GREEN CROSS Australia

greenlanediary.org

ANNEX 2: PLASTIC FREE JULY CHALLENGE'S CHECKLIST

(1 page)

Source: www.plasticfreejuly.org/action-picker.html

My Challenge Choices (Getting started) PLASTIC FREE JULY

WHAT TO AVOID	HOW TO AVOID IT	YOUR IMPACT Ocean/Landfill/Global warming	YES, I'LL DO THIS
Fill the yellow bin with plastics for 'recycling'	Avoid as much plastic packaging as you can		☐
Pre-packed fruit and veg	Choose loose products (skip the little plastic bag or put in a reusable bag)		☐
Lightweight plastic bags	Remember your reusable shopping bags or use a cardboard box		☐
Personal care products containing plastic microbeads	Check the products you buy for microbeads (polyethylene, polypropylene, nylon) visit beatthemicrobead.org		☐
Bottled cleaning products	Opt for refills, bulk store products or make your own alternatives. Choose glass or cardboard packaging		☐
Bagged dry foods	Buy from a bulk store (fill your reusable container) or opt for cardboard boxed product		☐
Pre-packed meat or fish	Shop at the deli counter or butcher or fishmonger for paper wrapped cuts or BYO reusable container		☐
Takeaway drink straws	Refuse plastic straws (or opt for a paper straw if they have them). BYO reusable straw		☐
Takeaway coffee cups	Bring your reusable cup or sit and enjoy a real cup		☐
Takeaway utensils and containers	Support vendors offering compostable alternatives (bamboo or card), BYO reusables or sit and enjoy 'dine-in'		☐
Bottled water	Fill a reusable bottle from the tap		☐
Bottled soft drinks	Reduce the amount (helps your health), or make your own with a sodastream or choose glass bottles (and recycle)		☐
Bin liners (or 'reusing' plastic shopping bags)	Have a sealed container for 'wet' scraps and compost or freeze until bin day. Line the kitchen bin with paper		☐
Scooping your pet poo in plastic bags	Buy cornstarch based compostable bags online or at a pet suppliers or consider a dedicated pet poo composting system at home		☐
Milk containers (plastic)	Choose waxed card or glass bottled brands (depending on your local glass recycling). Make your own nutmilk		☐
Plastic food wrap for leftovers and sandwiches	Use a reusable lunch box to store food, store food in containers or use beeswax wraps		☐
Littering: cigarette butts, balloons	Dispose of cigarette butts in the bin (they are plastic and wash into the ocean environment) Avoid releasing balloons (what goes up, must come down)		☐
Ignoring other people's litter	Pick up that plastic bag blowing in the street, empty food containers, straws etc.		☐

Avoid landfill waste

Reduce your eco-footprint

PLASTICFREEJULY.ORG

Protect the ocean

ANNEX 3: PRECIOUS PLASTIC'S INFORMATIVE SHEETS

(3 pages)

Source: https://preciousplastic.com/en/videos/download.html

Floating properties

floats on:	alcohol	vegetable oil	water	glycerin
PET 1	no	no	no	no
HDPE 2	no	no	yes	yes
PVC 3	no	no	no	no
LDPE 4	yes	no	yes	yes
PP 5	yes	yes	yes	yes
PS 6	no	no	no	yes

Visual properties

Type	name	properties	common uses	burning
PET	polyethylene terephthalate	clear, tough, solvent resistant, barrier to gas and moisture, softens at 80°	Soft drink, water bottles, salad domes, bisquit trays, food containers	yellow flame little smoke
HDPE	high-density polyethylene	Hard to semi-flexible, resistant to chemicals and moisture, waxy surface, softens at 75°	Shopping bags, freezer bags, milk bottles, juice bottles, iceacream containers, shampoo, crates	difficult to ignite smells like candle
PVC	polyvinyl chloride	Strong, tough, can be clear and solvent, softens at 60°	Cosmetic containers, electrical condult, plumbing pipes, blister packs, roof sheeting, garden hose	yellow flame green spurts
LDPE	low-density polyethylene	Soft, flexible, waxy surface, scratches easily, softens at 70°	Cling wrap, garbage bags, squeeze bottles, refuse bags, mulch film	difficult to ignite smells like candle
PP	polypropylene	Hard but still flexible, waxy surface, translu-cent, withstands solvents, softens at 140°	Bottles, icecream tubes, straws, flower-pots, dishes, garden furniture, food containers	blue yellow tipped flame
PS	polystyrene	Clear, glassy, opaque, semi tough, softens at 95°	CD cases, plastic cutlery, imitation glass, foamed meat trays, brittle toys,	dense smoke
OTHER	all other plastics	Properties depend on the type of plastic	automotive, electron-ics, packaging	all other plastics

Physical properties

Plastic	Thermal Properties				Strength		Density
Abbreviation - Brand name	Tm	Tg	Td	Cte	Tensile	Compressive	
	°C	°C	°C	ppm/°C	psi	psi	g/cc
PET - Polyethyleneterephthalate	245 265	73 80	21 38	65	7000 10500	11000 15000	1.29 1.40
LDPE - Low density polyethylene	98 115	-25	40 44	100 220	1200 4550		0.917 0.932
HDPE - High density polyethylene	130 137		79 91	59 110	3200 4500	2700 3600	0.952 0.965
PP - polypropylene	168 175	-20	107 121	81 100	4500 6000	5500 8000	0.900 0.910
PVC - polyvinylchloride		75 105	57 82	50 100	5900 7500	8000 13000	1.30 1.58
PS - polystyrene		74 105	68 96	50 83	5200 7500	12000 13000	1.04 1.05

Tm - crystalline melting temperature (some plastics have no crystallinity and are said to be amorphous).

Tg - glass transition temperature (the plastic becomes brittle below this temperature).

Td - heat distortion temperature under a 66 psi load.

Cte - coefficient of linear thermal expansion.

Tensile Strength - load necessary to pull a sample of the plastic apart.

Compressive Strength - load necessary to crush a sample of the plastic.

Density - aka specific gravitymass of plastic per unit volume.