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Plastic Waste Prevention in Gothenburg

A case study of current state and feasible measures to move up the waste hierarchy

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Master's thesis in Industrial Ecology

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Abstract

The applications of plastics seem unlimited but the material has been overused and side effects have been neglected. In Gothenburg, plastic litter as well as the increase in plastic waste and in the consumption of plastics are contradictory to the city's aim of a sustainable development. The current preference for plastic waste management instead of plastic waste prevention treats the symptoms and not the causes and moves the system into an unsustainable lock-in. The aim of this thesis is to understand how plastic waste can be prevented in the geographical region of Gothenburg. A literature review, semi-structured interviews, data of a material-flow-model of Gothenburg, waste and litter statistics for the city and the backcasting methodology were used to understand and evaluate the current system and envision what plastic waste prevention means in a sustainable future. Successful plastic waste prevention initiatives worldwide are investigated and compared to local ongoing waste prevention initiatives to evaluate possible implementations of initiatives currently lacking in Gothenburg.

The study shows that for a sustainable future, the way society thinks about plastic has to change. Also, some major regulatory changes are essential, and other minor legislative improvements could effectively contribute to tackle the plastics problem. Furthermore, five measures are suggested that could encourage plastic waste prevention in Gothenburg: (1) a package-free store, (2) adding an objective in the environmental goal of the city, (3) creating an online platform for information and innovation, (4) introducing a deposit-refund system for reusable coffee-cups, (5) actions to raise awareness by promoting international theme-days on plastics, initiating public pick-ups and building a trash inceptor in the canal. These actions combine intervention on multiple levels of the system by targeting different groups. Thus, these actions address multiple parts of the complex problem in order to achieve a move up the waste hierarchy a long-lasting and significant impact.

Keywords: plastic waste prevention, plastic pollution, waste hierarchy, backcasting, Gothenburg

Preface

This master thesis was written at the Challenge Lab at Chalmers University of Technology in Gothenburg, Sweden. The Challenge Lab is a place where students with different educational backgrounds come together to explore and drive sustainability transitions with a regional context.

The process of this project was divided in two parts. During the first phase, the research questions were identified. This was achieved by using the backcasting methodology to detect sustainability issues in the region. In the second phase, the work with the actual research questions was carried out. A brief summary of the the first phase, the whole process and the Challenge Lab is given in chapter 2. A more detailed elaboration of the process can be found in form of a report in Appendix A. The main thesis focuses on the work with the identified research topic.

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Introduction

1.1 Project background

A hundred years ago, plastics hardly existed. Today, it is everywhere. The production has increased exponentially from 2 Mt in 1950 to 380 Mt in 2015 (Geyer et al., 2017). It is in phones, cars, clothes, coffee cups, sports equipment, houses, airplanes, shampoo and tooth paste and much more. This is due to its very unique attributes. Plastic is durable, long-lasting, resistant to all kinds of liquids and lightweight. Using additives, these characteristics can be altered and specified. Plastics make cars and airplanes lighter and therefore more fuel-efficient and it keeps medical equipment hygienic at low costs. The applications of plastics seem unlimited, but the material has been overused and side effects have been widely neglected.

Plastics is accumulating in nature. The material does not naturally occur in the environment and can therefore not be taken care of. This means that plastics entering an ecosystem accumulates there. Around 4900 Mt of all plastics ever produced is accumulating in landfills and the natural environment (Geyer et al., 2017). Even the far most developed collection infrastructures can not prevent plastic leakage entirely implying that the total volume of plastics in the natural environment is increasing (World Economic Forum et al., 2014). Furthermore, plastics transcends man-made borders and the results of plastic pollution often occur far away from the origin. It is washed into rivers, which transport it into the oceans where it floats, is washed up on beaches or sinks to the sea bed (European Commissiosn, 2012). In may 2018, plastics was found on the most remote oceanic spot on earth (The Guardian, 2018). It has even been found in the air we breathe (Gasperi et al., 2018). In Bohuslän, a coastal area just north of Gothenburg, 6800 m^3 of plastics are washed up every year even though the region, the country and northern Europe have far developed plastic collection systems.

Plastic has negative impacts on the environment. Although the exact impacts are not yet completely understood, the proven down-sides of this material have been widely neglected up until now. Some of the more obvious effects are animals getting entangled in bigger pieces of plastics or animals confusing plastics with feed, which leads to an accumulation of plastic pieces in their stomachs. Wilcox et al. (2015) found that around 90 % of sea gulls' stomachs contain plastics.

Additives of the polymer can have severe health impacts. For humans, these include

reproductive toxicity, mutagenicity and carcinogenicity (Gasperi et al., 2018). The full scale of harm plastics have on ecosystems is not yet fully understood, however, it can be assumed that future research will not lead to reduced cause for concern (Eunomia Research, 2016).

To improve the situation, the amount of current and future plastic waste needs to be reduced. Prevention is the most effective measure to reduce waste (European Commission, 2008). The EU acknowledged this already in 2008 when they implemented the waste hierarchy as the most important tool for waste management (European Commission, 2018a). Also, prevention is the only measure that allows to reduce waste even before its occurrence. The lower and less effective measures of the waste hierarchy concern the treatment of existing waste. They are reuse, recycling, recovery and disposal, in the order of decreasing effectiveness (European Commission, 2010).

The location of Gothenburg provides an interesting geographical area to investigate plastic waste prevention. Gothenburg is a forerunner within Sweden concerning general waste prevention. Multiple waste prevention projects have proven successful over the last few years (Fahlgren, 2016; Lindroth, 2016). However there are still local problems with plastics.Examples are plastic parts and pieces that are washed up on beaches in Bohuslän (Lanne, 2013), plastic pellets pollution in the close-by plastic production site in Stenungssund was made public recently and it has been shown that 68 % of the fish in that area had ingested microplastics in their stomachs (Karlsson et al., 2018).

1.2 Aim and research questions

The aim of this thesis is to understand how plastic waste can be prevented in the geographical region of Gothenburg. The approach is to provide a comprehensive overview of the current situation in Gothenburg considering waste prevention including plastic consumption data, interviews with stakeholders, statistics of plastic waste and littering, the legislative context as well as ongoing initiatives tackling plastic waste. An evaluation of the current situation, including barriers, motivations and possibilities of waste prevention will be performed. In combination with the following research questions, the aim is to suggest actions and measures that are worthwhile to implement right away on a local level in order to ease the shift towards plastic waste prevention in the long run. This will be done by addressing the following research questions:

- What mindset change is needed to move from plastic waste management to plastic waste prevention in the future?

- What are possible measures and actions that can be implemented on a local level to prevent plastic waste?

1.3 Scope and delimitation

Plastics is a global topic consisting of countless individual sub-topics, ranging from the extraction of raw materials to health effects caused by additives. It is a widely used material and can consist of different chemical compositions. For this thesis, the focus is on the category of application rather than the specific kind of plastic from a chemical perspective. Therefore, when referring to *plastics*, different kinds of plastics are referred to but are divided into categories of their application and product type and the resulting waste stream. One category would for example be packaging. *Plastic* and *plastics* are used interchangeably.

The focus of this thesis is related to waste prevention, referring to actions and measures taken to prevent the creation of waste during the use phase. In other words, it describes steps taken before waste management is involved. Waste management options such as recycling and incineration is not part of this work. Waste prevention can occur in all steps of a products life cycle, ranging from material extraction to end-of life. Improving the design or the efficiency of extraction is not included in the scope. The target groups are the city and the consumers and actions that have an impact on them. The geographical delimitation is the area of Gothenburg.

1.4 Research approach and thesis outline

The research approach is visualized in Figure 1.1. Three main objectives where identified that will contribute to reach the aim of this research: (a) an investigation of the current situation including forces driving and hindering change; (b) an analysis of ongoing (plastic) waste prevention initiatives; (c) exploring the local relevance and context of plastic waste prevention and its development. To be able to reach these objectives, semi-structured interviews were conducted, literature was reviewed and data collected. Based on the findings, an evaluation of the current situation was made. The main findings of the thesis are divided into three main sections: (a) concepts for a sustainable future with a focus on waste prevention; (b) regulatory recommendations; (c) a list of suggestions of feasible actions and measures that will contribute to plastic waste prevention on a local level.

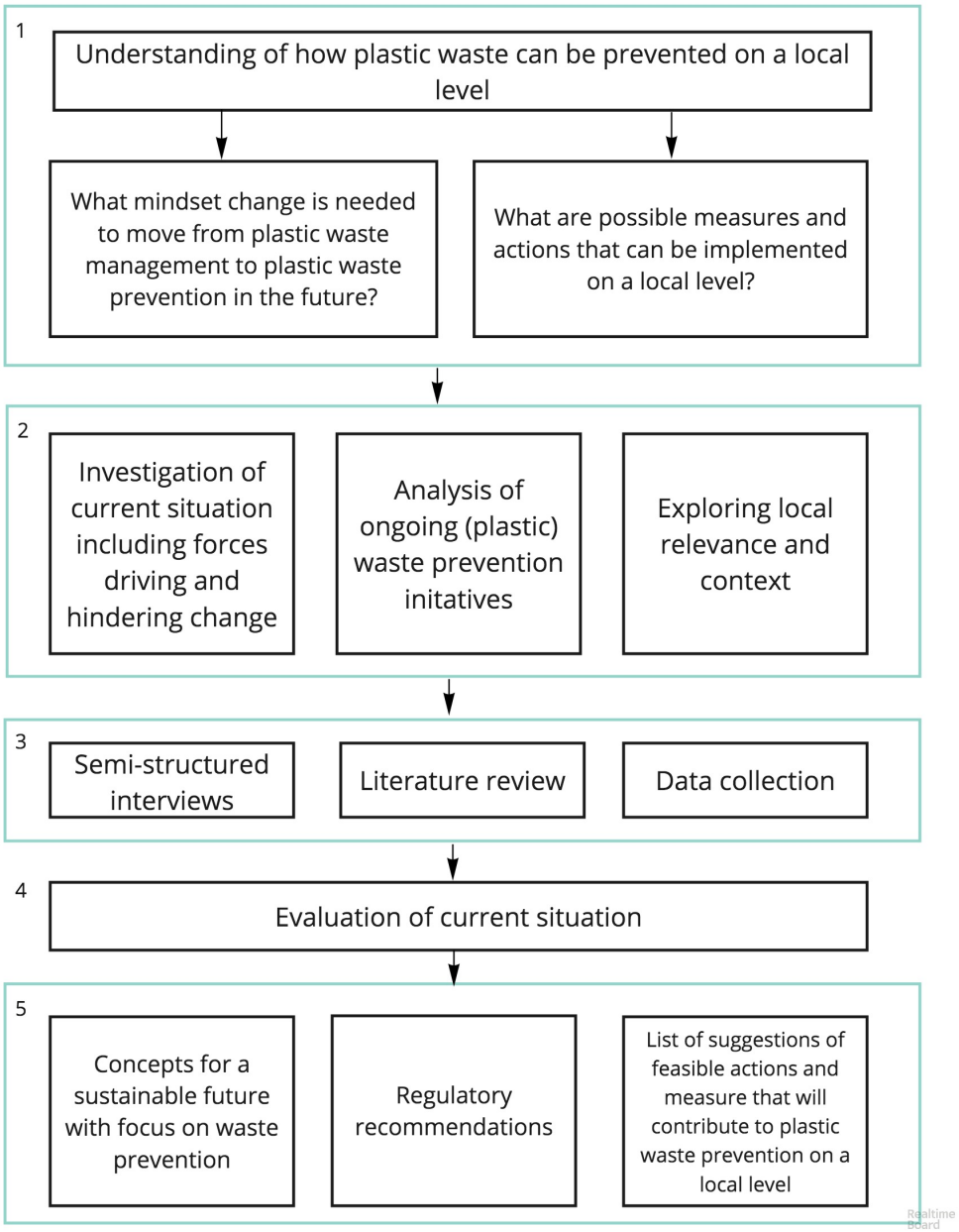

Figure 1.1: Overview of research approach. 1) Aim and research questions 2) Objectives of the study 3) Methods used 4) Evaluation of findings 5) Results

After this introduction, the process of how the research question was attained is described in chapter 2. This includes some general information about the Challenge Lab where this work was conducted and the process of identifying the research questions. In the following chapter 3 the methods used to obtain the results of this thesis are mentioned. After that, in chapter 4. the literature review performed is presented, concerning the research of plastic waste prevention including the definition, the legislative context, the waste management system in place in Sweden and Gothenburg as well as motivations and barriers concerning waste prevention. Chapter 5 shows the main takeaways of the conducted interviews. Next, in chapter 6, ongoing initiatives concerning general waste prevention in Gothenburg and

specifically plastic waste prevention initiatives around the world are displayed. In chapter 7, statistics for plastic consumption, household waste and littering will be presented for Gothenburg. An evaluation of the literature, the interviews, ongoing initiatives and statistics is performed in chapter 8. Chapter 9 will show what is needed to shift towards waste prevention and suggestions on actions that are able to contribute to plastic waste prevention locally in Gothenburg. A discussion about the conducted work (chapter 10) and some final conclusions (chapter 11) will complete the thesis.

2

Identifying the research questions

As mentioned in the preface, this thesis was conducted in two phases at the Challenge Lab. The first four weeks enclosed the first phase during which the research topic was identified. For the remaining 16 weeks, the research questions were addressed. The aim of this chapter is to give a brief summary of the first phase. First, a synopsis of the Challenge Lab is given explaining its purpose and functioning. This is followed by an introduction to the process of identifying the research topics in general and of this thesis in particular. A more detailed report about the first phase is attached in Appendix A.

2.1 The Challenge Lab

The Challenge Lab (www.challengelab.chalmers.se) is a platform at Chalmers University of Technology where master thesis students with different educational backgrounds are brought together to work with sustainability transitions in the region. The socio-technical challenges are both of a transformative and integrative kind since they are challenging the current system and connecting different actors in the region. The public sector, industry, the private sector and academia are brought together to understand the challenges and think about solutions that can initiate change (Holmberg, 2014).

The Challenge Lab was launched in 2014 with the aim of creating a hub connecting different actors in society, fostering from the interdisciplinary work environment that the Challenge Lab provides. The students are trained in leadership guided by a backcasting process for sustainability driven innovation. The Challenge Lab works with tranformational change that sparks with a small but well understood initiation, following the motto *"Think big. Start small. Act now."* . Key elements are the Backcasting methodology, self-leadership and stakeholder involvement, which will be explained in short in the following paragraphs.

Backcasting based on principles
The main methodological tool used during the Challenge Lab process is the backcasting methodology based on principles. It is a tool for transformational change divided into four steps. First, sustainability principles are identified. Next, the cur-

rent situation is analyzed. Third, solutions enabling a shift towards a sustainable future are identified. Last, strategies to implement the solutions are determined. This tool allows working with problems that are both complicated and complex in a structured way (Dreborg, 1996). During the first phase of the thesis, the first two steps of this methodology were performed.

Self-leadership
Discovering personal values, strengths and weaknesses and how to use them is the goal of self-leadership. During the first phase, multiple workshops were carried out to get a better understanding of one's personal identity. The main elements were the individual core values, motivation as well as strengths and weaknesses. Also, the personal appearance, miss-interpretation of strengths and overdone strengths were discussed to develop into a leader for sustainability transitions.

Stakeholder involvement
Involving all relevant stakeholders can be a difficult but useful task. First, they have to be identified for a specific challenge. Not all stakeholders might be relevant and each of them might follow their own subjective goals. However, different stakeholders can all contribute with their respective inputs. To which extent and how each stakeholder should and can be involved has to be identified for the individual case. Dialogues, discussions or workshops are just three possible methods to bring stakeholders together and perform as a group with more knowledge than each of the individual parties. The most common mode of interaction within the first phase is the dialogue, where stakeholders come together to learn from one another and together as a group.

2.2 Identifying the research questions

This section describes the process of identifying sustainability challenges and research questions briefly. A more detailed description can be found in Appendix A. Students involved in the Challenge Lab process worked on topics in three areas: Mobility, urban futures and circular economy. The research questions were identified by applying the first two steps of the backcasting methodology: a definition of principles for a sustainable future and an understanding of the current situation including an identification of leverage points (Meadows, 1997).

Principles for a sustainable future
The question of how a sustainable future should look like was answered by defining principles within the four dimensions of sustainability (see figure 2.1). These principles were obtained in workshops and then summarized in categories. The evolved principles were used as guidelines for a best case scenario when the current system was analyzed in the next step. They are a common and unique result of this year's Challenge Lab participants.

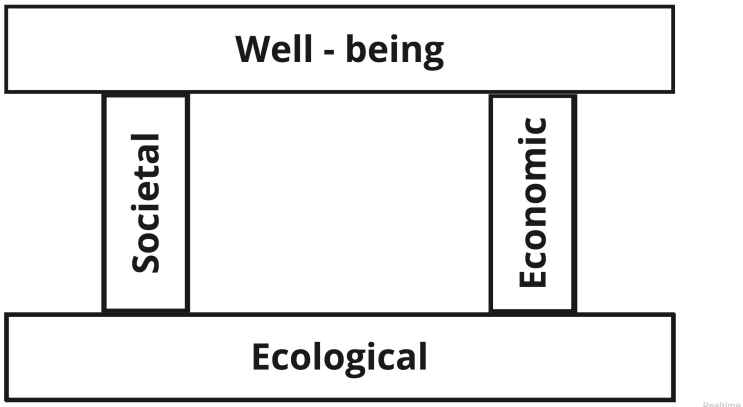

Figure 2.1: The four dimensions of sustainability; Inspired by Holmberg (2014)

Stakeholder dialogues
Stakeholders with different backgrounds and areas of expertise were invited to commonly create an understanding of the current situation within the three areas (mobility, urban futures and circular economy). Literature research was conducted as preparation. The involvement of these stakeholders took place in form of dialogue sessions based on the approach of *"learning together"* instead of arguing for a certain standpoint.

Identification of leverage points
Gaps, the difference between the current system and the desirable sustainable future, were identified with the knowledge gathered from the dialogues. By identifying places to intervene in the system (leverage points), the research questions were derived. Leverage points represent places in the system where a small change will bring about a substantial positive impact. The research questions each address a sustainability challenge in form of a gap and the key idea of how to tackle this gap.

The research question of this thesis has already been presented in Chapter 1. A more detailed description of deriving this specific gap, the leverage points and the research question can be found in the report about the first phase (see Appendix A).

3
Methods

The methods used to obtain the results of this thesis will be described in this chapter. First of all, a literature review was conducted. Next, statistics and data for the region were obtained from the city, a material-flow model and an app. Furthermore, semi-structured interviews with actors from different sectors were held. Key factors obtained from literature, interviews and data led to recommendable measures consisting of short-term actions and long-term efforts facilitating a mindset-shift. The necessary mindset shift is based on the backcasting methodology based on principles and leverage points by Meadows (1997). Finally, one of the short-term actions was further investigated to examine the feasibility of a concrete measure.

3.1 Literature review

To begin with, a literature review was conducted with the aim to find research related to the topic and to understand the legislative situation. To find relevant research about the topic, the search engines google, google scholar, the Chalmers library/Scopus and sciencedirect were used with the following keywords: "plastic", "pollution", "prevention", "legislation", "waste hierarchy", "waste management", "single-use plastics", "plastic ban", "plastic directive", "phase out plastics" and "marine litter". Also, some interviewees provided further literature. Later in the process, these keywords were refined to obtain more specific information. More detailed articles were searched for with these elements: "China's ban on plastic waste", "EU single-use plastics", "Waste Directive", "EU legislation marine debris", "EU plastic prevention initiatives", "initiative waste prevention", "zero waste cities", "zero waste initiatives", "action against plastic", "reduce plastic consumption", "waste statistics Sweden/-Gothenburg", "sustainable development goals Sweden/Gothenburg", "environmental strategy Gothenburg", "environmental code", "definition waste prevention" and "measuring waste prevention".

3.2 Waste statistics

To gather data explicitly for the city of Gothenburg, different sources were used. First of all, the provision of waste statistics by the city was used (Göteborgs Stad, 2018). In addition, the data from the Urban Metabolism analysis (UMan) model,

a material flow model at Chalmers, was analyzed (Rosado et al., 2014, 2016). For littering statistics in Gothenburg, data was obtains from a project between Keep Sweden Tidy Foundation, the environmental protection agency and the city of Gothenburg. Besides that, data concerning litter by an initiative called "litterati" (www.litterati.org) complemented the existing data. No other options to obtain further data for the specific region were mentioned in any interviews or in the literature.

3.3 Semi-structured interviews

Semi-structured interviews were conducted in order to obtain first hand information from a variety of actors such as politicians (regulating level), employees of the city (public sector), businesses (private sector), researchers (academia) and individuals involved in initiatives. Beyond that, the aim was to identify forces for and against the shift from waste management to waste prevention. In total, 23 interviews were held in person or via Skype or phone. Representatives of the following organizations, initiatives and companies were interviewed.

- Biopac Ltd (UK)
- Campact e.V. (GER)
- Chalmers Industriteknik
- Chalmers University of Technology
- Iceland Foods Ltd (UK)
- IVL Swedish Environmental Research Institute
- Kretslopp och Vatten, Göteborg Stad
- Litterati, LLC (NL)
- Lund University
- Center Parrty, national government
- Environmental Pary, regional government
- Univeristy of Gothenburg
- School of Business, Economics and Law, Gothenburg
- Zero Waste Europe (BL)
- Zwerfinator (NL)

The broad spectrum of interviewees provided a basis for understanding drivers and challenges and the legislative situation. Since defining the exact research questions was an iterative process based on the gathered information, interviews were less structured in the beginning and followed a clearer structure later in the process. Snowball sampling was performed in order to identify further relevant interviewees by following recommendations of previous interviewees (Noy, 2008). Besides these recommendations, the choice of interviewees was influenced by their role, their publications and recommendations from other interviewees. Notes were taken during the interviews and summarized concerning challenges, drivers, motivation, barriers and possible solutions. During the interviews, one interviewer led the interview while the second one took notes. After the interviews, the one leading the interview checked these notes. Different interpretations were discussed, missing parts added

and unclear parts revised with the interviewee.

All questions asked during the interviews were not the same in every interview. They differed depending on the role and relation of the interviewee to the plastic topic. The following questions were the basis for all interviews, follow-up questions were asked where they seemed appropriate.

- Do you think there is a plastic problem in Gothenburg?
- What is the problem from your perspective?
- How is your work related to this topic?
- What is your interpretation of plastic waste prevention? Do we need it?
- What are barriers/drivers concerning plastic waste prevention?
- What needs to change?
- Do you know about ongoing initiatives?
- Where does it make sense to prevent plastics in your opinion?

The notes taken during the interviews were discussed right after the interview. After that, a table was created using thematic analysis to summarize the statements divided into the following categories to easy the identification of forces for and against the shift towards waste prevention.

- Work sector
- Challenges
- Barriers
- Motivations
- Ongoing initiatives
- Possible Solutions
- Further Comments

3.4 Backcasting based on principles

Backcasting based on principles is explained briefly in chapter 2. It is a tool for transformational change divided into four steps (Holmberg & Robert, 2000). The first two steps were used to determine the necessary mindset-shift to move from waste management to waste prevention. The first step is the identification of sustainability principles. Without looking at the situation of the present, these principles describe what needs to be valid for a desirable sustainable future. These principles were then translated into the context of plastics and plastic waste prevention. The second step of this methodology is to get an understanding of the current situation which is a major part of this thesis. This provides a result for the first research question that addresses a mindset change concerning the use of plastics (see chapter 1).

3.5 Leverage points by Meadows

The methodology of leverage points by Meadows was used when evaluating the current situation, existing initiatives and recommendable initiatives. Leverage points are "places within a complex system [...] where a small shift in one thing can produce big changes in everything" (Meadows, 1997). That is, where small actions can lead to big change and move society towards a more sustainable future. In her publication from 1997, Meadows determined nine leverage points, starting with the least effective one (*"Numbers"*; standing for subsidies, taxes, standards) to the most powerful one: *"The mindset or paradigm out of which the goals, rules, feedback structure arise"*. Since complex systems cannot be generalized, leverage points were not used as a fixed recipe but as a guideline to think about the recommended initiatives and their probable implications on the system from another perspective. It complemented the process of understanding what change a certain action may or may not bring.

3.6 List of suggested measures

All the information gained through the above mentioned methods were the basis to determine a list of suggested actions. This was achieved by looking at ongoing initiatives in the city and plastic waste prevention initiatives found in literature and through interviews. The amount of investigated actions and measures was narrowed down to actions that are currently lacking or needs to be improved in the city. Some key factors were used to ease the process of comparing the initiatives. Key factors supporting the decision whether a measure should be suggested, were "category", "type of action", "addressed waste stream", "target group", "implementation", "leverage point according to Meadows" and "approach". Furthermore, the necessary paradigm-shift on a strategic level, corresponding to the highest leverage points by Meadows, was obtained by applying the backcasting methodology by Holmberg & Robert (2000).

3.7 Investigation of one concrete proposal

In order to further understand challenges to overcome when implementing possible solutions, one of the recommended actions was looked at in more detail. The idea of a deposit-refund system for coffee cups working like an existing system in Germany was tested concerning its potential in the local context. To do so, feedback for that system was obtained during meetings with employees of the city, persons in charge of the restaurants and cafés at the University, the innovation office at the University, possible producers of such a cup, the founder of the German company as well as multiple cafés and restaurants in the city who could join the system.

4

Literature review

The following chapter will give an overview of the research concerning waste prevention in general and plastic waste prevention in particular. First, a more detailed definition of waste prevention will be given and discussed due to the importance of understanding the meaning and different interpretations. This is followed by a review of the legislative context, the Swedish waste management system and its local implementation. The chapter will conclude with a synopsis of driving forces and barriers for prevention found in literature.

4.1 Definition of waste prevention

There is no common understanding of the exact meaning of waste prevention. Several definitions of waste prevention are used in different areas of society and in different parts of the world. For example, in France, composting is seen as waste prevention while this is not the case in Sweden (Corvellec, 2016). Furthermore, Hutner et al. (2017) found that waste prevention in local authorities is seldomly addressed in scientific research. Also, waste prevention shows an emerging societal interest that is questioning the current state of waste management (Corvellec & Hultman, 2011). A clarification of the definition of waste prevention is therefore necessary.

The most common understandings of waste prevention follow the definition by the OECD and the European Commission. According to the OECD waste prevention describes "measures taken before materials or products are identified or recognized as waste" (Vancini, 2000). These measures include avoidance, decrease at the source or product reuse. Theses actions aim to reduce both the quantity and character of waste. Hutner et al. (2017) describe these two different kind of measures as *quantitative waste prevention* (reducing the amount of waste) and *qualitative waste prevention* (reducing the environmental impact of waste). The European Waste Framework Directive is more exhaustive. It describes waste prevention as *"measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the re-use of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products."* (European Commission, 2008).

The different definitions of waste prevention can be applied to a wide range of activ-

ities. The European Environmental Agency (European Commission, 2018c) states that improving waste prevention management demands actions throughout the full product life-cycle, not only after disposal of the product. Waste prevention can occur at all stages, including extraction, design, production, distribution, consumption and waste management (Corvellec, 2016).

4.2 Waste prevention in a legislative and regulatory context

The situation concerning plastics today is a result of many influences among which the regulatory framework is essential. In the legislative context, waste prevention is usually included under waste management. Both are dealt with on municipal and national level. The latter one is strongly affected by the European legislation since member states are tied to it. The following section starts on the broad European level and narrows down to the regulatory context of Sweden and Gothenburg.

4.2.1 Plastics in EU legislation

Looking at the European legislation concerning plastic waste prevention in specific is complicated since there is no directive concerning plastics in particular. As stated by the European Commission (2013), plastic waste is not specifically addressed by EU legislation despite its emerging environmental impact. There is a variety of Directives targeting different parts of the plastic problem or certain items and groups of items, however, at the moment there is no directive in place handling the plastic waste and plastic pollution problem in a comprehensive manner. The following paragraphs will give an overview of the general approaches of directives, explain in short further documents and show the difficulty to find the necessary information when dealing with plastic waste prevention.

The European Commission has multiple kinds of treaties, some of which are binding and others are voluntary (Union, 2018). Regulations are binding legal acts to be applied by its entirety across the EU. Directives, the most common legal act concerning plastics, set out goals that all nations have to achieve. The process of how to get there, however, is up to the countries. Further treaties concerning plastics are not binding. Among those are Green Papers, Strategic Papers, Communications from the Commission to the European Parliament and further unspecified publications.

Prevention as the most effective way to reduce waste in general was included in the Waste Framework Directive (Article 4) together with the waste hierarchy in 2008 (European Commission, 2008). It gives a priority order for management legislation and policy (European Commission, 2008). Furthermore, the precautionary and sustainability principles are to be respected (Pilz, 2014). Except for shared cases on best practices, there is little information on how the waste hierarchy should be implemented and applied.

One of the major concerns when it comes to plastics, the chemical additives, is dealt with in the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation from 2006 (European Commissiosn, 2018). The concern about plastic additives has increased recently and the Directive is revised and improved steadily. Bisphenol A, for example, an additive that was found in plastic bottles, CDs, sports equipment, etc. was added to the list of of restricted substances because it is a reproductive toxicant (European Commissiosn, 2018).

Multiple Directives affect plastics but none of them in an exclusive and comprehensive manner. Besides the already mentioned Waste Framework Directive and REACH, the following Directives concern plastics in some way:

- Ecodesign Directive
- Packaging and Packaging Waste Directive
- Landfill Directive
- Urban Wastewater Treatment
- Ship-source Pollution Directive
- Port Reception Facilities Directive
- Marine Strategy Framework Directive
- Habitats Directive
- Birds Directive
- Water Framework Directive

All of the above touch upon plastics on very different topics (littering, marine pollution, etc.), different stages of the plastic life cycle (production, end-of-life, use phase) and different plastic waste flows (packaging, fish nets, etc.).

Besides the binding legislative acts, the European Commission has a variety of activities with the aim of voluntary action by states and industries as well as the attempt to move towards a common *European Strategy on Plastics in a Circular Economy* (European Commission, 2018b) including a *European Strategy on Plastic Waste in the Environment* (European Commission, 2013). Fact sheets are provided (European Commission, 2017) and reports published (Mudgal Lorcan Lyons Jonathan Bain Débora Dias Thibault Faninger Linda Johansson et al., 2011) concerning the urge of the problem and possibilities to act. Furthermore, there is information on *"best practices"* concerning waste prevention, a promotion of Green Public Procurement and a *Competitiveness and Innovation Framework Programme (CIP)* for environmental friendly packaging (European Commissiosn, 2012). One of the most recent publications from early 2018 pushes industry to submit plans on how to increase the recycling of plastics in order to prevent regulatory action (European Commission, 2018b).

4.2.2 Swedish waste management system

In line with the Directive of the European Commission requiring a waste and waste prevention plan from each member state, Sweden provided the national waste management plan and waste prevention program (Naturvårdsverket, 2018). Waste prevention is not only mentioned in the waste prevention program but also in the environmental code (Miljö- och energidepartementet, 1998) and national waste regulation (Miljö- och energidepartementet, 2011).

The national waste *management plan and waste prevention programme* provides an overview of objectives, policies and measures that have been introduced to prevent waste and to reach a more resource efficient waste management system. The aim is that the programme should provide support to the responsible authorities in the process of reaching goals connected to waste management and waste prevention (Naturvårdsverket, 2018).

Regarding packaging waste, paper waste as well as electric and electronic waste the producers are responsible for the collection and recycling of the discarded products. This is called *extended producers' responsibility* or short EPR (Miljö- och energidepartementet, 1998; Yngvesson, 2011). The nation wide material recycling rates for these materials have been increasing for the last couple of years, but the material recycling rates for plastic have been the lowest compared to the other materials throughout the years (see Table 4.1).

Table 4.1: Material recycling statistics in Sweden during the time period 2014 to 2016, in [%] (FTI AB, 2017)

Materials	**2014**	**2015**	**2016**
Glass	93	93,5	92,8
Cardboard	77,9	80,2	80, 40
Metal	72,5	73,0	77,5
Plastic	38,4	40,02	42,2
Newspaper	N/A	N/A	95,00

In Sweden, about 55 billion SEK of material is replaced in the socio-technological system annually of which 30 million SEK of material value is lost. This concerns steel in buildings that are demolished, plastic in packaging or other items that are thrown away and aluminum in vehicles that are scrapped. The loss is due to a 87 % loss of plastic material value, 58 % of the value of steal and 62 % of the value of aluminum. The large loss of value of plastics is due to a high incineration rate and a significant decrease in material quality after recycling (Re:source & Återvinningsindustrierna, 2016).

Municipalities have been allocated the responsibility of collecting and dealing with domestic waste. That means they are responsible that the waste is taken care of in an appropriate way. Energy recovery through incineration has become the most

dominant waste management solution in Sweden (Corvellec, 2016) since the introduction of a tax on landfilling in 2000 and a ban on landfilling sorted combustible and organic waste in 2005 (Eriksson et al., 2005). The recovered energy is mainly used for district heating. In Gothenburg, about 24 % of the district heating production in 2017 originated from household waste incineration (Ekh, 2017). Between 2000 and 2015, on average about 50 % of municipal solid waste has been incinerated (Avfall Sverige, 2017).

Municipalities have also been assigned the responsibility to provide a waste management plan containing measures on waste prevention (Miljö- och energidepartementet, 1998). The waste prevention measures in the municipal waste management program should provide procedures on preventing paper and packaging waste (Miljö- och energidepartementet, 2011).

4.2.3 Gothenburg Strategic Climate Programme

In 2014, the city of Gothenburg published an environmental program aligned with the national program (City of Gothenburg, 2014b). It consists of twelve environmental quality objectives that should be reached in order to fulfill the ecological dimension of a sustainable development of the city. These environmental quality objectives are very general, for example *Clean Air* or *Sustainable forest*. Problems with plastic pollution are related to some of them, especially *A non-toxic environment*, *Flourishing lakes and rivers*, *A balanced marine life* and *Reduced Climate Impact*. Intermediate objectives exist in order to specify the environmental quality objectives. For the *Reduced Climate Impact*, there are four intermediate objectives: *(1) Reduce carbon emissions (by 2020); (2) Energy use in homes will be reduced (by 2020); (3) Reduce production-based emission of green house gases (by 2035); (4) Reduce consumption-based emissions of green house gases (by 2035).* These intermediate objectives are goals for 2020 and 2035 that should be reached in order to achieve the reduced climate impact in 2050. An overview of the context of *Reduced Climate Impact* and its intermediate goals is given in Figure 4.1.

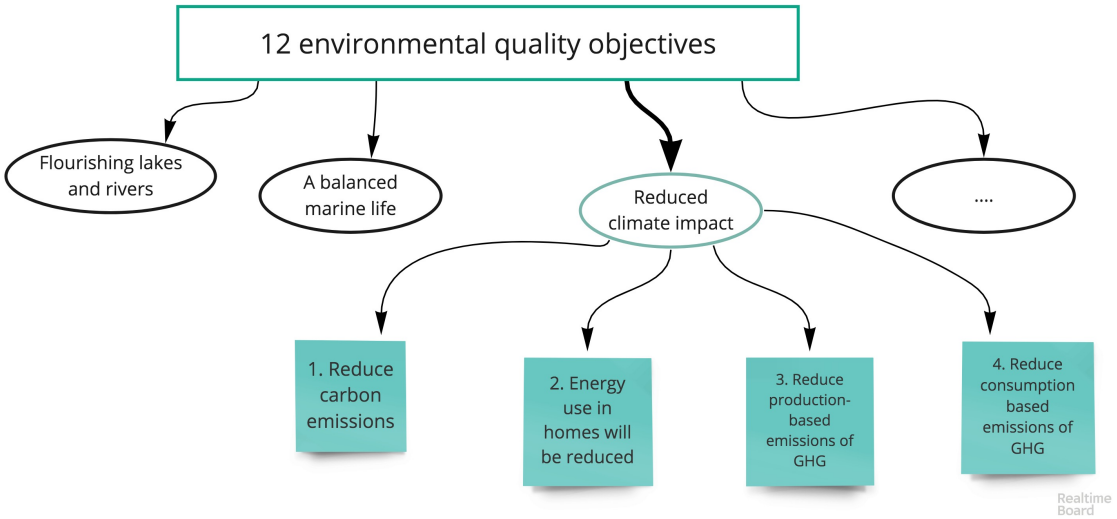

Figure 4.1: Context of quality objective *Reduced climate impact* and its intermediate objective from City of Gothenburg (2014a)

An in-depth action plan (the *Strategic Climate Programme*) has been developed in order to fulfill and concretize the environmental quality objective of *Reduced climate impact*. The *Strategic Climate Programme* was created to achieve the environmental quality objective of *Reduced Climate Impact*. It is divided into nine *Strategic Objectives*. The nine strategic objectives consist of concrete goals to be fulfilled in order to align with the superior goal of a *Reduced Climate Impact*. Three of them are closely linked to the plastics problem: *By 2030, the climate impact of food consumed in the City of Gothenburg will be reduced by 40 percent compared to 2010 (7.); The climate impact from our purchase of goods and materials should decrease (8.); The volume of household waste per person in Gothenburg will be reduced by at least 30 percent by 2030 compared to 2010 (9.)*. Figure 4.2 shows the the relationships visually.

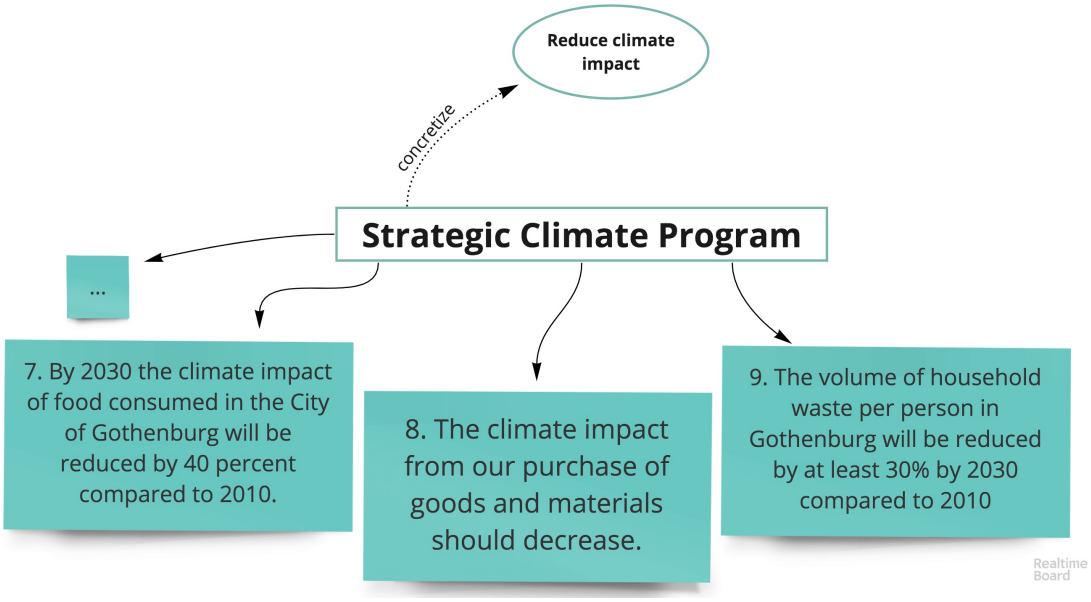

Figure 4.2: Visualization of the Climate Strategic Programme and its context (City of Gothenburg, 2014a)

The *Strategic Climate Programme* also consists of 24 *Strategies* divided into five areas, e.g. *The climate smart citizen* or *Climate-concious consumption*. The strategies "provide guidance in the task of achieving a sustainable and equitable level of emissions" (City of Gothenburg, 2014b). The strategies are actions while the strategic objectives declare targets. Eight of these strategies are directly linked to the three strategic objectives mentioned before and also concern plastics:

- Have knowledge and show decisiveness (1.)
- Support citizens to reduce their climate impact (2.)
- Educate a new generation of climate smart citizens (3.)
- Plan for an energy- and transport-efficient society (4.)
- Reduce the climate impact of food in our organization (20.)
- Reduce our purchases of resource-intensive goods (21.)
- Prevent waste and promote recycling (22.)
- Promote sustainable activities (23.)

Visual guidance of the structure of these strategies is given in Figure 4.3.

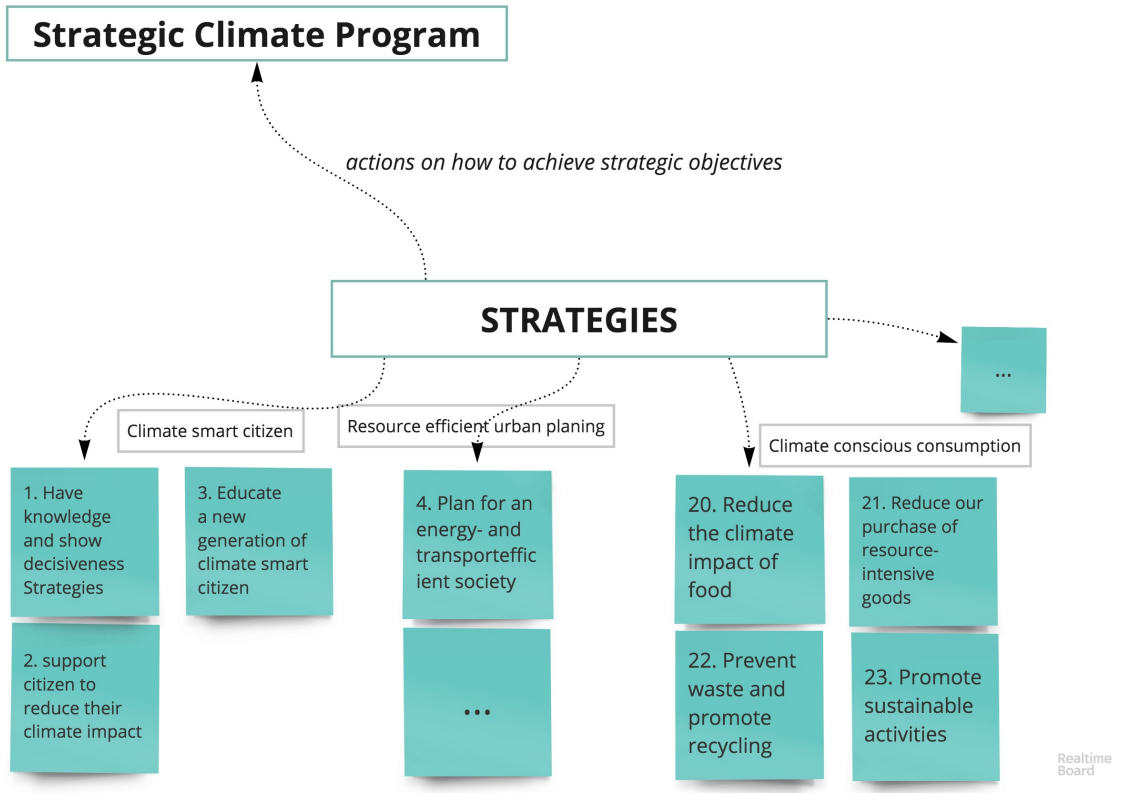

Figure 4.3: Context of strategies for the Strategic Environmental Programme (City of Gothenburg, 2014a)

4.3 Motivations and barriers of waste prevention

The implementation of waste prevention activities has been cautious and the focus is in general on end-of-pipe waste management (Hutner et al., 2017). The next section will give a synopsis of the literature research on motivations and barriers related to the implementation of waste prevention activities.

4.3.1 Motivations and drivers

Lately, waste has gained lots of significance on a European level. Subjects related to waste are high on the political agendas of the European Union: the conservation of natural resources, the implementation of resource efficiency as well as the decoupling of human consumption from its impacts on the environment. Further, the European Commission has provided guidelines for waste prevention programs, which all member states have committed to. These guidelines signify motivation to implement new waste prevention measures. (Hutner et al., 2017)

The public sector is considered an important driver for waste prevention. By using Green Public Procurement, a significant demand for alternative solutions can be created due to the considerable volume purchased. Also, the public sector is in

contact with many citizens. In that way, a wide range of citizens and stakeholders can be reached out to and influenced (ISWA, 2012). Being aware of and using such opportunities can encourage sustainable behaviour along different steps of a product's life-time (Hutner et al., 2017).

Research suggests that waste prevention measures have a high potential of ecologic and economic gains (Hutner et al., 2017; Pietzsch et al., 2017). Waste prevention is to be preferred in terms of resource efficiency compared to other waste management alternatives (Hutner et al., 2017) and there is a clear indication of waste prevention playing an important role in climate change mitigation (Pietzsch et al., 2017). Economic gains such as the cost reduction concerning waste collection systems for solid waste in municipalities can be an outcome since prevention measures result in a decreased amount of waste needed to be collected (Pietzsch et al., 2017).

4.3.2 Barriers and challenges

Even though there are clear motives and benefits of including waste prevention measures in the waste management system (Hutner et al., 2017; Pietzsch et al., 2017), there are several barriers that make the process more challenging.

Consumption patterns and consumer behaviour are an obstacle to waste prevention (Zorpas et al., 2015). Prevention related to domestic solid waste is closely connected to the lack of environmental awareness and the resulting behaviour of consumers. Furthermore, the consumer is strongly affected by the behaviour of any actor involved along the life-cycle, such as politicians, producers and retailers. Besides that, consumption patterns are closely related to peoples' income, education, age and individual consumption behaviours. So far, these factors seem to not have been taken into account methodically in the design of waste prevention programs (Wilts et al., 2013).

There seems to be a lack of incentives for private consumers, industry as well as the public sector. Interviews conducted by Hutner et al. (2017) show that individual actions are often seen as being insignificant or that the understanding of one's personal contribution is lacking. This is often the case when waste prevention is linked to personal effort, such as the process of researching and weighing different waste prevention options (Hutner et al., 2017). Economic aspects seem to be a large barrier as well. Even though preventing waste is considered to have economic benefits, it might imply high initial costs. This has resulted in waste management targeting the waste after being discharged rather than targeting the waste source (Hutner et al., 2017). This is also connected to the low prices of primary raw materials which decrease the economic incentive to prevent waste (Hutner et al., 2017; Wilts et al., 2013).

Furthermore, there exists general lack of knowledge and confusion about what is actually meant by waste prevention. Waste prevention is often interpreted as just

wanting to prevent waste from ending up on a landfill. Thus, incineration might be interpreted as a form of prevention (Hutner et al., 2017). This can lead to the conception of individuals not being responsible and even unable to prevent waste. Even though there do exist multiple of ways of preventing waste.

The waste hierarchy is insufficient when it comes to applying prevention in the existing system. Major issues are a limited specification as well as a lack of guidance, which hampers the realization of waste prevention activities (Van Ewijk & Stegemann, 2016; Zorpas et al., 2015). Also, well functioning recycling systems and infrastructure for energy recovery are hindering the shift of focus towards preventing waste (Zorpas et al., 2015; Hutner et al., 2017). In 2017, around a quarter of the district heating was provided through waste incineration (Ekh, 2017). One further problem is that waste managers are given the task of prevention (Van Ewijk & Stegemann, 2016). They work within the locked-in system favouring waste management over waste prevention. In general, waste prevention programs are only vaguely formulated and lack specific guidance for the implementation of concrete waste prevention measures (Van Ewijk & Stegemann, 2016; Eliasson, 2018).

5

Results from interviews

This chapter present answers given by the 23 stakeholders interviewed. The answers are not analyzed in a methodological sense. To get a better overview of what has been said, the answers are sorted and summarized in the categories of barriers, motivations and solutions. There has not been made any distinction on what has been said only once and what has been mentioned more often. The semi-structured interviews were used on a general level and no final conclusions were based on information from interviews only. They rather provided the possibility to complement academic research in an informal atmosphere.

5.1 Barriers and challenges according to interviewees

The stakeholders mentioned a variety of challenges and barriers that can be grouped in five categories: attributes of the material, system-problems, behavioural aspects, challenges with data, challenges with prevention and political barriers.

The material and its attributes
First of all, the material attributes of plastic were mentioned as a challenge in the sense that there is a lack of alternatives that can compete with plastics at a comparable price. The material's characteristics are difficult to replicate. Examples are the extension of shelf-life and the durability.

System problems
Problems with the existing system came up repeatedly. The legislation is not used efficiently enough, externalities are not represented in the price and small pieces of litter are excluded from fines. An additional barrier is the low price of virgin plastics compared to the cost of recycling. Adding on to that, the well developed waste incineration system in place was mentioned as an strong barrier for reducing waste. Furthermore, the plastics industry is strong and has a lot of insights and influence in the European Commission in Brussels.In general, the extended producer responsibility (EPR) scheme targeting producers is transferred to consumers instead of resulting in an increased responsibility of the companies. In the geographical region of Gothenburg it was expressed that there is a lack of companies providing adequate alternative solutions. In Sweden, municipal waste management is financed by taxes,

which makes it difficult to finance waste prevention projects, since there are strict guidelines for what the money can be used for.

Behavioural challenges
Concerning the purchase of products and their packaging, a challenge mentioned was the consumers' high price sensitivity. Furthermore, the desire of convenience as well as the trash-blindness came up in the interviews. It was observed that the overall awareness of the plastic problem rises, however, the connection with the individual contribution and thus the need to change oneself is usually not made. The on-the-go lifestyle was mentioned as another problematic issue related to waste generation.

Data challenge
Besides a lack of existing data as a basis for decision making and impact assessment, the cost of monitoring was brought up as a challenge. Difficulties collecting inflow data, for example produced single-use plastics was brought up as well.

Prevention challenges
A few difficulties were discussed directly connected to prevention. One major challenge seems to be how prevention can be measured since something has to be measured that does not exist. Also, it was said that replacing something is easier then avoiding it and there is a lack of physical space for waste prevention. Furthermore, there is the unresolved issue of where in society the prevention should take place because there is a big social class dimension factor; not every social class is producing the same amount of waste and has different potentials to prevent waste. Also, prevention today is in competition with waste management and there are multiple lock-ins for waste management such as the need for waste as fuel for an incineration plant. Beyond that, children and students do not learn about prevention as much as waste management. Recycling and incineration plants are visited but no place is visited to learn about prevention. Beyond that, there is the issue with the lack of applications of the concept in a lot of companies due to the missing knowledge of its economic advantage, the wrong assumption is that there is no money in prevention. Hence, it is often only used where it is helpful for the reputation.

Political barriers
The last category of challenges and barriers concerns politics. It was pointed out various times that prevention in general goes along with promoting a lower consumption which today is very difficult to stand for in politics. Also, recycling is a rather short term solution that shows quick results compared to the long-term strategic approach of prevention. Therefore, prevention is further down on the agenda. While plastics is quite high up on the agenda on a national level, it is by far not as high up on the agenda of the municipality due to the political structure of the system. There is a lack of national regulation that enables or forces municipalities to take action. Concerning the development goals of the city, the problem is the little weight of plastics compared to other waste streams. Therefore, the focus is on other waste streams.

5.2 Motivations and drivers according to interviewees

During the interviews, stakeholders mentioned a variety of motivations and driving factors within a very wide spectrum of intrinsic and extrinsic motivations. These have been grouped and summarized in the following categories: legislation as a driver, extrinsic factors, increasing awareness and successful examples.

Legislation as a driver
One motivation brought up was the EU's ambitions to improve legislation and implement more prevention measures which shows political willingness concerning the topic. It would also result in a higher pressure on national politics. Interviewed politicians reported general agreement on the national (Swedish) level that there is a need to act regarding plastic pollution. At the same time, it was raised that the Environmental Code in place could be used with a much stricter interpretation to achieve the necessary change. Also, legislation can change consumers' behavior quite rapidly. This could be seen from the mixed ban/fee regulation on plastic bags. Some stated that similar results could be expected for action against single-use items.

Extrinsic factors
One important factor that was mentioned is China's decision to no longer import Europe's plastic waste. Since the majority of Europe's plastic waste was exported to China before, a quick and effective measure is needed. Also, the increase in quality of alternatives to plastics was mentioned as a motivation. There are more and more applications where alternatives can duplicate the attributes of plastic.

Increasing awareness
Currently, there is a wave of happenings in the UK after the Blue Planet II series was released. As a result, companies and celebrities are promising to take action and phasing out single-use items. Furthermore, the parliament in England is considering to ban single-use plastics.

Successful examples as motivation for further action
In the region of Gothenburg in particular, prevention measures by the department of sustainable waste and water (Kretslopp och Vatten) have shown good results. This could expanded with a regulation on public procurement which can have a large effect and help to reach the city's environmental goals. Also, Sweden has banned microplastics from cosmetic products as one of only a few countries so far. This means plastics is on the political agenda and some measures have already been taken.

5.3 Possible solutions

The interviewees were asked if they had ideas on possible solution regarding plastic waste prevention. The suggestions have been categorized in the following way: legislation, actions by the city, initiatives and awareness, technical aspects and mindset change.

Legislation
A lot of the ideas mentioned are related to the different levels of legislation; EU, national and regional.Possible policy instruments that came up were a ban or tax on single-use items, a levy on packaging or regulation in terms of limiting the amount of layers of packaging to improve recyclability. In Sweden, a fee for littering small objects or other specified items was suggested. Also, the polluter pays principle (PPP) could be applied more effectively. The existing laws are sufficient according to one interviewee, they just have to be used more efficiently.

City Action
Public Procurement can cause a big impact with Göteborg Stad's 54000 employees. The already ongoing projects can be expanded and improved even further. Alternative business models could be supported stronger, e.g. a package-free store like the one in Malmö (www.grammalmo.se). Also, the existing legislation could be used in a more creative way within the region to trigger action and reaction. Monitoring how companies follow their issued permits is another action that the city could take. The yearly festival "Kulturkalaset" could be used as a test bed for reusable cups, an information platform and awareness creation. The city of Gothenburg have banned microplastics in their operations which could be done similarly on other products or items as well.

Initiatives and Awareness
The Keep Sweden Tidy Foundations (Håll Sverige Rent) already has some initiatives such as the yearly beach clean-up day (Kusträddardagen). Suggestions were mentioned concerning more campaigns increasing the visibility on the use of plastics, e.g. by phasing out plastics from childrens' bedrooms just like the campaign against BPA in baby bottles. Another idea mentioned was to make citizens more aware of their plastic use where it is especially disruptive.

Technical Aspects
Recently, the urge to find alternatives to plastic has become more visible through numerous new companies or businesses filling this gap. The quality of alternatives for different applications, e.g. paper, cellulose, algae and more bio-based and compostable materials for packaging is increasing. The attributes of plastic can be replaced step by step.

Mindset Change
Some of the ideas that were brought up aimed directly towards a change in behaviour and mindset. One example would be the suggestion to phase out all plastics, waste

stream by waste stream. For a lot of applications other solutions existed before plastics so it would be possible to go back to that stage. Furthermore, it was mentioned that changing habits and behaviour is difficult but possible as can be seen in England where the awareness is rising as a result of the Blue Planet II series.

6

Overview of ongoing waste prevention initiatives

This chapter will provide an overview of ongoing waste prevention initiatives. They are divided into two sections. The first one is about local initiatives regarding *general* waste prevention in or close to Gothenburg. They are on a general level because there are no initiatives ongoing in the city targeting specifically plastics. The second section will give an outline of ongoing initiatives globally connected to *plastic* waste prevention.

6.1 Local waste prevention initiatives

Among the projects studied are some that are performed and initiated by the department for sustainable waste and water (Krestlopp och Vatten) in the municipality. There are 11 completed projects referred to on their website (Table 6.1) of which a more descriptive table can be found in Appendix B. The initiatives have been examined regarding their targeted waste streams, target group and tools used. The main target group of the projects are departments and administrations at the city itself. The waste generated by the municipality and its action corresponds to about 25 % of the total waste generated in the city which is a strong reason for targeting its own operation to begin with.

The targeted waste streams are generally solid waste or specific waste that is produced during activities of the target group of the respective project. For example, the project with the aim to prevent waste in offices targets waste streams such as paper, packaging and food waste. The most common tools used are guidelines, checklists and good examples on how to prevent waste. Some of the projects have been successful in terms of amount of waste reduced and showed further positive effects, for instance improved working environment, economical benefits and more satisfied employees. Two examples of successfully implemented projects are the public kitchens' model to reduce food waste (Lindroth, 2016) as well as waste prevention practices at elderly homes (Fahlgren, 2016). Both started as pilot projects and due to the success and good feedback, these pilot projects expanded and pilot projects in schools and preschools have started. Furthermore, the city has now started to perform prevention coaching to achieve an even bigger impact.

Table 6.1: Overview of ongoing waste prevention initiatives by the department for sustainable waste and water at the city of Gothenburg. The translation of the project names have been made by the authors, a more comprehensive list of the projects can be found in Appendix B

Project name	**Waste Stream**	**Target group**
Scrap your waste	General solid waste	Public administration
Waste prevention in the office	Waste produced in offices (e.g paper, food waste, packaging)	Offices
Waste prevention at elderly homes	e.g food waste, incontinence pads, single-use items,	Elderly homes
Waste prevention in preschools and schools	e.g food waste, paper waste, furniture	Schools, preschools and kindergartens
Waste prevention in public procurement	e.g unnecessary procurement, packaging waste	Procurement offices
Waste prevention at conferences, hotels and catering	e.g single-use items, packaging, advertisement products, food waste	Clients (Conferences, Hotels, Catering)
Prolong life-time of IT equipment	IT-equipment	User of IT equipment
Gothenburg's model for reduced food waste	Food waste	Public kitchens
Waste prevention in apartment buildings	e.g construction waste, bikes, tools	Apartment buildings
Waste prevention at restaurants and cafés	e.g food waste, single-use materials, packaging	Restaurants, cafés
A world without garbage	e.g general solid waste	Consumer

As a next step to the existing guidelines and checklists, a report by the city on how citizens can reduce their domestic waste is going to be published during summer 2018. Investigations on how to reduce the consumption of single-use items have started as well.

Besides the ongoing projects by the department of sustainable waste and water, there are some more projects ongoing in the area of Gothenburg.The department of safe and nice city (Trygg, vacker stad) is in charge of projects related to litter in the city. They provide tools and gear for voluntary litter-pick-up projects. Similarly, picking-up-litter days for schools in the city and employees of the city are organized. In line with that, the Keep Sweden Tidy Foundation (Håll Sverige Rent) gathers citizens and organizations in cities along the coasts of Sweden to clean up beaches during the "save-the-coast day" (Håll Sverige Rent, 2018a). Furthermore, the city manages a project called Greenhack (Göteborgs Stad, 2017), which has the purpose of providing information to citizens about important topics by letting relevant stakeholders use their social media channels to post about their work or a certain topic (Göteborgs Stad, 2017).

6.2 International plastic waste prevention initiatives

A number of 42 initiatives targeting the plastic waste issue in different forms have been looked into. A complete list can be found in Appendix B. The investigated initiatives are connected to reducing or preventing the occurrence of plastic waste. The initiatives are located in different parts of the world and range from small scale local activities performed by individuals or companies to actions related to a change in the legislative context (see Table 6.2). The initiatives and actions target waste streams ranging from plastic waste in a more general form such as all kinds of single use plastics to specific plastic items such as plastic bottles or plastic straws.

Table 6.2: Overview of ongoing global plastic waste prevention initiatives gathered in main categories

Category	Description
Change in legislation	Ban on single-use items or plastic bags
City actions	City providing alternative solutions to citizens or raising awareness
Deposit-refund system for takeaway containers	Making it possible to reuse take-away packaging
Companies and Stores	Companies and stores taking action
Theme days	International days to raise awareness
Maps	Mapping out initiatives
Organizations and networks	Initiatives taken by organizations or networks

Numerous local governments, corporations, non-profit organizations, companies and individuals have initiated projects that aim to reduce waste. A study of waste prevention projects show that despite their variety in terms of waste stream, target groups and level of implementation they can be categorized by three types of actions: raising awareness, developing sustainable consumption and increasing material efficiency (Corvellec, 2016). In general, projects seem to be promoting an activity rather than forbid a certain action, except for bans introduced in several countries (Figure 6.1).

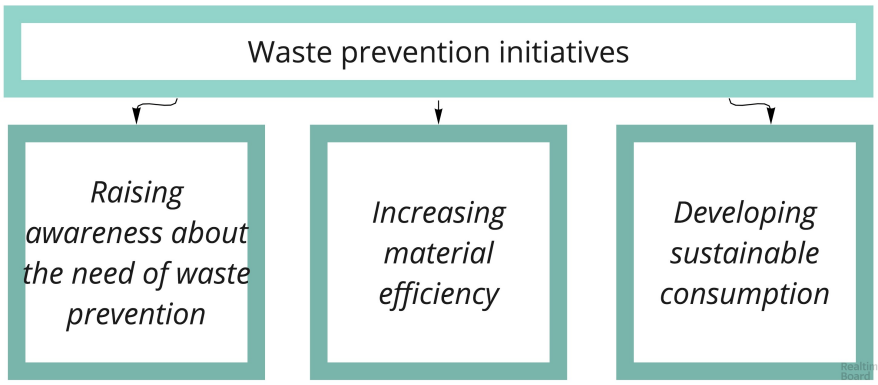

Figure 6.1: Overview of types of actions identified among waste prevention initiatives (Corvellec, 2016)

Studies show that the most frequent waste prevention activities are connected to raising awareness of environmental and material issues connected to waste generation (Corvellec, 2016). This has as well been the case among the initiatives looked at in this study. Further, it can be seen that most of the actions initiated by organizations or networks have the purpose to spread information on topics related to the consumption of plastics, the generation of plastic waste and plastics escaping the socio-technological system.

The majority of the investigated waste prevention initiatives are connected to the development of sustainable consumption (see Figure 6.1). Once the awareness rises, more initiatives arise giving practical advice and promoting activities that support sustainable consumption (Corvellec, 2016). In this study, such initiatives are bans on different kinds of plastic items or projects in cities providing opportunities for refilling water bottles. There are only few initiatives with the purpose to increase material efficiency, that is to reduce the total amount of required material for the production of a certain output.

7

Statistics for Gothenburg

This chapter presents data for the consumption and disposal of plastic products. First, the development of the consumption of plastics in Gothenburg is presented. Next, statistics for the domestic waste in the city and its development are discussed. Finally, litter statistics for the coasts of Sweden and specifically for Gothenburg are examined. Gothenburg is the second largest city in Sweden, located on the west coast, with 564400 citizens within the city boundaries (Göteborgs Stad, 2018).

7.1 Consumption statistics

The consumption of plastics has increased exponentially globally, in Europe and in Gothenburg. There is little disagreement on this development in a global and European context, see e.g. (Plastics Europe, 2017). In order to confirm this development also in a local context, data from a numerical model was used to evaluate the consumption of every day plastic items. The result shows an increasing trend for the available data from 1996 until 2011, which is in line with the European development.

Consumption data was obtained from a model at Chalmers University of Technology. The Urban Metabolism analysis (UMan) model quantifies urban material flows (Rosado et al., 2014, 2016) on the basis of material flow analysis. The categories concerning the consumption of plastics are on a rather general level. Therefore, they provide a rather qualitative assessment of the trend in the consumption of plastics rather than a quantitative one. The following Figure 7.1 shows the development and its trend for two sets of plastic items, which stand for the consumption of every day plastic items. The upper graph (a) shows the use of articles for the conveyance or packaging of goods of plastics, most of which are made for single-use. The second graph (b) depicts tableware, kitchenware and other household articles of plastics.

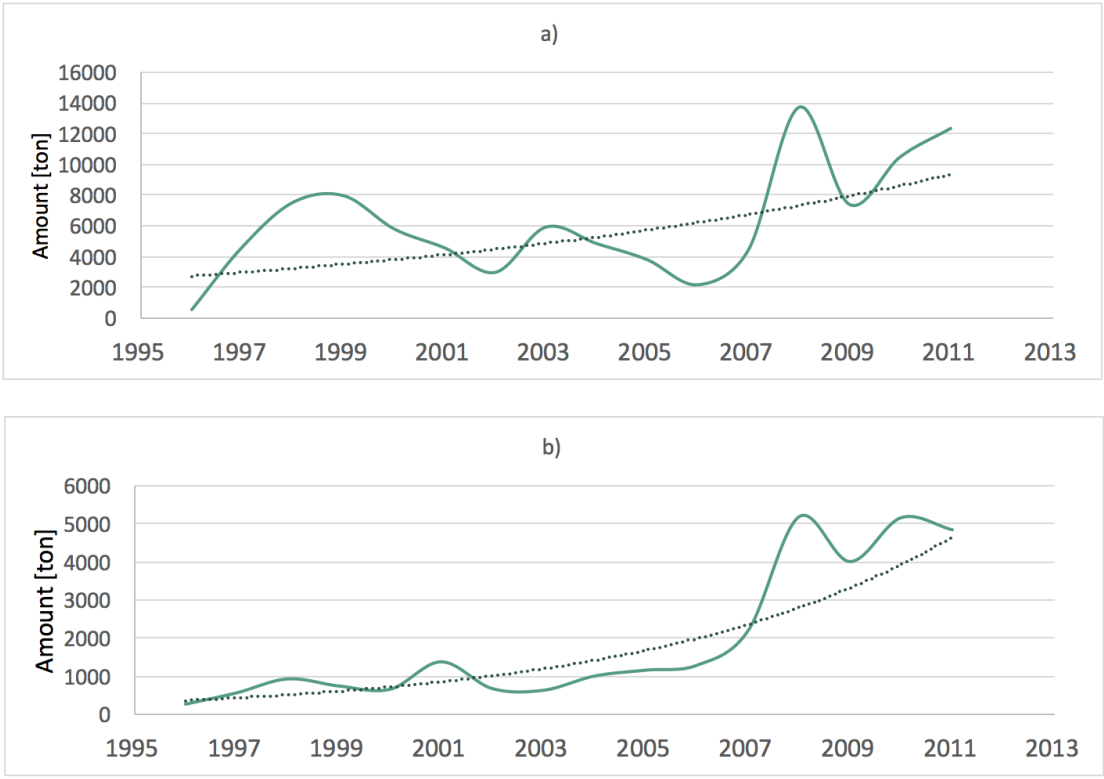

Figure 7.1: Graphs of consumption data from the UMan-model (Rosado et al., 2014, 2016). The amount of plastics is in tonnes. The graphs show a) Articles for the conveyance or packaging of goods, of plastics; stoppers, lids, caps and other closures, of plastics b) Tableware, kitchenware, other household articles and toilet articles of plastics

As can be seen in Figure 7.1, there has been an overall increase in the consumption of the depicted plastic items. Both graph show besides an overall increase also a peak around 2008, the year of the financial crisis. While expensive expenditures showed a strong reduction in consumption, cheap and every-day articles experienced the opposite (Butler, 2017). As mentioned before, a quantitative assessment of this data should be handled with care because of the model's structure. However, since the model used the same approach for all the years listed, it can be seen as a supplementary proof for the increasing consumption of plastics in Gothenburg. There was no data available for the time after 2011. However, extrapolating the data shows a continuing increase in the consumption which corresponds to the European development of production and consumption (Plastics Europe, 2017).

7.2 Domestic waste

In Gothenburg, 386 kg of waste was generated per person in 2017 (Göteborgs Stad, 2018). This number has shown a decreasing trend since 2008. The fractions of waste an average person from Gothenburg generates a year is shown in Figure 7.2.

Around 15 % (56 kg) of this amount is plastic packaging, paper packaging (with plastic layers) and paper. The biggest share is mixed waste with 194 kg.

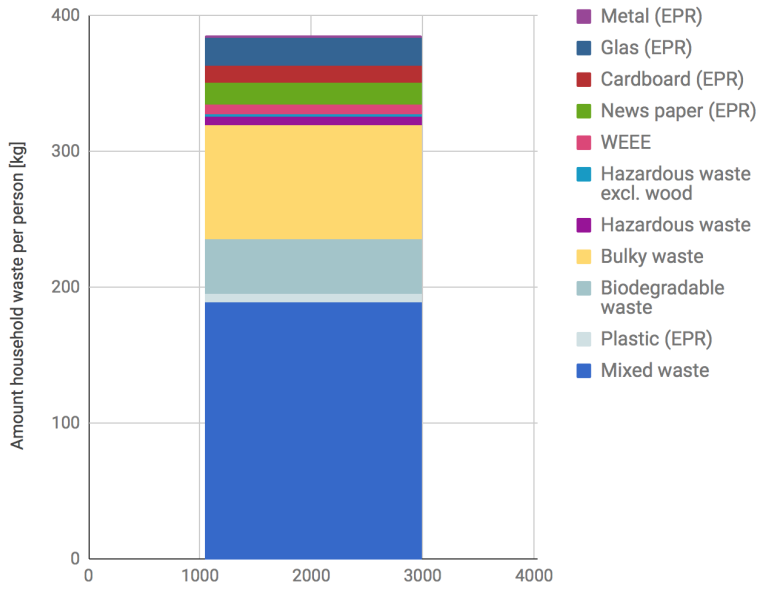

Figure 7.2: Amount of household waste [kg] divided into different waste streams. Statistics taken from Göteborgs Stad (Göteborgs Stad, 2018)

The plastic waste stream has been increasing in contrary to most waste streams and the total amount. The development concerning the amount of waste streams is shown in Figure 7.3. While there has been a decrease, a steady development or slight increase over the last ten years for most household waste streams, the plastic waste stream has more than quadrupled. Even though it represents not the highest amount weight-wise, it has increased by far the most out of the depicted streams.

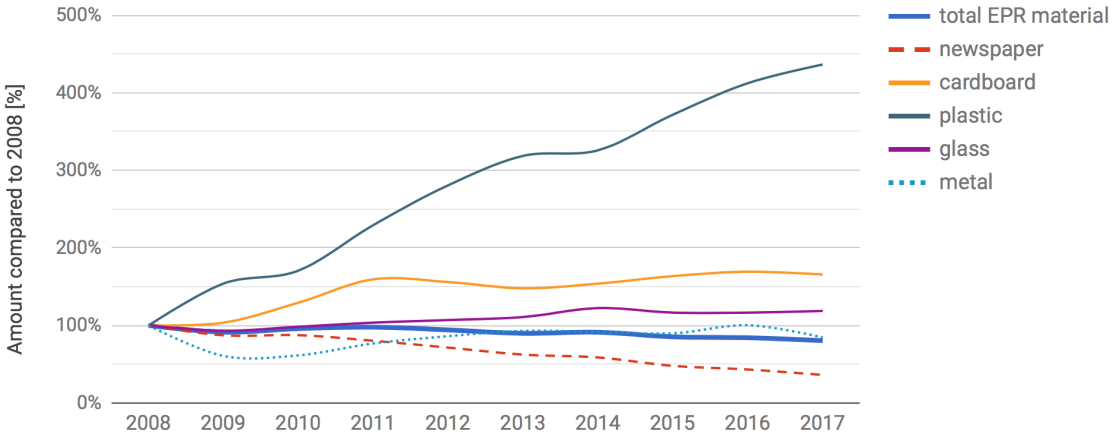

Figure 7.3: Change in amount of collected EPR materials during the time period of 2008 to 2017 (Göteborgs Stad, 2018)

The increased amount of plastic waste could also be due to an eventual improvement of the collection systems. However, there has been an increase in the consumption of plastics as well, as shown in the previous section. Therefore, even if the collection systems did improve to a certain extent this does not explain the significant increase in the amount of plastic waste.

A big share of plastic waste is not sorted properly and ends up in the mixed waste. An analysis of the collected mixed waste was performed by the department of sustainable waste and water in Gothenburg in 2016. The analysis showed that just roughly one third of the mixed was supposed to be disposed of in the mixed waste container. The majority of the remaining share consisted of food waste and packaging. Around 17 % of the mixed waste was pure plastics. Another 21 % were paper and paper packaging which is usually coated with a layer of plastic. The fractions of the mixed waste analyzed are visualized in Figure 7.4.

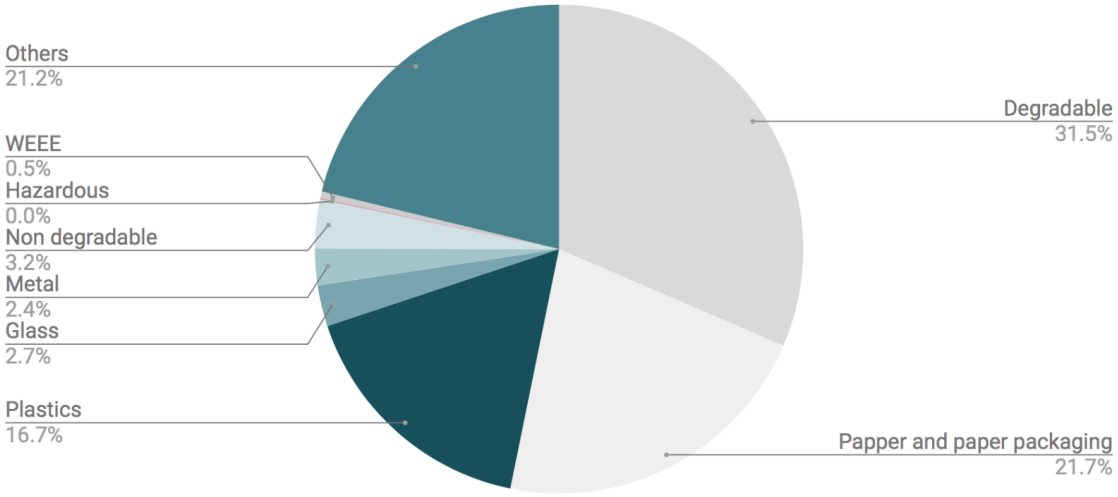

Figure 7.4: Fractions from analysis of mixed domestic waste in the city of Gothenburg in 2016

The statistics presented above will be further discussed in chapter 8.

7.3 Littering

Three sets of data are presented in this section. First, the main findings concerning plastics of a litter analysis on beaches by the Keep Sweden Tidy Foundation are presented. Next, the statistics of litter picked up in the city are shown. This is followed by the data of an organization working with an app to monitor litter.

7.3.1 Litter on Swedish beaches

The Keep Sweden Tidy Foundation examined ten beaches on the east and west side of Sweden and determined the ten most littered groups of items (Håll Sverige Rent, 2018b). The top seven out of these ten are all plastics or, in the case of cigarette buts, contain plastics. In total, 70 % of the litter found on those beaches was plastics. They also determined a substantial increase in the amount of plastics. From 2015 to 2017, the number of items that were found per 100 m increased from 44 pieces to 89 pieces. This corresponds to an increase of more than 100 %.

7.3.2 Litter pick-up in Gothenburg

In collaboration with the Keep Sweden Tidy Foundation, Statistics Sweden, the Swedish Environmental Protection Agency and Gothenburg's department safe and nice city (Trygg, vacker stad) litter has been picked up in the city (Finsberg & et. al, 2017). An analysis of what has been picked up is shown in Figure 7.5. The largest fraction of litter found is snus bags [1] and cigarette butts that include a plastic filter. The second largest fraction is other kinds of plastics. More than 75 % of the collected litter is related to plastics. In the figure, the fractions are based on the number of items collected.

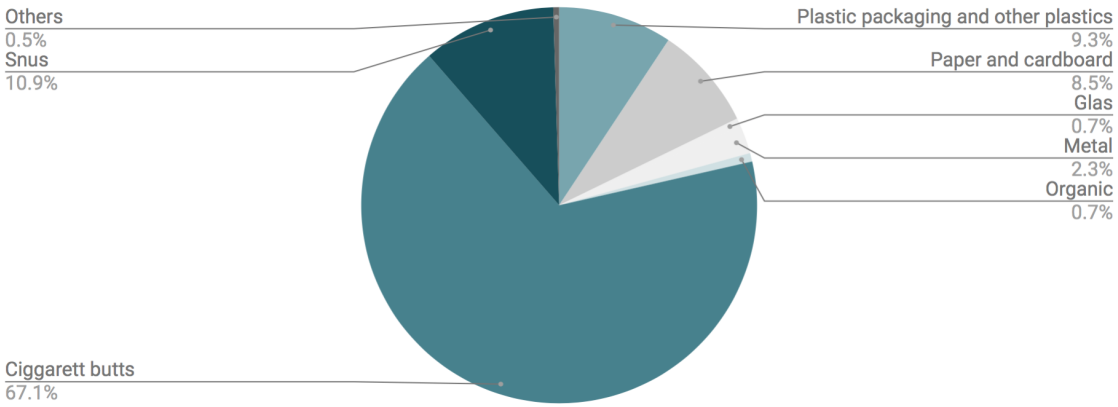

Figure 7.5: Share of plastic pieces found in the environment. Data provided by the city of Gothenburg

7.3.3 Litterati

Litterati is an organization that uses an app to monitor litter (Litterati, 2018). Pieces of litter are photographed, tagged and then disposed of properly. The photo is uploaded together with the tag and the GPS data to capture the exact location. On the website a world map shows all pieces picked up at their respective location and tags. The data for Gothenburg (up until April 2018) was used as a complement to the statistics presented before. This data has to be examined carefully for a

[1] a type of moist powdered tobacco, typically held in the mouth between the lips and gums.

variety of reasons. The data is not representative, not exhaustive and the tagging can be inaccurate. This will be further discussed in chapter 10.

The obtained data gives hints on what is littered in Gothenburg. The following table Table 7.1 gives an overview of the 15 most mentioned items that were picked up. In total, 629 items were photographed and tagged with over 900 tags. Many items were tagged with more than one tag. A lid of a coffee cup, for instance, could have the tags "plastic" and "single-use". Also, the tags clearly depend on the user. Some tags are just "litter" or "plastic" while others are very specific and include the name of the brand of the item. Some tags used for an identical item were grouped, for instance "cigarette box" and "cigarette pack". When there was an additional tag for the brand, this was not counted twice but once.

Table 7.1: Data from litterati - Tags used the most in Gothenburg

Item	**Number of tags**
plastic	230
cigarette	199
cigarette butt	131
cigarette box	27
packaging	95
single-use	55
cup	44
coffeecup	32
snus	43
snusbox	18
candy	30
lid	20
gum	18
can	17
extra, Marlboro	each 14

The tag used the most is "plastic". Next comes "cigarette". This includes tags where the word is part of the tag, such as "cigarette butt". The 131 cigarette butts are therefore part of the 199 tags of "cigarette" and not additionally. Despite the uncertainties, a definite conclusion can be drawn. Among the items that were picked up and tagged the most with this app are cigarette articles, packaging and other single-use items like coffee cups and lids.

8

Evaluation of current situation

This chapter provides an evaluation of the current situation based on findings from the previous chapters. The evaluation is conducted by combining findings in literature with insights from the interviews. The content has been sorted in five categories: legislative and regulatory context, problems related to waste prevention, waste prevention in Gothenburg and finally globally ongoing waste prevention initiatives, and analyzed.

8.1 Waste prevention in a legislative and regulatory context

Legislation concerning plastic waste, plastic pollution and plastic waste prevention is diffusive. On a European level, a variety of Directives include plastics, for example the Ship-source Pollution Directive (European Commission, 2009) and the Waste Framework Directive (European Commission, 2008). Except for the plastic bag Directive, there are no binding goals and targets. A comprehensive and strategic legislative basis addressing plastics is still at early stages of development. The topic has gained increased attention in the last few years and the European Commission has reacted with numerous announcements, strategic papers and green papers specifically addressing the plastic problem. In the media, a tax on plastics is discussed widely (Nienhaus, 2018; BBC, 2018). It seems like the search for appropriate policy instruments has begun. At the same time, the EU calls for voluntary action of national authorities and industry. The problem of legislative diffusion also leads to an inability of those who actually want to take action.

The waste hierarchy, as implemented in EU and Swedish legislation today is insufficient to work with waste prevention in an appropriate way. Even though waste prevention is declared as most powerful and most advisable measure to handle waste, there is a lack of knowledge and guidance to use this as a tool (Corvellec & Czarniawska, 2014). This was also mentioned during the interviews. Except for some "best practices" there is very little advice on *how* to implement waste prevention. Also, regulations in the Swedish law related to waste prevention in municipalities are not sufficient enough concerning responsibilities. To this point, it is mentioned in

the environmental code that the municipality is obligated to inform about measures to handle waste and about the content of the waste management program (Miljö- och energidepartementet, 1998), but nothing is mentioned about waste prevention measures.

Littering seems not to be addressed sufficiently. "Littering" is not part of the waste hierarchy even though it is the worst way to dispose of waste (Håll Sverige Rent, 2018b). This can lead to a reduced attention in the waste discussion. Also, littering has not been considered when the life-cycle of products or waste has been discussed (Håll Sverige Rent, 2018b). This has as well been the case in the waste hierarchy among EU member states. On top of that, littering small objects is not illegal in Sweden. Littering in general is prohibited, however, small objects are excepted from this law (Miljö- och energidepartementet, 1998). This is a clear mishandling since exactly those small objects make the vast majority of litter found in the city and on beaches.

8.2 Conceptual problems

A common understanding of what waste prevention is and how to work with it is missing. The definition given by the European Union is unclear, leaving room for interpretation. Some examples of different interpretation of what qualifies as waste prevention and what does not have been presented in chapter 4. The unclear definition makes waste prevention abstract and thus difficult to work with. This is worsened by the lack of guidance on how to perform and implement waste prevention measures. It may lead to confusion among different stakeholders in the plastic's life cycle where waste prevention should take place.

Measuring waste prevention is difficult. This is due to the lack of data, the unclear definition and the problem of measuring something that does not exist. Measuring prevention means to determine an amount that has been reduced and thus, does no longer exist. There are some methods on how to perform this but it remains a widely unresolved issue (Zorpas & Lasaridi, 2013). One example is to measure the difference between the amount before the prevention measure and after. However, this implies the need for data. Furthermore, it has to be made sure that the change is a result of the prevention measure and not another factor. The problem was already stated by the OECD (2014) by stating the need for commonly accepted prevention indicators. It remains a problem up until today.

Waste prevention is not a part of waste management. The waste hierarchy allocates waste prevention to a tool used by waste managers. However, preventing waste is, strictly speaking, detached from handling waste (Corvellec & Czarniawska, 2014). They are two different concepts at two different stages. Waste prevention encounters waste before it occurs while waste management works with already existing, generated waste. Due to the allocation of waste prevention as a part of waste management, the responsible body for implementing waste prevention comes from within

waste management. This means that this body may be unfamiliar, unaware or even over strained with the concept and its implementation.

The economic profitability of waste prevention is widely unknown. The economic factor is often essential in industry and could be a strong driving factor for waste prevention. However, the economic profitability of waste prevention measures are not well-known. Waste prevention thus seems more like a burden than a chance.

8.3 Swedish waste management system

Sweden has a far developed but locked-in waste management system that makes it hard for waste prevention to develop. In the international comparison, Sweden shows high recycling rates, incineration plants with high efficiency and far developed flue gas treating systems as well as small landfill rates. This makes Sweden a forerunner for waste management but, at the same time, it makes it very difficult for waste prevention measures to expand. Incineration plants and a high amount of waste depend on and support each other. An incineration plants needs lots of fuel in the form of waste. At the same time, when there is a lot of waste to handle, an incineration plant is a commonly chosen option. Sweden even imports waste at times in order to keep their incineration plants running (Nicastro, 2017).

The strategy for the future development focuses on recycling. Discussions and strategies concerning plastic waste widely neglect prevention and focus on recycling instead (European Commission, 2013). While recycling is not a bad option in general, introducing recycling systems with the necessary infrastructure before analyzing prevention potentials can result in yet another lock-in. And once the infrastructure is there, the incentive for prevention decreases again. Also, even the report by the Ellen MacArthur Foundation (2017), which is written in collaboration with the industry, comes to the conclusion that even the far-most developed collection systems cannot hinder leakage. This leakage, for example in the form of littering can be reduced by prevention but it is seldom in the center of attention when discussing the development of waste management systems.

There is a structural money allocation problem hindering waste prevention to expand. Municipal waste management in Sweden is financed through tax money, implying that the money can only be used for actual waste management. This excludes waste prevention measures Eliasson (2018). This results in a general lack of financial support and thus hinders waste prevention measures to be used more commonly. In Gothenburg, the department of sustainable waste and water has been allocated money to improve the current state on waste prevention in the city. This is a first step but the competition with waste management within the same department can be seen as critical.

The waste management system in Sweden is making it hard for waste prevention. Waste prevention is in competition with a far-developed waste management system. In Gothenburg, waste prevention measures have been adopted. Pilot projects have

proven successful and there is even a person in charge of waste prevention measures among Göteborg Stad's departments. The allocation of responsibilities remains unsolved to an extent.

8.4 Waste prevention in Gothenburg

The majority of ongoing waste prevention initiatives in Gothenburg targets directly Göteborg Stad. There have been successful waste prevention projects in the city. The department of sustainable waste and water have initiated pilot projects in recent years that have proven to be profitable, reduce waste, improve the work atmosphere and more (Fahlgren, 2016). Göteborg Stad is a good starting point for such measures since they generate about 25 % of the city's total waste. However, the efforts have so far been focused on Göteborg Stad and its departments while the target group of industry and consumers have not yet been targeted to a wider extend. There are some projects starting to do so and there is some information for a variety of bodies but there have been no successfully completed projects yet. Also, there is no data on how much this information is looked at and used. As a result, monitoring of possible effects is not possible.

The goal of the city to decrease waste has to be looked at critically. First, this goal looks at the waste generated per person. While this is a good number for evaluation and comparison, it has to be kept in mind that a decrease in the generated waste per person does not necessarily correspond to the same relative reduction of the total waste generated by the city's citizens (compared to 2010). This is especially true for Gothenburg with the city's plans of building large amount of apartments and work places (Älvstranden Utveckling AB, 2017). Including the predicted population increase from 514.000 (2010) to 665.000 (2030) (Västra Götalandsregionen, 2016) a household waste reduction of 30 % per person only results in a reduction of 10 % of the total amount. Furthermore, looking only at the weight and thus targeting the waste streams with the highest amount weight-wise does not necessarily correlate to a reduced environmental impact. Different waste streams can harm the environment to a different extent which is not respected with this goal.

The waste statistics provided by the city of Gothenburg can be misleading. There is a substantial amount of plastic based waste in the mixed waste that is not accounted for in the general statistics. This may give the impression of less plastic waste than there actually is. Figure 8.1 shows the two different statistics. On the left, there is the statistics as provided by the city of Gothenburg. On the right, the amount of plastic waste is included. The plastic share then increases by 32 kg per person. Beyond that, the monitoring of certain waste streams is under the responsibility of the producers due to the EPR.

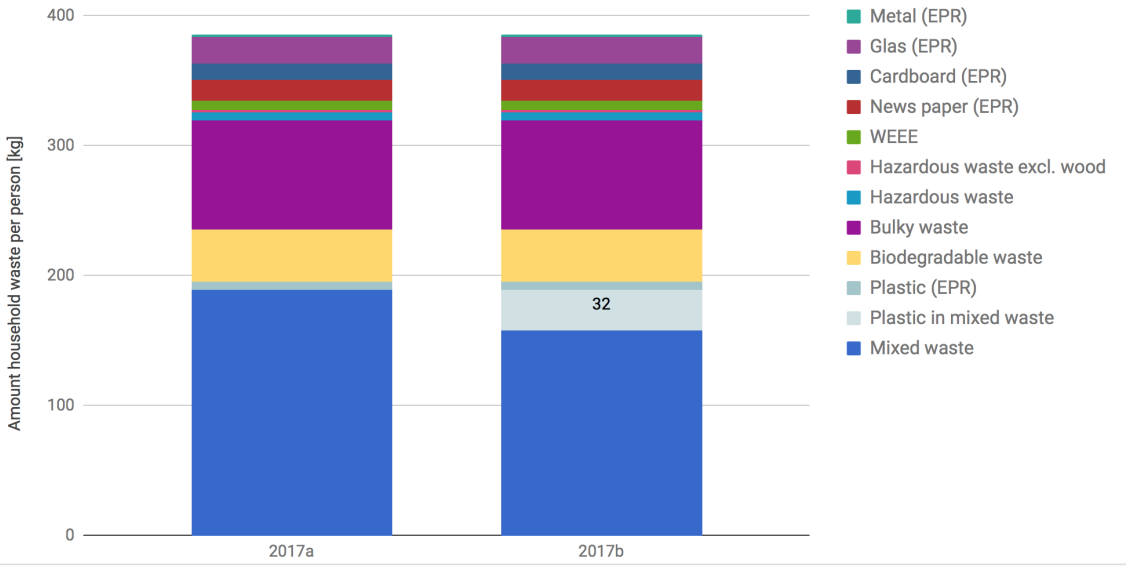

Figure 8.1: Amount of household waste in 2017 per person in Gothenburg. 2017 a) shows the statistics as they are usually shown. 2017 b) show statistics including the 32 kg of plastics in the mixed waste

Plastics has a severe environmental impact in the area of Gothenburg by leaking into the environment. What the waste statistics provided by the city of Gothenburg do not show at all is littering. When deciding on which waste streams to tackle based on the waste reduction goal or the statistics, it is widely neglected that there is a substantial waste stream missing: the waste stream that is *not* collected by the collection system. Concerning litter, all available statistics come to the same result. Plastics and plastic based items make more than 75 % of litter picked up in the city, the top seven items found on Swedish beaches are plastic based items and "plastic" was the tag used the most by users of the app "litterati". In combination with the long durability and non-biodegradibility, this makes plastics a very critical waste stream.

9

From waste management to waste prevention

This chapter concludes the main takeaways from the previous sections. It presents considerations on three levels: mindset-change, regulatory improvement and suggestions for local actions. First, concepts that need to change or be introduced to move away from plastic waste management and towards plastic waste prevention in the long-run are shown. Next, recommendations on a regulatory level are presented shortly. The third part shows a list of possible measures that can be implemented on a local level in order to initiate the shift from the current plastic waste management system to a sustainable plastic waste prevention system.

9.1 Old logic versus new logic

In general, it can be seen that the logic of today has a focus on after-life treatment, which can be seen as *symptoms treatment* (Bartl, 2014), while the new logic needs to have a focus on *treatment of the cause* itself. In Sweden, concerning waste management, there has not been any action changing waste management as drastically as the landfill tax in 2000 followed by the landfill ban in 2005 (Corvellec, 2016). Concerning waste prevention, no action has been taken, e.g. in terms of initiating taxation on material use, a limitation on the use of plastics or an extension of the existing deposit-refund system. The focus seems to be stuck on waste management. Thus, the following section will provide an overview and summary of what has been found during this study that is needed to move away from waste management and towards waste prevention in the long-run.

Today, waste management includes targets for increasing recycling and collection rates (European Commission, 2018b), while reduction targets would need to be addressed in the future. The focus on those targets is reflected upon in the available statistics, where only material recycling rates, incineration rates and landfilling rates are reported (Eurostat, 2017). Increased recycling targets help to decrease the extraction of primary resources (Bartl, 2014). A focus on reduction targets will also decrease the extraction of primary resources, but rather by decreasing the consumption of products. At the same time, having a focus on waste reduction will result in a decrease in energy and money needed to process the waste (Bartl, 2014).

In the current system, the price of a product is determined by the production costs. In the future, external costs in the form of environmental harm have to be internalized and reflected in the price. In the case of plastics, this translates into a price increase and, thus, a consumption decrease. Financial benefits from the higher price should be used to compensate for environmental costs.

The existing extended producer responsibility (EPR) does not fulfill its goal sufficiently. In general, it is not of interest to producers and retailers to decrease the consumption of products (Dubois, 2012; Bartl, 2014). Producers prefer paying a fee for collection and recycling than actually reducing waste (Bartl, 2014). The collection target for EPR should be complemented with a tax targeting producers for the waste fraction that has not been collected. This regulation would internalize the costs of waste disposal (Dubois, 2012). Furthermore, producers could be taxed for introducing certain products on the market, which has been discussed for coffee cups and food packaging in the UK (Vaughan Adam, 2018).

An important part of circularity is recognizing and using *waste as a resource*, but in the future the goal should be not to generate waste at all. Using waste as a resource contributes to a decreased material leakage from the system and reduced primary material extraction (European Parliament, 2017). However, it cannot hinder leakage entirely (Ellen MacArthur Foundation, 2017), which should be the aim of a sustainable system. Today, zero-waste is a commonly used term among waste managers (Zaman, 2014). However, the interpretations of this term varies and, often, it stands for avoiding waste ending up on landfills. A future with no waste in terms of total or almost total avoidance of waste by excessive waste prevention needs to be the goal (Bartl, 2014). Landfilling, and incineration as well as recycling should not take place (Bartl, 2014). This will contribute to an overall lowered consumption of resources.

The waste hierarchy in its current form is an insufficient basis for achieving reductions in material throughput in the economy. Even though waste prevention is included and ought to be prioritized, the positive impacts of the inclusion such as dematerialization are uncertain (Van Ewijk & Stegemann, 2016). The main focus of waste managers is still on waste management rather than on waste prevention, despite environmental benefits and contribution to climate change mitigation of waste prevention. A suggestion is to look at waste prevention detached from waste management because, unlike waste management, it has nothing to do with handling existing waste but rather measures before waste generation (Corvellec, 2016).

A comparison of the current system and a desirable sustainable system is summarized in Table 9.1.

Table 9.1: Table of concepts in waste management compared to waste prevention. Inspired by old logic versus new logic thinking by Carstedt (2017). The concepts were obtained by the authors.

Current system (old logic)	**Visioned sustainable system (new logic)**
recycling and collection targets	reduction targets
production costs	life-cycle costs
decrease loop outflow ("keep it in the loop")	decrease loop inflow ("decrease the loop")
waste as a resource	waste is undesirable
consumer is responsible for waste disposal	producers are made responsible for products
prevention within waste management	prevention not part of waste management

9.2 Regulatory recommendations

Regulatory changes of the system could ease the process of moving up the waste hierarchy. The suggested changes should be seen as a complement to the concepts mentioned in the previous section (Table 9.1). This section will give a synopsis of some regulatory changes that cannot be left unaddressed because they are an essential part for waste prevention.

Implementing bans or fees on certain products or items would ease the process of preventing certain waste streams. The city of Gothenburg has earlier taken the decision to ban microplastics among their own operations, which has been implemented successfully. A suggestion is to expand the ban to other plastic items such as single-use cutlery. Furthermore, introducing fees on other products could decrease littering of those products as well. In the sea surrounding the UK, it has been investigated that the amount of plastic bags has been decreasing since an introduction of a fee on plastic bags (Maes et al., 2018).

Regulations concerning litter should be extended. First off, adding a prohibition of littering small pieces to the environmental code might be an important signal. The largest amount of litter items found in nature are small pieces such as cigarette butts, which needs to be addressed. Secondly, incorporating littering as part of the waste hierarchy would contribute to increasing the significance of decreasing waste escaping the socio-technological system. Litter has not been considered when the life-cycle of products or waste has been discussed, even though littering is the most harmful way of plastic waste disposal (Håll Sverige Rent, 2018b).

There seem to be insufficient regulations in the Swedish law related to waste prevention in municipalities. The environmental code should include a statement that forces municipalities to inform about waste prevention measures. This could cre-

ate a higher level of ambition and more strategic work concerning waste prevention (Re:source & Återvinningsindustrierna, 2016). To facilitate the process of waste prevention in cities and municipalities, information about other municipalities' good practices should be spread (Eliasson, 2018). More information about good practices of other businesses could further contribute to decrease resource use and waste generation (Eliasson, 2018).

Allocating money for waste prevention measures in the city budget can foster the development of waste prevention projects. Municipal waste management in Sweden is financed with tax money, implying that the money can be used for actual waste management only. Allocating money this way excludes waste prevention measures (Eliasson, 2018). In general, this results in a lack of financial support and, thus, a lack of incentives to implement waste prevention measures. Despite these money allocation issues, in Gothenburg, the department of sustainable waste and water actually has been allocated money to improve the current state on waste prevention in the city. This action has resulted in successful projects (Fahlgren, 2016; Lindroth, 2016).

9.3 List of possible solutions for plastic waste prevention on a local level

There seems to be a need for practical examples and good practices of plastic waste prevention that can be easily implemented in a local context. After the evaluation of the situation in the area of Gothenburg as well as initiatives ongoing in the city and international, a list of actions will follow that aim to improve plastic waste prevention in the city (see Table 9.2).

Table 9.2: Table of suggested initiatives for the area of Gothenburg with associated leverage points according to Meadows (1997)

Nr	Action	Leverage point (Nr)
1	Package-free shops	Driving positive feedback loops (6)
2	Include plastic objective in Environmental Strategic Programme	Goals of the system (2)
3	Raise awareness in the municipality	The mindset or paradigm out of which the goals, rules, feedback structure arise (1)
4	Online platform	Information flows (5)
5	Deposit-refund system for reusable take-away coffee cups	Driving positive feedback loops (6)

9.3.1 Package-free shops

In recent years, more and more people have been shifting their habits to a *zero-waste* lifestyle, which implies living everyday life with the aim to not produce any

or very little waste (Chapman, 2017). This kind of lifestyle has resulted in a demand for package-free stores (Haynes, 2017). There is an increasing number of such stores globally. Furthermore, some traditional supermarkets have started to offer package-free isles (Taylor, 2018). In Gothenburg, there are some stores that offer some groceries in bulk. Two examples are "FRAM" (www.framekolivs.se) and "Bara bra mat" (only good food, www.barabramat.se).

Avoiding food packaging is environmentally beneficial, even though packaging in general only stands for a small weight percentage of a product. LCAs are a commonly used tool to investigate environmental impacts of packaging. Those LCAs mainly emphasize greenhouse gas emissions during the production of food and during transportation. This has resulted in complex packaging aiming to reduce carbon emissions, without having the end-of-life impacts of the packaging in mind. LCAs performed often consider waste management scenarios and thus often ignore environmental leakage of packaging (Schweitzer et al., 2018).

An increase in packaging does not reduce food waste. There exists an assumption that packaging is an important factor in reducing food waste. However, recent research has shown that this is not necessarily the case. Food waste has been increasing in line with the increased use of packaging (Schweitzer & Janssens, 2018). Problematic cases are multipacks and small format packaging. Multipacks cause an unnecessary grouping of products, which can lead to over-purchasing food. This is likely to drive food waste (Quested et al., 2013). Format packaging is critical because they tend to leak into the environment (Ellen MacArthur Foundation, 2017). Also, their recycling potential is low (Pilz, 2014)

Giving the consumer only one option of packaging (no plastic or paper but personal containers) when purchasing goods has benefits. Having the possibility to choose might have the result of consumers choosing the packaging they assume to be the most environmental beneficial. This might not be equivalent with the actual lowest presumed environmental impact (Van Dam, 1996). By only providing package-free groceries, this situation is avoided. The concept of a package-free store is summarized in Table 9.3

Table 9.3: Table of key factors with the purpose of identifying the relevance of the suggestion of a *(Plastic) Package-free store*

Key factor	**Description**
Category	Companies ans Stores
Type of action	Developing sustainable consumption
Approach	Store without packaging
Waste stream	Packaging
Target group	Consumers
Implementation	Local level
Leverage point	Driving positive feedback

9.3.2 Including objective in Environmental Strategic Programme

Today's consumption of plastics is unsustainable. The material is fossil fuel based and has a high environmental impact (Thompson et al., 2009). In Gothenburg, the plastic consumption has been increasing and so has the resulting plastic waste. Adding on to that, litter consists mainly of plastics and is an environmental concern. This is critical regarding Gothenburg's aim to develop in a sustainable way.

Plastic consumption is connected to many of the environmental objectives stated in the Strategic Environmental Programme of the city (City of Gothenburg, 2014a). Also, plastic consumption and plastic waste generation is strongly connected to the intermediate objective aiming to *reduce consumption-based emissions of greenhouse gases*. Plastic waste generation needs to be reduced to reach that goal. So far, plastics are only addressed as a waste stream in the household waste or through strategies on how to reduce microplastics.

The target of reducing household waste is not sufficient enough when aiming to reduce the plastic waste stream. The focus is on reducing the waste stream that corresponds to the largest amount weight-wise, e.g. bulky waste and food waste. Plastic is a light-weight material, which results in a relatively small waste stream compared to others, especially if the plastics in the mixed waste is not respected (see Figure 8.1). Plastic packaging has been increasing vastly among collected EPR materials while most of the others have been decreasing.

To ensure that plastic consumption, plastic waste generation and littering is reduced, an objective in Gothenburg's Environmental Strategic Programme needs to be added. It would be a complement to the existing nine objectives and could for example be called *Increase sustainable consumption of plastics* or *Decrease unnecessary use of plastics*. This way it is avoided that plastics will not be addressed. Specific targets or objectives have shown to lead to change. In the case of aiming for a reduced amount of household waste, the city has introduced successful projects, such as one project targeting food waste (Lindroth, 2016). This project has resulted in decreased food waste stream (Göteborgs Stad, 2018).

By including plastics directly in the environmental targets, the city would clearly recognize the dimension of the problem and show that it aims to combat the issue. A significant advantage of setting targets is that the outcome is set, but it is up to the actors how to reach them (Eunomia Research, 2016). This could have the effect of increased innovation and action (Science Based Targets, 2018). The concept of adding an objective in the Environmental Strategic Programme, is summarized in Table 9.4.

Table 9.4: Table of key factors for the suggestion *Including objective in environmental target*

Key factor	**Description**
Category	City action
Type of action	Raising awareness
Approach	Including target related to plastic consumption and waste generation in environmental target
Waste stream	Unnecessary plastic items
Target group	Citizens of Gothenburg
Implementation	Local level
Leverage point	Goals of the system

9.3.3 Raising awareness in the municipality

Creating awareness can bring about a mindset change and thus lead to a change of the system's rules and goals (Meadows, 1997). Different kinds of actions have the purpose to raise awareness on certain topics, such as human rights, animal rights and climate change. Difficulties with actions on creating awareness are to reach someone on a level that will result in a behavioral change. Often, the approach is to create an emotional attachment as a powerful driver for change. Instead of forcing people to change, the idea is to make them *want* to change by themselves. According to Meadows, the aim is to reach the highest leverage point (*The mindset or paradigm out of which the goals, rules, feedback structure arise*). This means that intervening at this point will most likely lead to a big change. Beyond that, research shows that apart from technology, environmental legislation and environmental management systems, human attitudes and environmental awareness are among the most important drivers of waste prevention (Pongrácz, 2009). Multiple campaigns on raising awareness concerning the plastic problem exist, some of which have been investigated during this study (see Appendix B). In Gothenburg, there is a lack of local actions creating awareness on problems related to plastic waste and plastic consumption. Therefore, the following section will provide some recommendations on what could be done in Gothenburg. The concept is summarized in Table 9.5.

Table 9.5: Table of key factors with purpose of identifying relevance of suggestion *Actions to raise awareness in the city*

Key factor	**Description**
Category	Actions by the city, individuals and organizations
Type of action	Raising awareness
Approach	Creating awareness by actions
Waste stream	Litter and single-use plastics
Target group	Citizens
Implementation	Local level
Leverage point	The mindset or paradigm out of which the goals, rules, feedback structure arise (1)

Mr Trash Wheel
In Baltimore, Australia, an individual initiated a project consisting of a trash inceptor. It collects trash floating in a river connected to the local harbor and is now part of the Waterfront Partnership of Baltimore's "Healthy Harbor Plan" (Waterfront Partnership, 2018). It is powered by solar cells and a water wheel using the natural current of the river. The litter is collected in a vessel and monitored. Afterwards, the litter is incinerated for energy recovery. It creates awareness through communication and personification. It has its own twitter account where pictures, numbers and videos are published and its birthdays are celebrated. Due to its success, a second one has been built for another location. A picture of *Mr Trash Wheel* is displayed in 9.1

Figure 9.1: Picture of "Mr Trash Wheel", the trash inceptor in Baltimore. Photo by Healthy Harbor Initiative

This project is a unique measure which tackles the plastic problem on different levels. First, it cleans the river and thus tackles the problem of the existing plastic waste, in particular the litter and keeps the litter from reaching the ocean. Next, it provides data on what ends up in the river, at what time of the year the most litter occurs and what items are littered the most. For instance, since may 2014 around 1.5 million pounds (680.000 kg) have been collected in total. The item collected the most is cigarette butts (over nine million since may 2014) followed by polystyrene cups (more than 730.000) (Goldsmith, 2017). Beyond that, it draws attention in a subconscious way (Snow, 2017). Tourists and citizens first look at it due its funny look before learning about the reason for it. This means, the topic is not forced upon them but they chose to deal with it by themselves.

This measure is an advisable option for Gothenburg. There is a canal in the city centre that is polluted. The pollution can be seen in particular during winter time when the floating litter is visible on the surface of the frozen canal. The canal flows into the river "Göta älv" which enters the sea right after. A balanced marine environment is part of Gothenburg's quality objectives. Thus, the pollution of Gothenburg's canal is directly connected to marine debris (City of Gothenburg, 2014a). Introducing a "trash wheel" would create curiosity and awareness in a place where a lot of citizens spend time.

Theme-days
Theme-days concerning plastic waste should be promoted more. There are international days that could be endorsed more. Examples are the *"international plastic bag free day"* (Zero Waste Europe, 2017), the *"International straw free day"* (Blue Ocean Network, 2017) and the *"Bring you own cup day"*. Another example is the "world coastal clean up day" (Ocean Conservancy, 2018) every third Saturday in September. Depending on the kind of theme-day, projects could be initiated involving organizations, companies and citizens.

Public litter pick-ups
Public litter pick-ups can increase the discussion and awareness among Gothenburg's citizens. First, participants share their experiences and get rid of the trash-blindness. Trash-blindness describes the phenomenon of people getting used to litter to an extent that they are not aware of it any more. Secondly, public litter pick-ups create interest among bystanders. This again creates awareness and curiosity which increases the general interest in the topic. This has been observed for actions taken by other litter pick-up initiatives (Trash Hero World, 2018). Safe and nice city (Trygg, vacker stad), a department of the city, has started to organize a litter-pick up for employees at the city, which takes place annually. However, it includes neither the public nor companies. Weekly public pick-ups could be organized as well. The city could for instance provide equipment to pick up litter or free transportation to the locations. The litter could be weighed and analyzed in order to obtain better data by monitoring litter in the city.

9.3.4 Online platform

A webpage has the potential to help waste prevention initiatives in Gothenburg flourish by connecting and inspiring individuals. It should be a platform for communication, where benefits and good practices for waste prevention can be shared. Information on waste prevention initiatives and related actions in the region can be gathered. Beyond that, successful actions from around the world can be displayed.

Driving waste prevention needs support and promotion. It has been claimed that there is a lack of knowledge on how to work with waste prevention. Besides that, good practices such as the project initiated in elderly homes (Fahlgren, 2016) can show the benefits of successful implementations. The purpose of such a network is to share and create ideas. That makes it possible for organizations and individuals to learn together and avoid making the same mistakes. The city of Amsterdam has been working with circularity and has created a platform to share ideas, create communities and projects and connect stakeholders (Amsterdam Smart City, 2018). One of the themes is "Energy, Water & Waste" which displays international projects, events, smart products, requests and companies working with these topics. It is possible for anyone to join this platform and become a part of the network. Concerning plastic waste, there are articles, projects and networkers looking for partners to tackle the problem.

The city of Gothenburg provides some information for different kinds of businesses and operations on how to prevent waste. However, the webpage is not a platform, there is no space for communication, there are no good practices and the webpage is just a sub-page of the city's general webpage. There is little information in other languages than Swedish and there is insufficient information concerning plastics. Therefore, a platform that promotes waste prevention in general and in particular plastic waste prevention in Gothenburg, should be created.

This platform needs to be well structured. It should be helpful for individuals, organizations and industry. Furthermore, it should combine general information, the possibility to ask questions, concrete good practices as a source of inspiration and a chance to share ideas, projects, contacts. It would be a network for any possible stakeholder concerning waste prevention. Close partners should be the Keep Sweden Tidy foundation and the city's project Greenhack. It could show shops that forego packaging as well as the water fountains in the city where one can refill their own water bottle. Also, there could be information on theme-days, public litter pick-up days or projects like the trash wheel. A synopsis of the concept is given in Table 9.4.

Table 9.6: Key factors for the suggestion of an *Online Platform*

Key factor	**Description**
Category	City actions
Type of action	Raising awareness and promoting sustainable development
Approach	Webpage with interactive platform
Waste stream	Plastics in general
Target group	Citizens, businesses and operations in Gothenburg
Implementation	Local level
Leverage point	Information flows

9.3.5 Deposit-refund system for reusable takeaway cups

Take-away coffee cups are good examples of disposable plastic items. The cups are only used as long as it takes to drink the coffee, but when thrown away. It takes hundreds of years for them to break down. Take-away cups used today mainly consist of paper but have a thin polypropylene (PP) layer to make them waterproof. This layer of plastic makes them difficult to recycle. To be able to recycle the cups, they need to be taken to special recycling facilities, which are rare. This results in only a small amount of those cups actually being recycled (Gabbatiss, 2018). Not only are the low recycling rates connected to the cups a problem, but also the fact that they are among the 10 most common items found along coastlines in Sweden (Håll Sverige Rent, 2018b).

The Scandinavian countries have the highest per capita coffee consumption in the world (Bernard, 2018). This results in a large unnecessary waste stream, which could be avoided by introducing a deposit-refund system for reusable take-away coffee cups. By avoiding the consumption of take-away cups, the waste flow is reduced. Due to the economic incentive of a refund, the risk of the cups being littered or escaping collection systems in a different way is diminished as well. An additional advantage with the system is that it provides an alternative to take-away cups, but still provides the possibility to drink the coffee on the go.

Deposit-refund systems for coffee-cups have successfully been implemented in other cities in Germany, such as Freiburg (www.freiburgcup.de) as well as cities participating in the deposit-refund system called "reCup" (www.recup.de) such as Berlin, Hamburg, Augsburg and more. It is possible for the consumer to return the used cup at any of the participating cafés, stores and restaurants in the city. In the case of reCup, the company is in charge for the cups, while the cafés pay a daily “fee” to participate in the system. ReCup is responsible for taking care of broken cups and providing new ones to the cafés.

An implementation of such a system should be considered as a solution to plastic waste generation on a local level. The implementation should be feasible within to-

day's structures because there are clear economic and environmental benefits. Not only has the implementation of such deposit-refund systems been successful, and resulted in a significant decrease in the respective waste stream, but it has also been shown that the use of a reusable alternative to disposable coffee-cups is environmentally beneficial in the long-term (Roy, 2017). In addition, there should not be a need for a major change in mindset or education needed regarding deposit-refund systems because there has been a well functioning deposit-refund system for PET bottles and aluminum cans in place in Sweden for a long time (Tojo, 2011). Also, research performed by Walls (2011) shows that alternative waste disposal practices, such as virgin materials taxes, advanced disposal fees, recycling content standards and recycling subsidies don't show as good results as the introduction deposit-refund systems.

To make the system more accessible, introducing a map or an app might be a good idea making it easier for the consumer to know which cafés are included in the system and, thus, where to hand in the used cup. The concept is summarized in Table 9.7.

Table 9.7: Table of key factors with the purpose of identifying the relevance of the suggestion of a *deposit refund system for takeaway cups*

Key factor	**Description**
Category	Deposit-refund system for takeaway packaging
Type of action	Increasing material efficiency
Approach	Making it possible for consumer to use reusable coffee cups
Waste stream	Takeaway coffee cups
Target group	Customers
Implementation	Local level
Leverage point	Driving positive feedback loops (6)

9.4 Investigation of the ReToGo

In order to understand the challenges and chances of implementing the suggested recommendations, one of them was chosen to be investigated in more detail. A deposit-refund system was decided on for multiple reasons. First, it is a well functioning system in Germany. Next, representatives of the city claimed that small start-ups like this one are missing here in the city. Also, the idea was discussed with a person in charge of the 22 cafés and restaurants at the university's campus and positive feedback was received. The idea was treated as a start-up idea and communicated as such to the stakeholders. The investigation included discussions with representatives of Chalmers' Konferens who are in charge of the cafés and restaurants on campus, the innovation office at Chalmers, representatives of the city, the

founder of the company "reCup", the company working with that system in Germany and, finally, possible producers and participants. The name of this project is "ReToGo - The reusable cup To Go".

Talking to one of the founders of the existing company in Germany initiated the idea to adapt a similar system here in Gothenburg. One of the founders explained that the motivation has been to have sustainability at the core of their company, including the idea itself, the business model, the bank they use, etc. Another motivation was a statistical number provided by the "Environmental Action Germany" stating that more than 300.000 single-use coffee cups are being used every hour in Germany (Deutsche Umwelthilfe, 2018). They further explained problems with other alternatives to single-use cups, such as lignin-based cups or bamboo-based cups. According to them, the material used for the cups, polypropylene, is not the ideal and final solution but the best at the moment. They excluded the possibility of us being in competition here in Sweden and encouraged us to actually implement this here as well.

The idea is to avoid single-use coffee cups by shifting to reusable cups and a deposit-refund system. The owner of the cups would be ReToGo. The restaurants and cafés pay a certain amount for the cups which is slightly higher than the production costs. The participating stores then give the cup to the customer for the same amount. Thus, the stores do not make any profit with the cups. The customer gets a small incentive to chose the reusable cup over the single-use cup. Different options are possible: price reduction with the reusable cup, a fee for the single-use cup or no choice, there are only reusable cups. The cups can be refilled (not for free). The customer can return the cup at any participating store, an app maps all of them out. Restaurants and cafés pay a participating fee every day and wash the returned cups. They save money by not having to buy single-use cups and increase their profits through a higher amount of customers entering the locality.

The structure of restaurants and cafés at Chalmers provides a good starting point. Most of the existing cafés and restaurants belong to the Student Union and are managed by Chalmers Konferens. This gives the opportunity to start the project with 22 places and a community that visits these places regularly. The idea was presented to persons in charge of Chalmers Konferens and an actual implementation was discussed. Challenges concerning specifically the cafés and restaurants on campus were addressed. The difficulty of monitoring a clear ecological benefit and a lack of dish washers at certain places were two concerns. The general sentiment after some meetings was cautious but positive. There are some minor challenges but they can be resolved and there is a general interest. A test with prototypes would be the next step.

The idea is ready to be launched if some of the mentioned issues can be resolved. The ReToGo idea was further presented to the Innovation Office at Chalmers. They provide help for start-ups at the university. The feedback was positive, there were no major issues that we had not addressed or thought of. The advice was to test

the project in a small scale as a next step. Beyond that, multiple possible producers in the region were contacted in order to get a first cost and time estimation for the production. With two interested companies, rough cost estimations were conducted. The next step towards an actual company would be to make a 3D model and a finance plan.

The idea could be taken to a commercial level. Different options for the future are reusable cups at more cafés, reusable cups at sport events and conferences or a further development of the cup with a QR code on the cup to monitor usage. The development of a sustainable lid is another option. A major issue that has not been resolved yet is the financing for the substantial initial costs.

10
General discussion

The following chapter is a discussion about the conducted work in this thesis. First, the relevance of the obtained results will be evaluated critically. Next, the description of the current situation as presented in chapter 8 will be examined. A discussion of the methods used will follow. Finally, it will be reflected critically whether these methods and the obtained results give a satisfactory answer to the research questions.

10.1 Discussion of main findings

This section will begin with a general discussion about the results. After that, the concrete proposal of a deposit-refund system will be discussed and put in context. Next, the list of recommendations will be analyzed followed by an evaluation of the regulatory recommendations. Finally, the necessary mindset change will be reviewed.

The time frame has limited the extent of the results. The work of this thesis was limited to 20 weeks. Therefore, not all recommended concepts could be evaluated in detail. Numeric evaluations or studies with the result of certain actions where looked for but seldom found. A definite statement whether the suggestions will lead to certain changes cannot be made. Another reason for that is the amount of external factors that can influence such a project. The attempt was to include as many factors as possible but there may be some factors like the financing of a project that we did not respect to a sufficient degree.

The idea of a reusable coffee cup in a deposit-refund system was evaluated to an extent that seemed reasonable within the scope of this thesis. However, there are plans to continue with this project in the future. The aim was to see what it would take to realize one of the initiatives in Gothenburg. Most likely, more challenges that have not been considered might come up once this concept is actually implemented. However, due to the positive feedback, the interest for collaboration among multiple stakeholders and the functioning concept in Germany, the ReToGo may be translated into an actual start-up after the this thesis. Concerning the environmental impact, there are a lot of studies with very different results. Evaluating the environmental impact of a single-use cup and comparing it to the suggested reusable cup is difficult. There are a lot of assumptions needed for this analysis, e.g. the

soap used in the dishwasher, the kind of dishwasher or the disposal. In general, most studies show an improvement for polypropylene cups compared to single-use cups after a certain amount of usages. This amount differs widely, starting at 20 usages (Roy, 2017). The suggested cup is designed to be used around 500 times.

The list of recommendations is not absolute. It is a result of the methods used, qualitative categories used to decide on the relevance of the suggestion and already existing knowledge. The ideas for the suggestions are based on already existing knowledge, since they are similar measures existing elsewhere. Proposed actions have been implemented successful in a similar context. The extent of success of the actions looked at is difficult to quantify as well as the context where it has been implemented to some extend differ from the context in Gothenburg. It was attempted to justify the procedure and decisions made at all stages but the possibility of an unsatisfactory justification cannot be completely excluded at all times. As many factors as possible were included in the evaluation of the ongoing initiatives but more factors might exist. The complemented use of leverage points by Meadows (1997) was used to additionally assess the initiatives. A detailed analysis of all projects concerning their initiation, development process was not within the scope of the thesis, but might have influenced the decisions made on suggested recommendations. As a verification, the list of recommendations was presented to and discussed with the department of sustainable waste and water in order to reveal eventual weaknesses these actions could face when implemented, discuss the feasibility of the concepts and their actual implementation. The feedback was positive and this report will be used for both information and inspiration in their future work.

The regulatory recommendations are not more than a complement to this thesis. The European and Swedish legislation and strategies are a major part of problems related to plastic, and have been studied in context of the scope. However, the aim of this work was not to go into detail of regulations, European legislation and the complex dynamics of politics. Nevertheless, certain parts of the regulatory framework stood out and this work seemed incomplete without mentioning some obvious findings concerning issues related to plastics. Therefore, these recommendations are included but not explored in detail. They concern mainly littering in some way and prevention to an extent.

Concepts on what focus society should have in the future to promote waste prevention instead of waste management is a somewhat abstract translation of sustainability principlesto context of the plastic problem. It was influenced by Göran Carstedt's approach of thinking about leadership in the future and the backcasting methodology. The sustainability principles that need to be valid for the desirable sustainable future were obtained during the first phase. An exhaustive list can be found in Appendix A. The application on the plastic waste problem is the authors' interpretation of these principles based on their knowledge. The resulting statement can and absolutely should be challenged and questioned in order to push the discussion.

10.2 Discussion on evaluation of current situation

The understanding of the current situation is a core element of this thesis, but due to its complexity some aspects might inevitably be missing. The statistics and the ongoing initiatives will be discussed in this section.

The statistics may be incomplete to some extent and strongly depend on certain factors. The allocation of plastic waste in the statistics was not the same all the way through. Plastics were either mentioned directly as "plastics", included in "plastics and packaging" or even in a broader sense together with "paper and packaging". This is critical because it remains unclear what fraction the plastic part is for these scenarios. In Sweden, there are different containers for paper, paper packaging and plastic packaging. While it is obvious for the latter one, paper packaging usually contains some plastics in form of a layer on the paper itself but it is just a fraction of the paper packaging weight-wise. Also, the littering data only represents certain parts of the city and may not be representative for the city as a whole. To verify this data, the *litterati* app and its data was used and main tendencies compared. The *litterati* data itself is not representative. It depends on what the users pick up which can neither be seen as comprehensive nor representative of what is littered.

Our final list of ongoing initiatives locally might be incomplete while the list of initiatives around the world is definitely incomplete and should not be seen as comprehensive or representative. They are a result of mainly information from interviews and the literature review. Some initiatives that were found simply did not provide sufficient information about the action itself, their development, process or involved actors so that an evaluation to a satisfactory degree was not possible. This played a bigger role for initiatives elsewhere because the range of initiatives was considerable. More effort was put into finding more information for local initiatives and projects. The aim of the list of initiatives around the world was not to be exhaustive or representative but rather to give an overview of different existing measures and a compilation of measures that seem feasible to be implemented in Gothenburg. Economic aspects of an eventual implementation were not considered.

Plastic waste prevention has not been addressed in research to a high degree yet. This is why further information on helpful literature was respected. Additional literature was recommended by experts and found in articles as references. Even though the acquisition of literature used could be seen as diffusive, all the literature that was used is specifically mentioned and can be revised.

10.3 Discussion on methods

The choice of methods was a decisive factor for the development of the final results. Using a variety of approaches instead of focusing on a few specific ones helped to obtain a wide perspective on the issue. Statistics were used to examine the local

significance of plastic waste prevention. Literature and interviews were conducted as part of the process of understanding the complex situation concerning plastic waste prevention both on a global scale as well as in Gothenburg. The European influences on the city, the development of the consumption and the mindset concerning plastics were essential elements for the evaluations of the current situation. It also helped to understand where in the system a small change could lead to a substantial positive impact. Including all those factors was necessary to provide sufficient clarity for the high complexity of this topic.

The performance and evaluation of the interviews did not follow a strict methodology. Therefore, the evaluation can not be described as an analysis in methodological terms. The interviews were neither recorded nor transcribed nor translated as normally recommended in qualitative research. The approach of snowball sampling helped to identify relevant stakeholders and interviewees in the very narrow topic of plastic waste prevention within the extremely broad field of plastics. Although a lot of different voices were heard, the perspective from the plastic industry, local companies and citizens were not part of the interviews. The concrete choice of interviewees was based on availability, interest, representation of a sector or group, knowledge, publications, recommendations and individual activities as mentioned in chapter 5. The categorization and presentation of the main findings from the interviews are influenced by our own interpretations of what has been said.

10.4 Relevance of research topic

Formulating the final research questions was an iterative process. During the first four weeks of this master thesis, sustainability issues were identified. One of them appeared to be the way consume plastics today. However, afterwards, it was still unclear to some extent what the exact issue in the local context is and what research question/-s would address the problem adequately. That is why the research question was reformulated at different stages during the process. It was split into multiple sub-questions and, finally, ended up at the two presented research questions that were addressed in this thesis. While the topic of how we use plastics today was set from the beginning, formulating these two research questions was an iterative process in order to make them as concise as possible.

Instead of having a given research assignment, using the backcasting methodology at the Challenge Lab provided a basis to determine relevant sustainability issues ourselves. Without prior knowledge, it was somewhat difficult to understand the exact challenge. However, it was an interesting process with the opportunity of a very applied and locally relevant research. A more detailed discussion on the first Phase can be found in Appendix A.

The research questions addressed the shift from the situation today towards a desirable sustainable future explicitly for plastics. This already includes the assumption that today's system is unsustainable. With the two refined research questions, the

topic was addressed both on a rather theoretical and abstract level as well as on an applied level. It could be answered *what mindset change is needed to move from plastic waste management to plastic waste prevention in the future*. To answer the second research question, a list of five *possible measures and actions that can be implemented on a local level* was developed.

What waste prevention is in detail, how it can be implemented, what the impacts are and how they can be monitored is a fairly new research topic. The relevance and societal interest for how to combat the exponential increase of plastic usage is emerging and, thus, the possibilities of preventing plastic waste show both scientific and public interest. The topic has mad it to the top of the European agenda. The European Union will soon present a concept to decrease the impacts of single-use plastics this summer and initiated a new approach towards the use of plastics (REF).

11
Conclusion

There is a problem with the use of plastics in Gothenburg. Different statistics and further data presented in this thesis are proof of the plastic problem. The consumption has been increasing exponentially in Europe over the last decades and data specifically for Gothenburg showed that this city is no exception. Having quadrupled, the collected plastic waste stream is also the one that has by far increased the most over the last ten years while most other waste streams have stagnated or even decreased. Furthermore, plastic items make the vast majority of litter found in the city and on Swedish beaches. Evaluating ongoing initiatives and legislation, it could be shown that current measures do not tackle the plastic problem of the city adequately.

For a sustainable future, the way society thinks about plastic has to change. Today, society overuses plastics and underestimates the environmental impacts. The externalities are high but not reflected in the price. Instead of continuing with the tremendous increase in the consumption of plastics, the awareness of the true costs has to rise and behaviour has to change accordingly. This is especially true for the consequences of inconsiderate littering. The system as a whole needs to move from waste management to waste prevention. Stakeholders along the life cycle of plastics have to involved to tackle the problem at the source and achieve a lasting long term effect.

There are measures that could bring along substantial change with considerable effort. Five initiatives that have been proven successful under similar circumstances are recommended to be adapted in Gothenburg. The compilation consists of very different initiatives tackling the problem form various angles. They are no either-or options but would have the biggest impact if combined. The aim of these actions is to move today's system towards a sustainable future.

Plastic waste prevention in particular and waste prevention in general has not been addressed by research in depth so far. Analyzing the success of prevention measures and determining appropriate indicators to monitor and assess waste prevention initiatives is needed. Further research is recommended to establish viability of the possible measure to decrease plastic waste. Work is needed to evaluate what benefits are gained from different kind of plastic waste measures. Topics that can be investigate include for example reduction in environmental impact or investigations on what benefits related to social impacts do exist. Additional, incentives for taking part in waste prevention actions could be investigated. The work of this thesis could

be continued by analyzing the implementation and results of a concrete measure in Gothenburg.

The plastic problem is complicated and complex. It cannot be solved in isolation and needs to be addressed on multiple levels. Backcasting can be a good tool for a wicked problem like this and bring together industry, academia and the public sector to commonly work on the topic. The need for national and international legislation and collaboration remains. A mindset change is needed on a global scale to solve the problem, but small-scale local initiatives are substantial to start the movement towards a sustainable future, following the motto *Think big, Start small, Act now.*

There's no time to waste!

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A

Phase I Report

Challenge Lab

Identifying the Research Question

When, Where and How to Prevent Plastics in Gothenburg

Report on the First Phase of the Challenge Lab Master Thesis

May 3, 2018

Challenge Lab

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Fabian Hein

Chalmers University of Technology

Contents

1 The Challenge Lab: Introduction and Background

Think big, start small, act now! (The Challenge Lab, 2018)

The Challenge Lab is a platform where Master students from Chalmers University of Technology with different educational backgrounds are brought together to work with sustainability transitions in the region. The socio-technical challenges are both of a transformative and integrative kind, since they are challenging the current situation and connecting different actors in the region. The Challenge Lab provides a basis for confronting those challenges with an interdisciplinary approach (Holmberg, 2014).

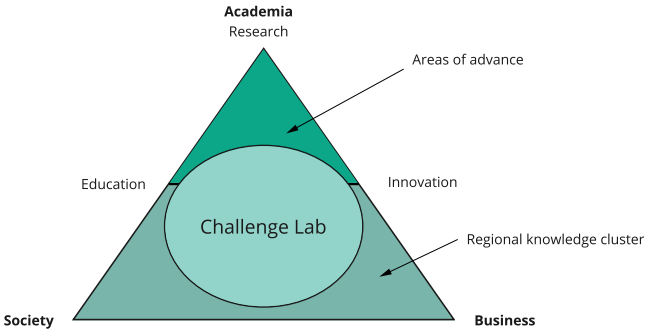

Figure 1: The Challenge Lab as a connection between the different areas of the regional knowledge cluster (Holmberg, 2014)

In 2008, Chalmers University of Technology decided on sustainability being the driving force for education, research and innovation. The university has since been increasing collaboration within the organisation but also with external stakeholders, through the founding of a matrix organisation Areas of Advance (AoA). Through the Areas of Advance (eight thematic fields: Production and Transport, Building Futures, Life Science Engineering, Energy, Material Science, Nanoscience, Nanotechnology, Information and Communication technology) research, education and innovations related to the thematic fields are connected with each other. The AoA's also have a key role in aiding the collaboration within the regional knowledge clusters (five knowledge clusters: Marine Environment and Maritime Sector, Urban Futures, Green Chemistry and Bio-based Products and Life Science) (Holmberg, 2014).

The Challenge Lab was launched with the aim of creating a hub connecting different actors in society, fostering from the interdisciplinary work environment that the Challenge Lab provides. Actors from academia, government and industry are brought together by

the students to solve local sustainability challenges (Figure 1).

The task of the Challenge Lab is defined by its creator Holmberg (2014):

- *'Strengthen the educational dimension in the knowledge triangle within the Areas of Advance.'*

- *'Provide a natural hub for the triple helix actors within the five regional knowledge clusters, where all parties are drawn because of the students, as they all have a stake in the students.'*

- *'Build trust within the clusters through students. A defining feature of students is that they are simultaneously non-threatening and challenging, a feature crucial to the kind of change society greatly needs, positioning the students to be powerful change agents.'*

- *'Give the students the opportunity to develop unique skills in working across disciplines and from a challenge-driven perspective.'*

The main methodological tools used during the Challenge Lab process are first of all the backcasting from principles methodology. Next is self-leadership with the aim to identify one's personal values, strengths and motivation. Adding to that is stakeholder involvement to ease the understanding of the current system.

The master theses written at the Challenge Lab are divided into two phases. The focus during the first phase is on getting a deeper understanding of the ongoing situation and thus being able to identify sustainability challenges and identifying a research topic. During the second phase, the research topic is investigated.

The topics for the Challenge Lab 2018 were urban futures, circular economy and mobility. These were the main areas that were further categorized in the process. They were a starting point for investigating gaps and as a guidance for limitation concerning sustainability challenges in the region.

2 Theoretical Framework

In this chapter an overview of theoretical tools, concepts, frameworks and approaches used during the first phase is given. These are used to identify sustainability gaps and to define the research question. First of a description of the Backcasting Methodolgy is given, followed by a brief description of the theoretical concepts of inside-out perspective and outside-in perspective.

2.1 The Backcasting Methodology

Three traditional approaches are used in the field of futures-oriented studies: forecasting, scenario studies and backcasting (Figure 2). The most commonly used tool is the traditional forecasting, where the most likely future is predicted, followed by scenario studies with the aim to explore alternatives futures. The third approach is backcasting which can be seen as a kind of scenario study (Dreborg, 1996) created to show what *should* happen (Vergragt and Quist, 2011). Backcasting is the methodology used at the Challenge Lab.

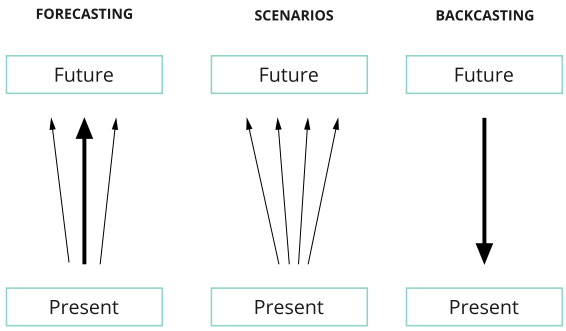

Figure 2: Forecasting, backcasting and scenario studies. Figure inspired by Dreborg (1996)

Backcasting is a methodology of planning which is helpful when approaching problems with high uncertainty and complexity, as well as when present trends are part of the existing problem (Holmberg and Robert, 2000). Backcasting is in particular useful when the problem studied is *'complex, there is a need for major change, dominants trends are part of the existing problem, the problem is to a grate extend a matter of externalities and the scope is wide enough and the time horizon long enough to leave considerable room for deliberate choices '* (Dreborg, 1996). Challenges related to sustainability transitions are often both complex and uncertain, which makes the backcasting approach suitable for solving these kinds of long-term problems (Dreborg, 1996).

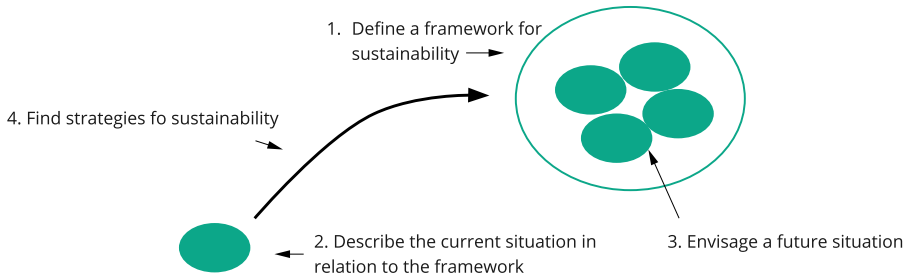

Figure 3: Principle of the Backcasting Methodology. Inspired by Holmberg (2014)

The main idea of the backcasting methodology is to plan from a future vision of a wanted outcome and understand what needs to be done today to get to the desirable state in the the future (Holmberg and Robert, 2000; Vergragt and Quist, 2011). This is done by proceeding the following four steps (Figure 3);

Step 1 - defining a framework and criteria for sustainability,
Step 2 - describing the current situation in relation to the framework,
Step 3 - envisioning future sustainable solutions and
Step 4 - finding strategies for sustainability (Holmberg and Robert, 2000).

Each step is approached by the two different perspectives described in the following sections of the report; the outside-in perspective (REF to chapter) is used with the aim to analyze the system from a bird's eye perspective while inside-out perspective (REF to chapter) is focusing on the individual part of the process (Holmberg, 2014). The theory for the four steps is described in the following subsections.

2.1.1 Step 1 – Defining a framework and criteria for a sustainable future

During the first step of the backcasting methodology, the aim is to define and discuss a framework and criteria for a sustainable future. It is important to be aware of the influence of current trends when identifying the criteria for sustainability. The process of defining the criteria should be detached from the current trends (Holmberg, 1998). The vision of the future state is based on criteria for sustainability in four dimensions; economic, ecological, societal and well-being (see figure 4). The economic, ecological and societal dimensions are the base of the well-being dimension. Therefore, they must be fulfilled to ensure present and future well-being Holmberg (2014). The principles should

be principles of the outcome *(sustainability)* and not the transition *(sustainable development)* (Holmberg and Robert, 2000). The following four system conditions expressed by Holmberg and Robert (2000) must not be violated to avoid further deterioration of our planet. The conditions must always be considered when defining criteria around concepts of possible future states.

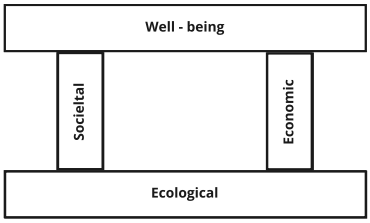

Figure 4: The four dimensions of sustainability; Inspired by Holmberg (2014)

2.1.2 Step 2 – Describing the current situation in relation to the framework

In the next step of the backcasting methodology current activities and competences are analyzed in relation to the sustainability criteria defined during *Step 1.* The analysis is carried out regarding the four sustainability pillars. An important result of this step is the identification of ongoing non-sustainable activities (Holmberg, 1998). Having gained an overview of the ongoing situation, gaps between the current situation and the desirable future can be identified. Some gaps might be more obvious than others and there is no limitation in the variation of the complexity and complications of the gaps. With the knowledge about the system and the existing gaps, leverage points in the system can be recognized. Leverage points are places in the system, which are ranging from small change in numbers to shift in mindset, where an intervention could be carried out to move the system towards the desirable future state (Meadows, 1997).

2.1.3 Step 3 – Envisioning future sustainable solutions

Having the knowledge about existing gaps (*Step 2*) between the current situation and the desirable future state (*Step 1*), solutions which will move the system towards sustainability are being envisioned, based on the sustainability principles defined. The overall idea of the third step is to free the mind of restrictions set by present conditions to be able to envision a wider range of solutions by doing so. Since the previous steps only set general guidelines, there are several possible future solutions. Creativity helps to break the barrier of being stuck in thinking in traditional ways, the way that led to the

existing system. Any solution no matter how absurd it may seem can contain valuable information. The key is to analyze why an idea may or may not work, which key factors determine the quality of the solution. Having understood the system dynamics in the previous steps obviously helps to rate possible solutions (Holmberg, 1998).

2.1.4 Step 4 – Finding strategies for sustainability

The last step in the backcasting methodology is to find strategies, which implies the identification of feasible ways to implement the envisioned future solutions. As explained before, technology diffusion is one example to work with spreading a technological product (Robinson, 2009).

To ease the process of identifying strategies, it is recommended to consider the following guiding questions (Holmberg, 1998):

-*"Will each measure bring us closer to sustainability?"*

-*"Is each measure a flexible platform for the next step towards sustainability?"*

-*"Will each measure pay off soon enough?"*

-*"Will the measures taken together help society to make changes at a sufficient speed and scale to achieve sustainability without too many losses for humans and other species during the transition?"*

The strategies that are able to consider all the points mentioned in the questions, will have a high chance in moving towards the future desirable state (Holmberg, 1998).

2.2 The Inside-Out Perspective

While being part of a sustainability transition, being aware of one's personal vision is an essential driving force (Holmberg, 2014). The Inside-Out perspective focuses on the individual. In the context of driving sustainability transitions, it is about learning about and being aware of one's own core values as well as strengths and weaknesses, how they influence our actions and how they can be used in a positive way.

One central aspect of the inside-out perspective is to work with one's own values, norms and principles. These have developed through childhood, personal experiences, cultural norms and many more external factors and significantly influence one's actions, mindset and behaviour. It is an iterative and never-ending process to work towards the grassroots of one's personal driving force. Usually, multiple levels of identification with certain values are worked with. At the bottom, some core values are essential to describe the motives of our actions. These core values are not universally defined but depend on the individual interpretation and meaning. On further levels, additional values shape the

individual way of thinking, identification and interaction. Those ones are not equally fundamental compared to the core values (Ryan and Deci, 2000).

Being aware of one's values can help understand one's intrinsic motivation, what kind of work aligns with these values as well as help to connect oneself with the work carried out (Ryan and Deci, 2000). Furthermore, it can be extremely useful for the interaction with others; especially when they have different experiences or cultural norms, etc. The understanding of how that determines problem approaches, communication, setting priorities and much more is crucial for a successful collaboration. Always having in mind where behaviours can originate from helps with a respectful social interaction. Working with values does not only show personal benefits in a work environment, but can also help to prioritize leisure, influence the personal well being and, furthermore, understand the origins of and tackle intercultural differences and find common ground (Sandow and Allen, 2005).

In conclusion, the inside-out perspective is a useful supplement for each individual in order to locate motivation, promote a respectful interaction and understanding as well as to determine a commonly explored basis of the involved participants to work together and to work in the same direction.

2.3 The Outside-In Perspective

The outside-in perspective supplements the inside-out perspective. The focus is not on the individual but on the outer system. This outer system can look very different depending on the context. When relating it to the first step of the Backcasting methodology, it means bringing the individual needs and values together to form a common ground, principles that need to be valid in a sustainable future (Holmberg and Robert, 2000).

When it comes to the second step of Backcasting, where an understanding of the current system is developed, the outside-in perspective is especially important because the focus is on the system itself. It is not limited by the inspected system but also asks how this system is connected to other systems and, furthermore, how and why the system developed into the present system. A Multi-Level-Perspective constitutes multiple levels from a product-technology system up to a societal system. It is crucial to always be aware of the current standpoint when analyzing the current situation, whether technological aspects or rather legislative ones are being discussed (Geels, 2005; Joore and Brezet, 2015).

Exploring the system dynamics is crucial when moving on to understanding how the system will react to possible solutions, which is the third step in Backcasting. Design Thinking can be supplementary or even the main approach at this stage. Is is not about designing a product in the first place. Using Multi-Level-Perspective, Design Thinking moves the question at least one level up by asking what need is to be fulfilled instead of a product. It is for itself an iterative process of opening up and narrowing down, weighing

and testing (Joore and Brezet, 2015). For any kind of solution, this process will combine an understanding of how the system works and where a certain solution would intervene in the system. What change is done and what consequences go along with it is central to understand how much of an impact that can be achieved (Meadows, 1997).

In the last step, strategies of implementation have to be thought of. The outside-in perspective describes this transition. It is the understanding of how technology diffuses and evolves from niche-markets to mainstream, how the process of legislation works and how a behavioural change occurs (Robinson, 2009).

3 Method: Backcasting Step 1 and Step 2

In the following subsections the methodology of the first part of the project is presented *(Phase I)*. First criteria for sustainability were defined, followed by a understanding of the current system and the identification of leverage points. These steps were performed with the main aim to identify the research question.

The first and second step of the backcasting methodology have been applied during this phase of the project. Group activities, brainstorming and workshops, background research, stakeholder dialogues and interviews have been the main tools used.

3.1 Definition of criteria for Sustainability

Criteria for a desirable future were defined in accordance with the four dimensions of sustainability (see figure 4). Workshops related to self-leadership and criteria definition were performed alternately.

Self-leadership
In preparation of the self-leadership workshop, all the students had individually picked attributes that they value highly. The workshop started with dividing the group into smaller groups of three students. In the smaller groups everyone took turns in talking, listening and being in charge of timekeeping. The student talking shared personal stories related to the chosen values, while the other student sitting in front of the person talking, was active listening, that is, only listening and nodding or asking the person talking to give more precise examples. This exercise increased self-awareness, listening skills and built trust among the group.

Furthermore, each student had to reflect upon their strengths and weaknesses. These characteristics were reflected upon by finding the respective opposites but also how these attributes could be misinterpreted if being overdone. This process lay ground for increasing one's self-awareness and the process of reflecting on what kind of strengths would complement one's owns.

In addition to the previous exercises, a workshop on defining one's personal mission statement was held. The aim of the workshop was to combine personal values with criteria for sustainability and formulate a few lines that can guide the individual in their actions.

Criteria definition
The big group of students was divided into smaller groups, where every group was assigned one of the dimensions of sustainability. Each group got the assignment to write down keywords associated with the topic discussed. After a while, all members except of one, moved on to another topic and discussed keywords for that different topic after being informed about the keywords of the previous groups. Those that had not yet been formulated were added to the already existing ones. This continued until all of the

groups had been able to add keywords associated with all the pillars of sustainability. Afterwards, all the topics were presented and keywords were added or redefined. The result of this exercise is presented further down in the result section related to step 1 of the backcasting methodology (REF to chapter).

3.2 Stakeholder dialogue - Identification of leverage points

To get an understanding of the current situation, stakeholder dialogues and interviews were performed. Stakeholder with different backgrounds and areas of expertise were invited to take part in the process. The dialogues were facilitated and documented by the students.

Stakeholders from academia, public and private sector were represented during the dialogues and made it possible to get a broader view of ongoing actions and the gaps between the system today and the desirable future. Three dialogues were conducted before the Challenge Lab process started, and the rest were held during the first phase of the Challenge Lab process. The dialogues usually started with a presentation by the stakeholder and their work, followed by a second part with focus on questions asked by students. Two students were in charge or guiding one dialogue each. The organization of the dialogues was mainly their choice. For the majority of the sessions, different tools such as Check-ins, different feedback tools like the fishbowl concept (REF to fishbowl!) were used.

The results of the dialogues were sometimes already quite precise leverage points and other times a rather general formulation of problems in the current system. With the input of the dialogues, discussions in groups for each of the topics took place, interim results were presented and discussed.

4 Results

The result from Phase I (step 1 and step 2 of the backcasting methodology) will be presented in the following section. The results are underlying outcomes for the topic investigated and the research question formulated in the end of the chapter.

4.1 Definition of criteria for Sustainability

The first part of the processes leading to the definition of sustainability criteria was focusing on each group members own values, strengths and weaknesses. The aim was to get a better understanding of oneself and others being part of the Challenge Lab group. Workshops conducted during this process resulted in a list of personal core values.

This process was the base for the next step were keywords were identified and used to describe the desirable sustainable future (REF back to chapter!). The keywords are not aiming to describe solutions for a sustainable future but rather characterizing this sustainable future. Keywords and criteria for a sustainable future are sorted into the four different subcategories for sustainability; well-being, social sustainability, economic sustainability and ecological sustainability. The actual list of keywords can be found in Appendix A. One has to be aware of the fact that the keywords without context can be interpreted quite differently. Main findings originating from the discussion around the keywords and their respective interpretations are summarized shortly.

Social sustainability
Social sustainability is focusing on how we can live together. These concerns cultures, a variety of groups (e.g. gender, ethnics, religion), classes and individuals. It can be divided into horizontal relations, vertical relations as well as equity and justice The associated keywords in Appendix A are sorted by those subcategories.

Economic sustainability
During the process of identifying criteria for the economic dimension of sustainability, the question 'How can capital be managed for the future?' was addressed. The management of capital is divided into natural capital, man-made capital, human capital and financial capital The process resulted in the idea that in general economic sustainability can only be reached if measures taken are in line with a long-term vision as well as conscious consumption. Resources need to be fairly distributed and the distribution processes need to be transparent.

Ecological sustainability
The ecological sustainability is referring to societal activities being in line with nature's carrying capacity. It is the very basis to ensure conditions that allow humans to live on the planet, for current as well as future generations. Broken further down, it is about keeping a balance between extracted and produced substances by humans in correlation

with the degradation, carrying and restoring capacity of the earth. The principles defined for ecological sustainability are presented in Appendix A.

Well-being
Having identified keywords and criteria for the three base dimensions for sustainability, the dimension of well-being was addressed. The keywords for the dimension of well-being are concerning the question 'What is a good life?'. Referring to well-being of today's and future generations. Overall, the need for equity and equal opportunities was identified as essential for achieving well-being. More specific keywords can be found in the Appendix A.

4.2 Stakeholder dialogue - Identification of leverage points

The process of identifying challenges and leverage points resulted from dialogues and interviews carried out with stakeholders invited to the Challenge Lab. The dialogues contributed to the understanding of the current system of the region as well as the challenges related to specific sustainability transition. There were five dialogues held within three days. Stakeholders were mainly from academia and the public sector, but some representatives of companies where present as well. The level of each individual student's participation depend on the topic being discussed since the literature review before the dialogues and usually been focused on one of the three topics.

During the dialogues carried out on the topic of circular economy, the regional goal of reducing waste was mentioned as well as the city's aim in moving higher up in the waste hierarchy pyramid. During interviews with stakeholders the lack of a holistic approach on the issue was identified. These issues were underlying conditions for the identification of the research question.

4.3 The research question

A brainstorming and discussions after the dialogues specifically on plastic waste led to a variety of gaps concerning plastics. The concrete gap that would be the basis of our research question was the lack of prevention strategies for plastic use and therefore plastic waste. After a lot of feedback from presentations and discussions, the finalized research question was formulated. The thesis aims to come up with recommendations for reducing plastic waste by addressing the main research question; 'When and where is it effective and worthwhile to avoid plastics in the Gothenburg region?'. To be able to answer the question, secondary questions were formulated:

- What are possible measures and actions that can be implemented on a local level?
- How can the focus be shifted from waste management towards waste prevention in the future?

During the process of answering the questions above, the goal is to identify important stakeholder to involve further in the process. The next step will be to come up with recommendations for what measures can be implemented on a local level in the area of Gothenburg.

5 Discussion

The setting of the Challenge Lab differs from the usually predefined conditions for writing a master thesis at Chalmers University of Technology. The Challenge Lab gives students the opportunity to formulate a research questions on their own, after having had the chance to investigate the current local situation as well as reflect on one's own values, interests and strengths. This resulted in a strong motivation and ambitions level in tackling the challenge.

The whole process during this first phase resulted in the research questions. However, during the process , much more than that was accomplished. Working in the changing groups and discussing developments helped to gain a wider and more comprehensive overview, made overlappings and connections clearer and trained the critical thinking. Being aware of the bigger picture by switching between the levels (system level, topic, challenge) manifested the dimension and scope of each research question and the system dynamics around it.

Addressing the inside-out perspective was very helpful to develop as an individual, meaning to take the time thinking about one's own values and how they were shaped. Also, it clearly helped to dive deeper into one's strengths, how they can be perceived when overdone and how to use that knowledge in a positive and constructive way.

The formulated research question for this thesis was explored late in the first phase, mainly because it was not specifically linked to one of the topics (urban futures, mobility, circular economy). Even though it clearly has a strong connection to the circular economy, it never came up in either the group discussion nor the stakeholder dialogue. Circularity, waste as well as transmaterialization and dematerialization were addressed but not exactly plastics as a single topic. It was rather personal interest and a brainstorming about plastics that started the process leading to the research question. The topic had therefore not been addressed in depth up to that point and was a little premature in the first discussions, since the discussion between students started after the dialogues had ended.

Another challenge with the topic was to determine a concrete gap in the extremely wide topic that has a local importance. In general, the refineries in the region make a local connection obvious (REF to refineries), however, there was still a need to specify whether to work with recycling, redesign, chemical additives, ocean littering; which sub-system to look at, e.g. plastics in cars, in electronics, in toys and where we had possibilities to actually intervene in the system. This was especially difficult because a variety of plastics is used everywhere in our daily lives in very different forms and for very different purposes. The actual research question addressed is a combination of personal interests, literature research, information from the stakeholder dialogues and discussions.

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Appendix A Keywords for a sustainable future

1. Social Sustainability

S.1 Horizontal relations (interaction within and between groups)
•Acceptance
•Communication
•Cooperative - Learning
•Empathy
•Helping each other
•Openness
•Participation
•Respect
•Trust

S.2 Vertical relations (interactions with institations)
•Accountability
•Adaptability
•Alertness
•Awareness
•Integrity
•Representation
•Respect
•Responsibility
•Transparency
•Trust

S.3 Equity/justice
•Consciousness
•Equal access (education, freedom, safety)
•Equal opportunity (legal and normative)
•Equal rights (legal and normative)
•Fairness
•Freedom of movement
•Impartiality
•Inclusion
•Power balance
•Welfare

Ecological Sustainability •Alterations made in the crust or biosphere should be reversible
•Meeting the needs of the earth (planet and living beings) today, without compromising

its ability to meet the needs of tomorrow
•Preserve, Protect,Restore/regenerate
•Serve the environment: Substances should be produced/extracted so that they can be degraded/reabsorbed within reasonable time

Economic Sustainability

Econ.1 General
•Conscious consumption
•Fair distribution
•Long-term-vision
•Transparency

Econ.2 Natural cap
•Efficiency
•Substitutability
•Sufficiency

Econ.3 Man-made capital
•Dematerialization
•Flexible and adaptable systems (buildings, transport, infrastructure)
•Life-cycle assessment
•Maintenance
•Sharing

Econ.4 Human capital
•Collaboration
•Shared and accessible knowledge
•Sub-category to increase

Econ.5 Financial capital
•Fair distribution of wealth
•Growth indicators
•Responsible investments

Well-being

W.1 General:
•Equal opportunities
•Equity

W.2 Knowledge:
•Access
•Broader connection
•Education
•Global participation

W.3 Autonomy (self-determination):
•Deciding one's own fate
•Freedom
•Independence
•Ownership of your time

W.4 Self-fulfilment:
•Recreation for personal Development and Opportunity to pursue Happiness
•Space for self-expression Self-improvement/ development
•Spirituality

W.5 Purposefulness:
•Appreciation
•Contribution
•Love
•Respect
•Sense of purpose

W.6 Belonging:
•Acceptance
•Acceptance of diversity
•Community
•Culture
•Family
•Freedom
•Identity
•Inclusion
•Personal independence
•Positive social interaction

W.7 Subsistence:
•Clean air
•Clean water
•Employment
•Food security

•Home
•Minimum wage
•Nutritious food
•Safety
•Secure
•Sufficiency

W.8 Health:
•Access to health care Services
•Good health (mental, physical)
•Green spaces
•Recreation
•Weather

B

Ongoing initiatives

Table B.1 Ongoing waste prevention initiatives in Gothenburg by the department of sustainable waste and water

Table B.2 Ongoing international initiatives on plastic waste prevention. Sorted after the category of the measures

Table B.1: Overview of ongoing waste prevention initiatives by the department for sustainable waste and water at the city of Gothenburg

Project	**Waste Stream**	**Target group**	**Tool**
Scrap your waste (Skrota Skräpet)	General solid waste	Public administration	Coaching and Presentations
Waste prevention in the office (Förebygga avfall på kontoret)	Waste produced in offices (e.g paper, food waste, packaging)	Offices	Guidance, checklist and examples
Waste prevention elderly homes (Förebygga avfall på äldreboendet)	e.g food waste, incontinence pads, single-use items	Retirement homes	Guidance, checklist and examples
Waste prevention in preschools and schools (Förebygga avfall i förskola)	e.g food waste, paper waste, furniture	Schools, preschools and kindergardens	Checklist
Waste prevention in public procurement (Förebygga avfall vid inköp och upphandling)	e.g unnecessary procurement, packaging waste	Procurement offices	Checklist
Waste prevention at conferences, hotels and catering (Förebygga avfall vid beställning av konferenser, hotell och catering)	e.g single-use items, packaging, advertisement products, food waste	Client (Konferences, Hotels, Catering)	Checklist
Prolong life-time of IT equipment	IT-equipment (Förläng livslängden på IT-utrustning)	User of IT equipment	Video and guidance
Gothenburg's model for reduced food waste (Göteborgsmodellen för mindre matsvinn)	Food waste	Public kitchen	Practical examples
Waste prevention in apartment buildings (Förebygg avfall i flerbostadshus)	e.g construction waste, bikes, tools	Apartment buildings	Checklist, examples of measures
Waste prevention at restaurants and cafés ((Förebygga avfall på restauranger och kaféer)	e.g food waste, single use materials, packaging	Restaurants an cafés	Checklist and examples
A world without garbage (En värld utan soppor)	e.g general solid waste	Consumer	Examples

Category	Nr	Action description	Approach	Location	Waste stream	Type of action	Leverage point	Main target group	Level of implementation in Sweden
Legislation	1	Single use plastic bag ban	Ban	Australian region	Plastic bags	Developing sustainable consumption	Rules of the system (4)	Shops/Supermarkets, Consumers	National
	2	Ban on plastic bags	Ban	France	Plastic bags	Developing sustainable consumption	Rules of the system (4)	Shops/Supermarkets, Consumers	National
	3	Ban on plastic dishes	Ban	France	Plastic dishes	Developing sustainable consumption	Rules of the system (4)	Consumers	National
	4	ban plastic bags in 2002	Ban	Bangladesh	single-use plastic bags	Developing sustainable consumption	Rules of the system (4)	Consumers	National
	5	Ban of single use bags	Ban	Rwanda	single-use plastic bags	Developing sustainable consumption	Rules of the system (4)	Consumers	National
	6	Ban of single use bags	Ban	China	single-use plastic bags	Developing sustainable consumption	Rules of the system (4)	Consumers	National
	7	Ban on plastic bottles in public spaces	Ban	San Francisco	Water bottles	Developing sustainable consumption	Rules of the system (4)	Consumers	National
	8	Planned ban on all single use plastics by 2021	Ban	Costa Rica	Single use plastics	Developing sustainable consumption	Rules of the system (4)	Consumers	National
City actions	9	New fountains and bottle-refill	Building new fountains	London	Water bottles	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local

Category	Nr	Action description	Approach	Location	Waste stream	Type of action	Leverage point	Main target group	Level of implementation in Sweden
	10	Drinking fountains across the city	Building new fountains	Copenhagen	Water bottles	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local
	11	Provide alternative solution to water bottles	Provide alternative solution to water bottles	Evanston	Water bottles	Developing sustainable consumption	Driving positive feedback loops (6)	Event Clients, Consumers	Local
	12	The trash Wheel, a trash inceptor in Baltimore	Awareness, data	Australia/ Global	Litter in river	Raising awareness	Information flows (5), mindset (1)	Consumers	Local
Deposit system for take-away packaging	13	RECUP	Deposit-refund system for coffee-cups	Several Cities in Germany	Coffee Cups	Increasing material efficiency	Driving positive feedback loops (6)	Cafés Consumers	Local
	14	Refill-it	Deposit-refund system for coffee-cups	Hamburg	Coffee Cups	Increasing material efficiency	Driving positive feedback loops (6)	Cafés Consumers	Local
	15	Freiburg Cup	Deposit-refund system for coffee-cups	Freiburg	Coffee Cups	Increasing material efficiency	Driving positive feedback loops (6)	Consumers	Local
Companies/ Shops	16	GRAM Malmö	Shop without packaging	Malmö	Food packaging	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local
	17	Iceland	Ban plastic packaging	England	Plastic packaging	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local

Category	Nr	Action description	Approach	Location	Waste stream	Type of action	Leverage point	Main target group	Level of implementation in Sweden
	18	Biopac	Cellulose based packaging	England/Sweden	Plastic packaging	Developing sustainable consumption	Driving positive feedback loops (6)	Company	Local
	19	ICA Gislaved	Ban on plastic bags	Gislaved	Plastic bags	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local
	20	Ouni	Package free shop Luxemburg	Luxemburg	Plastic packaging	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local
	21	Ekoplaza Amsterdam	Plastic free isle	Amsterdam	Plastic packaging	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local
	22	Package Free	Package free shop New York	New York	Plastic packaging	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local
Theme days	23	International plastic bag free day (3rd of July)	Creating awareness	International	Plastic bags	Raising awareness	The mindset or paradigm out of which the goals, Rules, feedback structures arise (1)	Consumers	Local
	24	Bring-your-own-cup day (diff dates)	Creating awareness	International	Coffee Cups	Raising awareness	The mindset or paradigm out of which the goals, Rulss,	Cafés Consumers	Local

Category	Nr	Action description	Approach	Location	Waste stream	Type of action	Leverage point	Main target group	Level of implementation in Sweden
							feedback structures arise (1)		
	25	International straw free day (3rd of Feb)	Creating awareness	International	Plastic Straws	Raising awareness	The mindset or paradigm out of which the goals, Rules, feedback structures arise (1)	Consumers	Local
Labeling /Licenses/Maps	26	Responsible Cafés		North America	Coffee Cups	Raising awareness	Driving positive feedback loops (6)	Cafés Consumers	Local
	27	Refill	Map of where you can refill you water bottle	United Kingdom	Water bottles	Developing sustainable consumption	Driving positive feedback loops (6)	Consumers	Local
Organisations/Networks	28	Precious Plastic	Knowledge, tutorials, techniques	Global	Plastic waste	Raising awareness	Information flows (5)	Consumers	Local
	29	Litterati	Collecting data through users' activity in app	Global	Litter	Raising awareness	Information flows (5)	Consumers	Local
	30	My Little Plastic Footprint	Calculating footprint	Global	Plastic	Raising awareness	Information flows (5)	Consumers	Local
	31	Trash Heroes	Picking up litter	Global	Litter	Raising awareness	Information flows (5)	Consumers	Local

Category	Nr	Action description	Approach	Location	Waste stream	Type of action	Leverage point	Main target group	Level of implementation in Sweden
	32	surfrider foundation	Creating awareness through network and actions	Global	Plastic waste	Raising awareness	Information flows (5)	Consumers	Local
	33	Zero Waste Europe	Network with cities, experts, leaders in Europe	Europe	Waste	Developing sustainable consumption	Information flows (5)	City	Local
	34	Plastic soup surfer	Creating awareness through network and actions	Global	Plastic waste	Raising awareness	Information flows (5)	Consumers	Local
	35	"campact" campaign against plastic	Awareness campaigns and pressuring EU politics through signature gathering	Germany/ Europe	Plastics in general	Raising awareness	Information flows (5)	Politicians Consumers	Local
	36	Greenpeace: “break free from plastic”	Campaign to raise awareness	Global	Single-use plastic	Raising awareness	Information flows (5)	Consumers	Local
	37	Ocean clean up project	Awareness clean up, data	Global	Plastic waste	Raising awareness	Information flows (5)	Consumers	Local
	38	The last straw	Awareness creating though information	Australia/Global	Plastic Straws	Raising awareness	Information flows (5) / Mindset (1)	Consumers and Business	Local

Category	Nr	Action description	Approach	Location	Waste stream	Type of action	Leverage point	Main target group	Level of implementation in Sweden
			on their webpage and membership						
	39	Surfers against sewage	Beach cleans and education	United Kingdom	Plastic Waste	Raising awareness	Information flows (5) / Mindset (1)	Consumers	Local
	40	movies (great pacific garbage patch)	Knowledge, Awareness	USA, global	marine litter	Raising awareness	Information flows (5) / Mindset (1)	Consumers	National
	41	Blue Planet II series	Knowledge, awareness	UK, global	marine litter	Raising awareness	Information flows (5) / Mindset (1)	Consumers	National
	42	Campaign to take action against plastics	Awareness, Info public for politicians	Europe	plastic	Raising awareness	Information flows (5) / Goal of the system (2)	Politicians Consumers	Local

Nr	Source
1	http://www.independent.co.uk/news/world/single-use-plastic-bags-ban-western-australia-state-2018-a7942366.html
2	https://www.thelocal.fr/20160701/what-does-frances-ban-on-plastic-bags-actually-mean
3	https://apnews.com/54a14fa0bee742618906007606a39166/france-bid-adieu-plastic-dishes-controversial-ban
4	http://www.bbc.com/news/uk-24090603
5	https://www.huffingtonpost.com/tom-carver/rwanda-plastic-bags_b_2680631.html
6	http://www.theguardian.com/environment/2009/may/22/china-plastic-bags-ban-success
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