

# CONSUMER FOOD WASTE BEHAVIOR IN THE NETHERLANDS

## Households with children



(Bakker, 2022)

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Minor sustainability  
EBP 2002  
Date: 02-02-2023

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### **Introduction**

Every year 1.3 billion tons of food is wasted globally which is causing substantial economic,

environmental and social damage. Food waste contributes to 8% of global greenhouse gas emissions and takes up 30% of the world's agricultural land that is used to produce food that later goes to waste (Principato et al., 2021). It is expected that by 2030 food waste will increase to 2.1 billion tons annually (Aydin & Yildirim, 2021). This large amount of food waste is threatening global food security and currently 11% of the world population suffers from undernourishment and with a food system unable to feed a population prospected to reach 10 billion by 2050, this is unacceptable (Oliveira, 2021). The topic of food waste has gained more attention globally and is described by the UN as one of the Sustainable Development Goals. SDG 12 aims for responsible consumption and production and subgoal 12.3 focuses on reducing food waste at retail and consumers level by 2030 (UN, 2015).

Food waste occurs during all stages of the food supply chain but the causes of food waste per country differs. In developed countries food generation and consumer behavior are the main causes of food waste (Calvo-Porrall et al., 2016). Consumer behavior accounts for 1/3 of the total food waste. Changing consumer behavior contributes to a significant reduction of food waste. But changing food waste behavior in developed countries is a major challenge. At EU level, the total food waste in 2020 reached around 57 million tonnes. Household food waste represented around 55% of the total (31 million tonnes).

This report will focus on the Netherlands because it ranks 5th among all European countries that wastes the most food. From the 2.8 million tonnes of food wasted in the Netherlands around 1 million tonnes is wasted through households per year (Statistics Explained, n.d.). In addition, the authors of this report are Dutch and share the cultural background of the target population. The Netherlands also has the target of SDG 12.3 of reducing food waste (from 2015) by 50 percent by 2030.

Food waste during the consumption phase means the leftovers in a household and foods that are purchased (and cooked) but not consumed. One determinant of food waste behavior is household composition. Households with children tend to waste more food and this report will focus on the behavior of these types of households. Children influence food waste not only through their attitudes and behaviors but are also indirectly influencing parent's meal planning, shopping, cooking and serving behavior (Kansal et al., 2022). Research conducted in the Netherlands about food waste showed that a household with children wastes around 26,1 kg per year per person compared to 14,2 kg per year per person (pppy) for households without children. In addition, it showed that children in the age of 0-4 years old waste the most food (33,2 kg pppy). Children in the age group of 4-12 waste 25,2 kg pppy and children older than 13 years waste 19,3 kg pppy (Derksen, 2019).

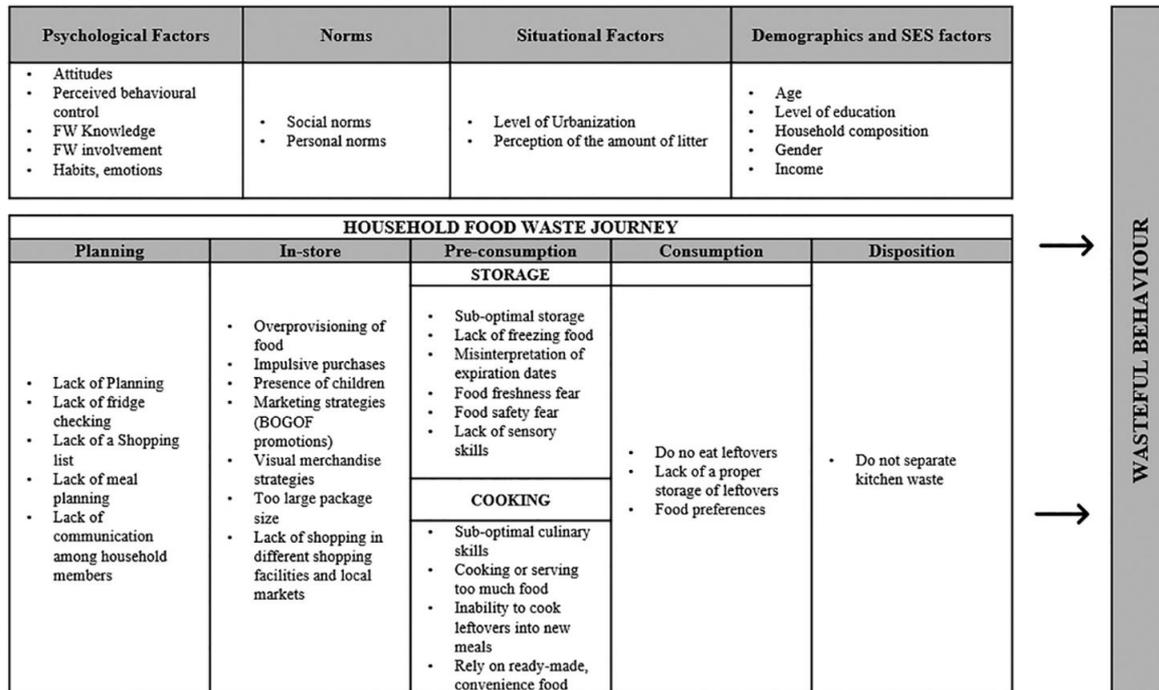
Food waste needs to be tackled at all levels of the supply chain but in the Netherlands the consumer level is most important because Dutch households contribute the most to food waste (Oliveira, 2021). To solve the problem and reduce food waste in households it is important to change consumers' behavior. The main objective of this report is to design an intervention that could change food waste behavior within households with children in the Netherlands. A sub question is how could the impact of the intervention be evaluated?

## **Research**

The focus of the research has been on Dutch households in particular. The Dutch government wants to achieve SDG 12.3 by increasing the consumers' knowledge about food waste. In addition, the food industry could help consumers to purchase smaller portion sizes in-store and provide more information about the expiration date of food (Rijksoverheid, n.d.). Food that is mainly wasted at the consumer level are products that are perceived as undesirable when these products are close, at or beyond the best-before date or differ visually or sensory from what is perceived optimal or normal

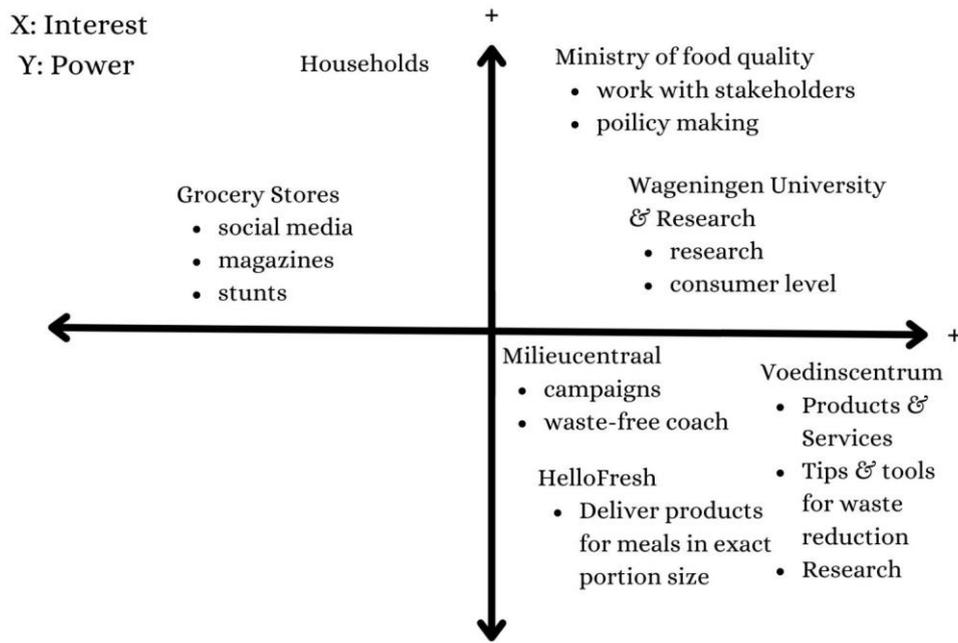
(Aschemann-Witzel et al., 2015).

Principato et al. (2021) developed a framework explaining several causes of household wasteful behavior (figure 1). In the figure on the top are the causes of consumer food waste behavior. Causes are psychological factors, norms, situational factors and demographics and SES factors. Below that the journey of the waste within households is shown. From planning food shopping all the way through to the disposition of the food. Within this journey you see where and in what way the food is wasted.



**Figure 1 - Household wasteful behavior framework.** Note. Reprinted from The household wasteful behaviour framework: A systematic review of consumer food waste, by Principato et al., (2021), Industrial marketing Management Volume 93, 2021, Pages 641-649, ISSN 0019-8501, <https://doi.org/10.1016/j.indmarman.2020.07.010>.

Voedingscentrum (2019) mentions multiple factors that contribute or have an influence on the behavior. These factors are awareness, attitude, social norm, knowledge, skills, environmental factors, time and opportunity, technology and infrastructure (Voedingscentrum, 2019). To have an overview of the stakeholders that (could) have an influence on the household food waste behavior figure 2 is created.



**Figure 2 - Stakeholders for household food waste behavior.**

Several case studies with behavioral interventions regarding household food waste are found. Case studies specific to household families with multiple children were not found, so the general households case studies were reviewed. Graham-Rowe et al. (2019) investigated the ‘self-affirmation theory’ in food waste reduction behavior. The theory is based on people’s image of their self-integrity. Another case study about food waste is about an evidence-based intervention to reduce waste at households (Pelt et al., 2020). In this case three interventions were performed that were based differently (information, awareness and dissonance). Both of these case studies showed that it was most effective when the people became aware of the gap between their normative beliefs (what they should do to reduce food waste) and their past transgressive behaviors (their actual past behavior). A positive approach leads to better results than a negative approach with behavior awareness.

### **Methodological approach**

To examine the causes of food waste behavior, questionnaires, waste diaries and Waste Composition Analysis could be performed. In the first two, consumers answer questions about their daily habits with regard to their food waste behavior or answer hypothetical questions regarding the topic in an experimental setting. These types of assessments provide detailed information on motivation for wasting, but individuals are not successful in correctly estimating their contribution to food waste, so quantitative results from these assessments must be judged with this in mind (Voedingscentrum, 2019). In Waste Composition Analysis (WCA), the waste of households is physically separated, categorized and weighed and will then provide information on the composition of the waste, for example based on avoidability/unavoidability or the type of waste (leftover meals, remnants in packaging, cooking residuals) (CEC, 2021). In combination with questionnaires or waste diaries, this could provide useful information on the reason why people waste food (CEC, 2021).

Waste composition in the Netherlands has shown that there is a decreasing trend in household food waste (Voedingscentrum, 2019). However, it is not enough to reach the 2030 goal stated in SDG 12.3 (Lipinski, 2022). Between 2015 and 2019, there has been a decrease of 63.7 kg to 52.1 kg of waste on average for Dutch households (Voedingscentrum, 2019). This is a decrease of 11.6

kilograms. This means that there needs to be a reduction of at least 20 kilograms by 2030 on average per household to adhere to the goal of reducing waste by 50% by 2030. According to an analysis of the progress of this sustainable development goal, it is apparent that in general countries are not on track of reaching this goal (Lipinski, 2022).

### **Future analysis**

Different factors were found to be of importance in food waste behavior. It is difficult, however, to find numerical data (for example WCA data) on the effect of one single factor on the amount of food waste that is prevented or caused by a change in this factor. Because of the lack of data and complexity, and with the goal in mind of designing an intervention as a recommendation future analysis is used. Future analysis studies explore different futures in order to better understand and potentially influence it (Biggs et al., 2021). One example of future analysis is scenario planning. Scenario planning/development is a type of analysis in which one can explore the effect of uncertainties in the future, without attempting to predict it (Biggs et al., 2021).

This project will use scenario planning as it gives the opportunity to discuss the driving factors of household food waste without having data in kilograms per factor. Scenario planning is being performed with the framework of a 2x2 double uncertainty matrix (Biggs et al., 2021). In this approach, one first investigates the drivers that are considered to have high impact and uncertainty in the future and extrapolate the two most important ones to their opposite extremes to form a Framework for Scenarios. This framework consists of four cells each representing a different possible outcome, based on the 2 uncertainties (Figure 3). The scenarios resulting from this scenario framework are then described more extensively in the form of a story (figure 4). Based on these outcomes, there is a discussion on the implications and eventually a recommendation is made.

### **Assessment framework**

For developing the scenario framework and the scenario narratives, the phases of scenario planning from Rowland et al. (2014) are followed (see appendix 1). In the previous section phase 1 is explained and in this section phase 2 will be addressed.

### **Scoping**

The scope of the research will be on micro-level because the intention of this research and assessment is to focus on food waste behavior of households with children in the Netherlands. The literature search described in the introduction showed the current state of this topic and the several causes of food waste.

### **Key drivers**

For scenario planning a framework is established that identifies driving forces and uncertainties. The authors perceive climate change and population growth as the main important drivers of change. Climate change is impacting food security, which eventually could lead to more people struggling to have sufficient food supplies (Wheeler & Von Braun, 2013). In addition, population growth means more people need to be fed. This means that more food needs to be produced which comes with the fact that more food is wasted. Reducing food waste contributes to less greenhouse gasses which impacts global warming, and less wasted food means that more people could be fed. These two factors call for action from governments but also individuals are important factors for reducing food waste and its related problems.

## Uncertainties

The literature search established knowledge and technology as key uncertainties when it comes to reducing food waste behavior. The reason for this is that these factors will likely undergo change in the near future. Currently, the Dutch government's approach to reducing household food waste is by information campaigns. This means that the future will bring a change in knowledge distribution and perception. The trend of the use of technology is expected to increase. Technology is defined as applications and other technological devices that could inform or support consumers/households by reducing food waste. Knowledge includes knowledge and/or awareness about the environmental and economic impacts of food waste but also refers to skills that consumers have to reduce food waste.

## Systematic literature research

### *Knowledge*

“Knowledge” is meant here in a broad sense; it can refer to knowledge on the environmental or economic impacts of the food that is wasted in a household. It can also refer to the skills that contribute to reducing food waste, for example knowing how to prepare food with leftovers, knowing how to properly store food products, or knowing how to make a shopping list, etc. It can also refer to awareness on the environmental impact food waste has on the planet in general.

In the Netherlands, there are many channels through which households receive information. Most households own a television and/or a radio. In addition, billboards on the streets can often be seen in cities, newsletters are available, and here is also the emergence of social media. All of these channels are accessible and visible for both parents and children to some extent. How much information and knowledge is obtained and shared in the future cannot be predicted, so therefore it is considered as an uncertainty.

The following keywords were used to look for articles regarding knowledge and food waste reduction for our scope: *'intervention' AND 'knowledge' AND 'skills' AND 'reduce food waste' AND 'household composition' AND 'Europe'* (time range: 2017-2023). Some other terms that were used are ‘food waste’, ‘families’, ‘information-based interventions. **Appendix 2** shows an oversight of the relevant studies included in the systematic literature research.

### *Results*

First of all, there seems to be very limited research on the effect of information or knowledge-based interventions specifically for households with children. These types of interventions are either performed on household level, with no exact information on household composition, or on school, thus excluding parents. Even though the Dutch institution for food information ‘Voedingscentrum’ mentions knowledge and skills as one of the core reasons for food waste behavior in Dutch households (Voedingscentrum, 2021). In addition, the literature shows that knowledge alone is not sufficient enough to change food waste behavior. Information-based interventions will not be the most impactful interventions (Nisa et al., 2019; Soma et al., 2020). There does seem to be a need for more information according to interviews with European citizens (van Geffen et al., 2020; Toma et al., 2020; Gaiani et al., 2018). The literature suggests that the way in which information is provided could be very important. For example, the way data labeling is provided (“Use by”, “Best before”, etc.) makes a difference in food waste. Test subjects are more willing to waste food with the “Use by” label (Toma et al., 2020).

### *Technology*

The use of technology for reducing food waste in households is still emerging. The predicted trend is that there will be more technologies developed for household use but how this trend is developing and accepted by consumers is quite uncertain depending on financial, social and behavioral factors. For

example, households who have the resources to purchase and maintain technology may waste less food than households who cannot afford (expensive) technology.

There are several technologies and applications developed for food management and food redistribution. Disposal of fresh food is a big contributor to food waste where technology could help reduce this problem by informing consumers for example about the expiration date of the product. Redistributing food applications are available, but for this report the focus will be on food management applications since this is perceived by the authors as the most convenient and less time consuming for households with children.

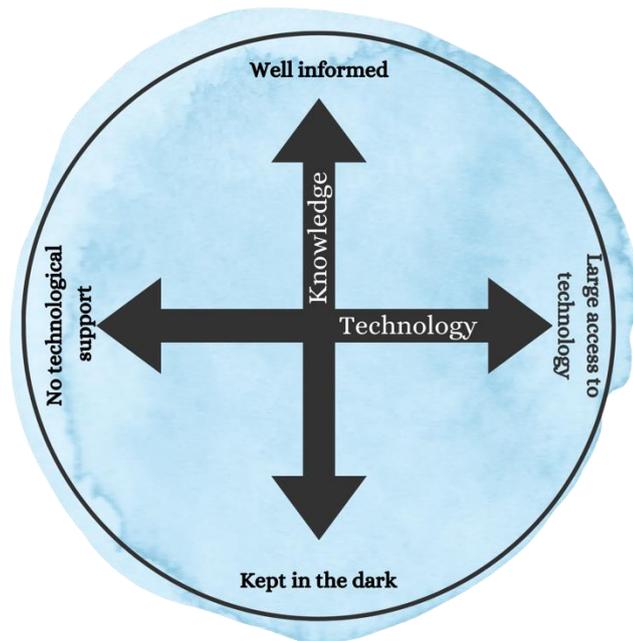
The following keywords/string is used to search for relevant articles that use technologies as an intervention with the aim of reducing food waste: *'intervention' AND 'technology' AND 'apps' AND 'reduce food waste' AND 'household composition with children' AND 'Europe'*. The articles were filtered by the years 2018 until 2023. **Appendix 3** shows an oversight of studies that used technologies and measured its effectiveness for reducing food waste in households.

### *Results*

Most of the studies show that households are willing to use technology for reducing food waste. One important outcome in the majority of the studies is that the use of technology is increasing household's awareness, knowledge and intention to change their behavior and reduce food waste. Technology could help in all phases of food waste behavior such as planning, shopping, storing, preparing and consuming food. One major barrier that is found in the literature research is that the use of technology is not effective when consumers are not aware of food waste in general and/or their contribution through their behavior or when consumers do not care about the problem. Many of the studies done were still using prototypes. This shows that not many households/consumers are using these types of technologies or that these are not readily available or affordable to them. It shows a gap between the current use of technologies against food waste in households and what is expected in the future or seen as a desirable state. Another gap found is that many of the technologies focus on households in general and not specific on households with children. Only the study about gamification included some data about households with children but the results are presented as a whole household and not specifying for children and parents. The literature is in general positive about the possible effects of technology for reducing food waste behavior in households. The future and further research have to show how technology is actually contributing to food waste reduction behavior.

From this systematic literature research, one case study was found that was especially interesting. In the study by Devaney et al. (2017) an information and tool-based intervention led to a decrease in food waste of 28% in 4 weeks. More information about this intervention can be found in **appendix 4**.

## Scenario framework

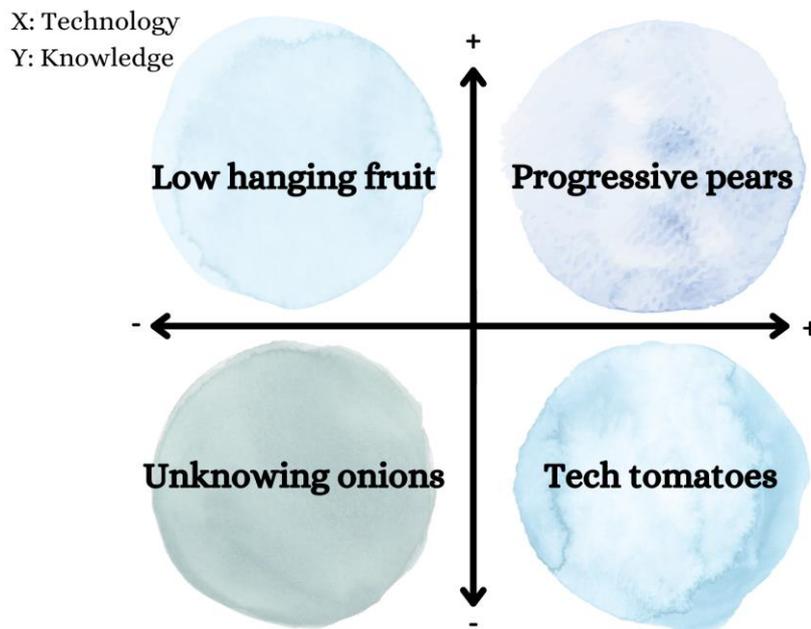


**Figure 3 - Scenario framework**

- **Well informed:** households are well informed on the environmental and economic impacts of their food waste behavior. Households have the knowledge, awareness and skills to change their behavior. Households are behaving in such a way that it contributes to a reduction of food waste. The government is increasing the provision of households with information and knowledge.
- **Kept in the dark:** households are kept in the dark on the environmental and economic impacts of their food waste behavior. Households do not have sufficient knowledge and skills to change their behavior or households are ignorant about the problem and feel that they do not contribute as much to food waste. Households do not want to change their behavior or do not know how to change their behavior. The government would not provide households with extra information and knowledge.
- **Access to technology:** households have sufficient (financial) resources to access and use technologies that contribute to less food waste. These technologies contribute to more convenience and could support households changing their behavior. Households are willing to use these technologies to reduce their impact on food waste. The increasing trend in development of technology for food waste continues.
- **No technological support:** households do not have sufficient (financial) resources to access and use technologies that contribute to reducing food waste. Households are not willing to use technologies to reduce their food waste and change their behavior. There is no increasing trend in the development of technology used for reducing food waste.

### Assessment of the problem

The variables of interest have been identified and the scenario framework has been established, the scenario narratives are developed. Figure 4 below shows the four scenarios.



**Figure 4 - Scenarios**

**Low hanging fruit**

In this scenario, the Dutch government is focusing solely on tackling food waste through providing information to households. The households receive infographics that can be used in the kitchen, with regards to food storage and cooking. Institutions such as Voedingscentrum play an important role in the data collection and spread of information. There is the use of a campaign on national TV, social media and on billboards to increase awareness. Households are provided with knowledge on the environmental impact of their waste and on how to reduce it. These actions will lead to an increasing amount of knowledge and awareness about the environmental and economic consequences of their food waste behavior. However, the government is not supporting their campaign with recommending and investing in technological tools. Maybe some families interested in technology, that have access to sufficient resources, will have a smart fridge but the vast majority is not using types of technology to support their behavioral change because they do not know about the existing tools and/or are not able to afford them. The households try to behave based on their current knowledge about food waste and by using the tools that they have at hand; they are contributing in small steps to reducing it.

**Progressive pears**

The government is providing information to households making them aware of the effects of food waste on climate change, their contribution to the problem and how this contribution could be lowered. Just like in the Low Hanging Fruit scenario, the information is spread through different channels, reaching households with children from different backgrounds. Next to promoting awareness, the government invests in technology that supports the knowledge they provide. (Social) entrepreneurs take the opportunity of the need for food reduction by developing new technological tools that will help families with children in reducing their food waste. Because of the interest of the government in reducing food waste, their investments in the development of technologies will help in a wide application. Households will be supplied with good quality storage options, will be advised to make use of gadgets such as FridgeCams and know how to properly use the technology. With the awareness rising, they will start making use of applications that make reducing food waste more convenient. The availability of knowledge and technology leads to change in behavior.

### **Tech tomatoes**

The government focuses on developing technological tools that make food waste reduction convenient. They expect households to know about the current status of the food waste problem and the ways to reduce it to some extent. There is interest for the technology branch to earn money on food waste reducing tools. Households are starting to use technology such as food management applications or smart fridges because they can afford it and are influenced by their social networks. They want to show that they are modern and move with the time. In addition, households are using technology because the children think it is cool and futuristic and the parents could have financial stimulation by using all the food products and not throwing them out. However, households are not so much aware of their behavior and might not care about the food waste problem. They are not being made aware how food waste is contributing to environmental and economic problems. Some of the households might look into background information regarding food waste themselves, stimulated by using technology that is addressing the problem. Their behavior is mitigated through the use of technology.

### **Unknowing onions**

In this scenario, households are not being made aware of their food waste behavior or they do not care about the environmental and economic impacts of this behavior. The campaigns of the government are not effective, and this leads to the wasting of a lot of food, and thereby also money. There is not a lot of motivation to change behavior since there is no incentive in doing so as far as Dutch households are concerned and since they are not supported in doing so from outside of them at hand tools. There is only some technological development to make reducing food waste more convenient and households are not very aware and skilled to use the tools they have at home. Negative effects on the climate due to food waste will not be noticeable in the Netherlands in the short future, so without information and increasing support these households will continue behaving as they do.

### **Analysis of scenarios**

The analysis of the effects of the scenarios are based on assumptions after literature research, and not made by experts. The mentioned effects and impacts must be interpreted as relative to the other scenarios.

### **Low hanging fruit**

In this scenario, there is only increased knowledge but no technological support for this knowledge, it is expected that there will be no major behavioral changes in households, unless households have a very strong motivation due to social/personal norms and a skillset to change their behavior. The expected impact of this scenario on reducing food waste is estimated at medium because knowledge is not being reinforced by technology. Campaigning or providing information to households through other ways will be a medium expense for the government, and since there is no application and distribution of technology, this bears low costs. Therefore, the economic cost of application of this scenario would be moderate. Distribution of information is expected to have a low to medium environmental cost, depending on the channel of information. It is expected that it will to some extent contribute to reaching SDG 12.3 by 2030 but not satisfactory.

### **Progressive pears**

It is expected that the combination of knowledge and technology will significantly improve the behavior of households and reduce food waste. The impact is estimated at high because literature shows that a combination of knowledge and technology contributes to food waste behavior change. The costs are estimated to be moderate to high mainly because of the use of technology, in addition to extra information and skills that are required for using new types of technology. Although smart

fridges etc. do exist it is not mainstream yet. To make it more mainstream more technology needs to be developed and produced, which contributes to higher costs and will have a burden on environmental and economic factors. These types of technologies could be expensive to buy (except for the use of (free) applications) and not every household is able or willing to purchase these types of technologies. The environmental impact of the reduced waste is high, but this should be offset by the environmental burden of developing technologies. It is expected that this scenario will have a moderate to high contribution to reaching SDG 12.3.

### **Tech tomatoes**

The literature has shown that technology itself is increasing awareness and knowledge. Therefore, technology is replacing the uncertainty of the factor of knowledge to some extent. It is possible that households are using technology for fun but are not very much aware of how much of their food waste is contributing to the environmental or economic problems. There is the risk that apps or new gadgets might get boring after a while and without knowledge on the importance of using them this affects the impact. It is estimated that the impact will be moderate on reducing food waste because it will offset some change in behavior in households and technology can improve their knowledge and skills. The costs are also estimated to be moderate because technology costs could be high, and the development of technology is a burden for the environment. It is expected that applying technology on itself will contribute to an accelerated progression towards reaching SDG 12.3, but not sufficient to completely reaching it.

### **Unknowing onions**

It is expected that this scenario will not contribute to food waste reduction. With no increased knowledge and no technology making food reduction convenient, there will not be a shift in food waste behavior. Therefore, it is expected that this situation will have a low impact. The economic costs are being estimated at low to medium because there is no intervention to finance but because there is no significant change in the behavior of households and therefore the same amounts of food as usual are wasted, municipalities will have to keep making expenses to correct for the behavior of the households to improve the waste management. Because there is no reduction in food waste, there is an expected high environmental cost. This scenario will keep us at the current rate of reaching SDG 12.3, which is a contribution far from enough.

### **Intervention**

Based on the literature and the analysis of scenarios, the expectation is that an intervention that combines technology with knowledge would have great potential in reducing food waste in households with children towards reaching SDG 12.3. A way of doing this is by introducing a mobile application. In the target group households with children the use of mobile applications won't come as a new and difficult concept. This type of technology can come with many features and is therefore widely applicable and adaptable.

With the idea for a mobile app, gamification will be applied to reach the goal of reducing food waste. Gamification is the use of game design in non-game situations, such as in this case, reducing food waste. In the context of sustainability, gamification has already been proposed. The elements of games are used to increase productive motivation and induce positive behavioral change. For example, in promoting sustainable nutritional behavior (Berger et al., 2016). A mobile application targeted at reducing food waste could come with many different features that can be adapted based on the need of the situation. Some proposed features to involve all family members to use the app are the following:

- Mini games

- Live challenges
- A feature supporting food management
- Facts and infographics
- Recipes
- A reflection/waste diary

(See appendix 5 for examples)

Children but also adults could be motivated in using this type of technology by applying a reward system. Rewards systems, such as earning badges or points, are crucial elements for the effectiveness of gamification. However, there is the danger that it will limit the intrinsic motivation by focusing on the extrinsic reward systems (Lewis et al., 2016). Hopefully, by not only focusing on game elements but also information elements, this effect can be limited. This intervention requires clear explanations that are understandable to users of different ages and it is also important to keep in mind the way messages are brought over. To test the impact of this intervention in a trial with a control and a test group, we propose to apply the common techniques that are used in food waste research, waste composition analysis combined with questionnaires. In the long term, testing the effect of this intervention would be a difficult task, as it is hard to indicate to what extent the use of an application has contributed to the total reduction in waste of households.

### **Expected effects on scenarios**

- Low Hanging Fruits

The intervention would have some impact on this scenario by forming a step for households into more technological support, and a motivation for them to apply their knowledge through the reward system.

- Progressive Pears

In this scenario, households are already informed and used to technology. So, in this case the impact of this intervention would also come from the increased motivation to reduce waste through gamification.

- Tech Tomatoes

In this scenario, the information provided through the application will have a positive impact as it creates a basis of understanding for the use of technology. Here, the information could create a larger intrinsic motivation.

- Unknowing Onions

In this scenario, it is expected that such an intervention would have the largest impact. These households would be insufficiently informed and supported with technology, so this application could provide a useful start in going away from a low reduction of food waste.

### **Challenges**

It is expected that the proposed intervention is also targeting other causes of food waste behavior (see figure 1 from Principato et al., 2021). For example, technology and knowledge could improve perceived behavior control because knowledge and technology are giving households the skills and resources to control their behavior. The more households are supported (through the intervention and with resources) the fewer obstacles they perceive which will improve the intention to change their behavior and show the wanted behavior (Ajzen, 2011). The increasing knowledge through the intervention could also improve the situational factors, like the perception of the amount of litter a household is producing. This is reflected in the intervention through the use of reflection questions. In general, the intervention/application is feasible because developing an application is not that

complicated. A challenge for the development is the use of scientific, state of the art data. There are several data gaps and it is unsure how technology/application is influencing and supporting behavior change in the long term. Another challenge of the intervention is to convince households to download the application and use it.

### **Future research**

Based on the literature research and systematic literature review performed in this report it showed that there are several data/information gaps in the literature. For example, there was insufficient data available why households with children tend to waste more food (these are more like assumptions). In addition, there is no data to be found that differentiates between households with one, two or multiple children or households that have one or two caretakers. Furthermore, the effect of technology for changing food waste behavior in the long term is a field that is under researched, most studies are done in an experiment but there is not sufficient data available on how much food waste is reduced in a real-life setting. Moreover, practical data on the effect of knowledge interventions on food waste behavior is insufficient, which makes it hard for policymakers to implement the right interventions to increase knowledge. In addition, future research could focus on which cause of food waste behavior is contributing the most to food waste and how an intervention could be designed to address multiple causes in the same intervention.

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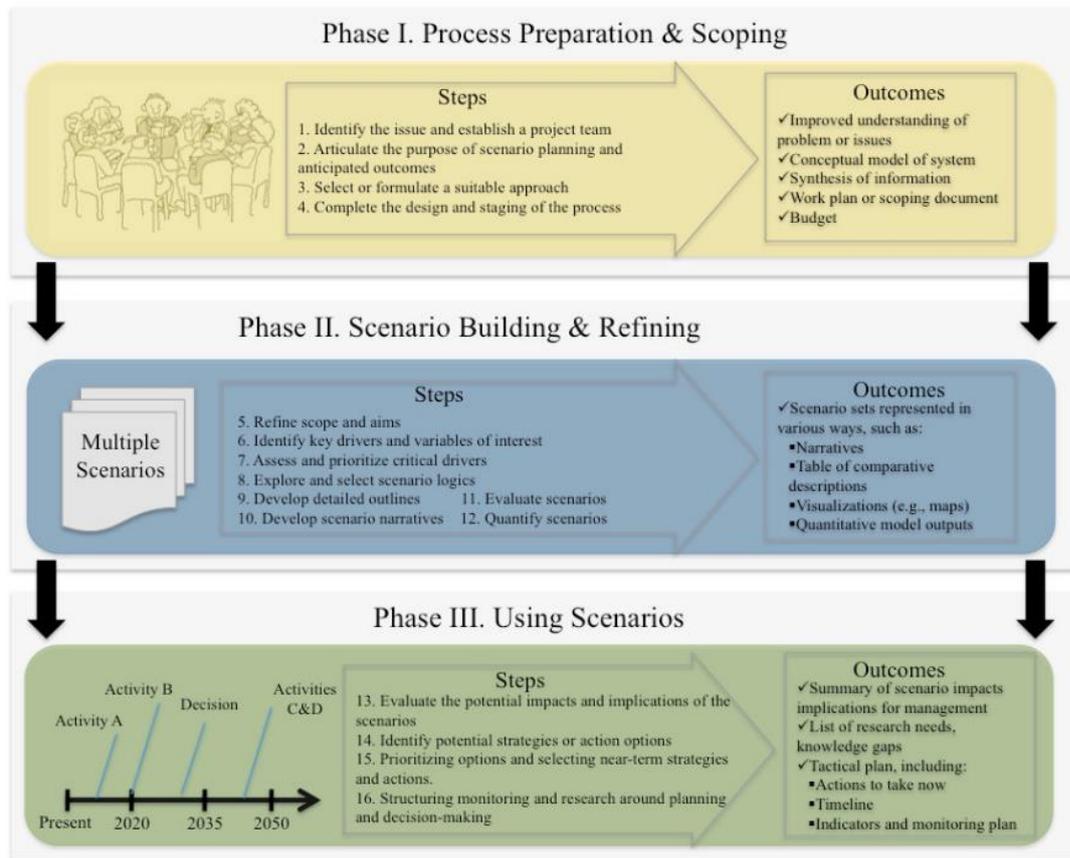
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## Appendix 1 - Phases of scenario planning



**Figure 1.1. Three phases in the scenario planning process (modified from Wiseman et al. 2011 and others). More detail about the phases, the steps within each phase, and outputs for each phase can be found in Section 2.**

**Phases of scenario planning.** Copied from Rowland, E. R., Cross, M. S., & Hartmann, H. (2014). *Considering Multiple Futures: Scenario Planning To Address Uncertainty in Natural Resource Conservation*. U.S. Fish & Wildlife Service.

## Appendix 2 - Systematic literature research on knowledge and skills

Type of study	Results
Focus group study based on the motivation-opportunity-ability framework for food waste behavior	<p>Participants agreed that improving skills for food handling would help to reduce food waste. They specifically refer to improved skills in planning, creative cooking, prolonging shelf-life and estimating food safety.</p> <p>However, consumers are limited by their perception of good quality food and might see reducing food waste as a factor that contradicts this value.</p> <p>(van Geffen et al., 2020)</p>
Different interventions, one of them information-based through the use of fridge magnets with storage information, a newsletter and an informational booklet	<p>Participants were most satisfied with the use of the fridge magnet, as it works as a simple reminder. However, the information-based intervention in this study did not provide significant results compared to the control group.</p> <p>Information-tiredness is an important limitation to keep in mind.</p> <p>(Soma et al., 2020)</p>
Intervention combining information, tools and governance in a 5-week trial with households	<p>There was a reduction of 28% in household food waste. It is expected that this is due to the combination of different interventions.</p> <p>Information was provided on: food seasonality, shopping, farmer's market encouragement, storage, cooking, the food waste hierarchy, economics of waste, and composting.</p> <p>(Devaney et al. 2017)</p>
The difference in interpretation of data labelling	<p>There was a significant difference in food waste between different data labels ("Use by", "Best before", etc.)</p> <p>The results indicate that consumers that check dates more often are more likely to not consume a product after the date, but that the group that checks most frequently is also the group most in need of better labeling information. The understanding of the labeling is an important factor, explaining a fifth in the variance in behavior in this study.</p> <p>(Toma et al., 2020)</p>
Participants were asked about their food wasting behavior in an interview	<p>89% Of respondents reported wanting more information on the environmental impact of their waste and on alternatives. 35% reported to waste less if they were better informed about the monetary value of food waste, 25% if they were better informed on environmental impacts.</p> <p>While taxes or more expensive food would only</p>

	<p>be a reason for 4.4% and 4.5% resp. (Gaiani et al., 2018)</p>
<p>Meta-analysis of randomized controlled trials testing behavioral interventions to promote household action on climate change</p>	<p>Statistics, in-home displays, factual feedback and energy labels do not have big impact on itself. Appealing to the need of climate mitigation has a higher impact. (Nisa et al., 2019)</p>
<p>Systematic review on consumption-stage food waste interventions</p>	<p>The author of this study provides policy implications at the end of the review. These include using information-based interventions as one of the ‘low hanging fruits’ among interventions that do not have the biggest impact but also do not have high costs, maintenance or side effects. Also, the use of social media in campaigning is suggested. (Reynolds et al., 2019)</p>

### Appendix 3 - Systematic literature research technology

Technology	Effectiveness
Fridge thermometer	<ul style="list-style-type: none"> <li>• 92% of people given used it</li> <li>• 22% of those found their fridge was not cool enough</li> <li>• 94% changed the temperature successfully</li> <li>• 43.8% of respondents who changed the temperature said at least some of their food lasted longer as a result of change</li> </ul> <p>(Inspiring food waste behaviour change, 2016)</p>
Intelligent fridges	<ul style="list-style-type: none"> <li>• Measuring the internal environmental conditions of the fridge and regulating the environment to optimize storage conditions</li> <li>• Manage supply activities and shopping lists</li> <li>• Detecting and monitoring food packages and their content</li> <li>• Alerting consumers about expiration dates,</li> <li>• Suggesting recipes to consumers with the food products or packages stored in the fridge</li> <li>• Could provide consumers with updated knowledge of the status of stock in the fridge via the use of barcodes</li> <li>• Addresses all causes of food waste storage, planning, shopping, preparation and consumption</li> </ul> <p>(Liegeard, J. &amp; Manning, L., 2020)</p>
MySusCof - Application	<ul style="list-style-type: none"> <li>• 10 of 11 participants agreed that the application had increased their intention to change their food waste behavior and their knowledge about food waste</li> <li>• 8 out of 10 agreed that it improved their attitude and awareness about the food waste topic</li> </ul> <p>(Haas, n.d.)</p>
Alert system - Food management application	<ul style="list-style-type: none"> <li>• Alerts users to consume food nearing its expiry date</li> <li>• The system can increase supply knowledge</li> <li>• Within a qualitative study, pervasive technology successfully decreased self-reported food waste by providing subtle nudges to participants regarding food that is about to reach its expiry date</li> <li>• The nudges to notify participants can be applied to a mobile app to push notifications to the user</li> <li>• The application will not be effective for consumers who are not aware of/or conflicted about food waste</li> </ul> <p>(Hanson, V. and Ahmadi, L. 2022)</p>

<p>Visual stock list - Food management application</p>	<ul style="list-style-type: none"> <li>• Visual representation of food in the home that could be accessed remotely through a mobile device to increase supply and location knowledge</li> <li>• In a case study of 3 different mobile applications, updating the food inventory list and visual photo of the fridge interior was the most effective for increasing supply and location knowledge</li> <li>• When using the FridgeCam camera and mobile application, participants used the photos of the inside of their fridge as a memory aid and information source before or during grocery shopping</li> <li>• Entering foods and products into the mobile application must be as quick, convenient, and easy as possible to ensure the consumer utilizes the feature otherwise it will inhibit use</li> <li>• The application will not be effective for consumers who are not aware of/or conflicted about food waste</li> </ul> <p>(Hanson, V. and Ahmadi, L. 2022)</p>
<p>Recipe recommendation - Food management application</p>	<ul style="list-style-type: none"> <li>• One study showed that participants expressed the need for recipe recommendations following an alert about food expiry</li> <li>• Recipe recommendation was the most helpful feature for increasing food literacy</li> <li>• The FoodEd mobile prototype successfully improved food literacy by educating participants on proper food storage and handling methods and best-before dates</li> <li>• The application will not be effective for consumers who are not aware of/or conflicted about food waste</li> </ul> <p>(Hanson, V. and Ahmadi, L. 2022)</p>
<p>Color coding the fridge - Smart fridge</p>	<ul style="list-style-type: none"> <li>• Color Coding the Fridge aims to raise people’s awareness of what they have in the fridge, in order to reduce expired food waste</li> <li>• The study used interviews and visuals</li> <li>• Seven households participated</li> <li>• Expired food waste is caused by lack of visual overview of what the fridge contains</li> <li>• Used a color-coding scheme where each color represents a food group and its placement in the fridge</li> <li>• It is reported that color coding reduces food waste by a quarter to a half through heightened awareness of the content of the fridge</li> </ul> <p>(Hebrok, M., &amp; Boks, C., 2017)</p>

MyFoodways Application	<ul style="list-style-type: none"> <li>• Households can tell the application which ingredients they have in their house/fridge and the application will suggest a recipe for them (MyFoodWays, 2018)</li> <li>• 9 out of 10 users claim that the app helped them to eat in line with their values</li> <li>• 35% of the users eat more seasonal meals</li> <li>• 43% enjoy more recipes that are suitable for using leftovers (Robinson, 2019)</li> </ul>
Fridgecam	<ul style="list-style-type: none"> <li>• The FridgeCam is a camera that is attached within the fridge displaying its content and sends images to a website</li> <li>• In the study, some users actually used the camera to plan shopping for instance by accessing the website</li> <li>• Some were confronted with the disparity between their perceived and aspired food practices and their actual food practices</li> <li>• An intelligent fridge may provide consumers with updated knowledge of stock, and what is about to expire and should be used</li> <li>• It may answer to causes of food waste addressed in literature including food storage, planning, shopping, preparation and consumption, provided it can be successfully integrated into the household routines (Hebrok, M., &amp; Boks, C., 2017)</li> </ul>
Gamification	<ul style="list-style-type: none"> <li>• Study examined the effectiveness of three information campaigns to raise awareness in households about food waste</li> <li>• The group that used gamification significantly produced less waste of edible foods (Soma et al., 2020)</li> </ul>

## Appendix 4 - Intervention design combining knowledge and technology

	<b>HomeLab Framework</b>	<b>Week 1: Concretisation</b> Baseline data collection & establish understanding of current eating habits & practices	<b>Week 2: Acquisition</b> Connect to food production, raise awareness of environmental impact of food choices & grow your own	<b>Week 3: Storage &amp; Preparation</b> Educate about optimum storage conditions, engage in portion control, inspire new meal ideas & plan meals	<b>Week 4: Food Waste Recovery</b> Raise awareness of impacts of food waste, promote waste hierarchy, & compost unavoidable waste
<b>Governance</b>	<b>Rules &amp; regulations</b> Targets and guidelines set each week	No interventions	Carbon Targets	Food Safety Guidelines	Brown Bin Regulations
<b>Tools</b>	<b>Products</b> Tools, technology and new food options that may facilitate more sustainable food shopping, cooking and disposal	No interventions	Organic Fruit and Veg Box (delivered to each home)		
			Home Aquaponics Kit Meal Planning Website Compostable Food Waste Boxes Protein 1: Organic Meats	Fresh Storage Devices Fridge Triage Box Portion Control Tools Magnetic Shopping List Protein 2: Sustainable Fish	Electronic Composter Bin Odour- and Fly-Reducing Spray Protein 3: Vegetarian Options
<b>Education</b>	<b>Information &amp; Inspiration</b> Behavioural guidance and motivational events	Future Kitchen Visions	Food Seasonality Shopping Infographic Farmer's Market Encouragement	A-Z Storage Guide Personal Chef Visit	Food Waste Hierarchy Economics of Waste Home Composting Guides

**HomeLabs intervention design. Copied from:** Devaney, L., & Davies, A. R. (2016). Disrupting household food consumption through experimental HomeLabs: Outcomes, connections, contexts.

## **Appendix 5 - Example features for intervention**

- Mini games.
  - Quizzes that increase knowledge, or mini games that can teach skills that are applicable to real life cooking or storing situations.
- Live challenges.
  - Daily challenges related to food waste, such as collecting from the fridge products that need to be consumed within that week.
- A feature supporting food management.
  - By means of a tracker, giving users the option of managing the content of their cabinets and knowing what needs to be consumed.
- Facts and infographics.
  - Infographics or facts on the value chain of food, or about the ways of storing food in the fridge.
- Recipes.
  - Creating or finding recipes with leftovers.
- A reflection/waste diary.
  - Making users answer daily or weekly questions in order to raise awareness. For example: “What is the largest item you have thrown away this week and what was the reason for this?”