SMART ENVIRONMENTS PROJECT

DOCUMENTATION REPORT

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Chapter 0: Introduction

The news is full of disasters everyday. They can be small or big, or fast or slow occuring. The goal of this project is to tackle one of these disasters and make the world a more sustainable place. Our team consists of seven members who all collaborated enthusiastically in this project. They are Natsuki Collin, Kevin Friesacher, Marleen van Gerner, Sterre Kuijper, Max Liebe, Kimberley Siemons and Victoria Tyminski.

The disaster we've chosen to tackle is 'food waste'. While this doesn't sound like a disaster at first, it really is. So what makes this a disaster?

Food waste is a slow occurring disaster. This means that the impact of all the food that is thrown away isn't immediately noticeable, but it will be noticeable over time.The total waste produced is 1.3 billion tonnes. Every year more food is thrown away… Not only is this a waste disaster but it also contributes to other crises. Rotting food causes 10% of greenhouse gasses thanks to the massive amounts of methane gas that it produces. The landfills waste space on our planet and make the soil unusable for the future. Food waste is also a huge humanitarian problem. Produce disposal is a disaster occurring all over the world, on many different levels.

The solution we came up with is a 'Smart Cupboard'. In this cupboard you can store different kinds of food. You can say in the app which kind of food you added stored in the cupboard and the cupboard will tell you if it is a good storage place for the food based on temperature and humidity. If not, it will recommend a better place. You can keep track of the expiration date of the product with the app. The app will give a notification if the food is about to expire, so that the consumer can use it in time.

With this solution we hope to reduce food waste on the consumer's side, because a lot of food is still thrown away at households. The Netherlands Nutrition Centre claims that consumers share the biggest percent (33%) of food loss. Most people in the Netherlands are ready to decrease their food waste but are stopped by difficulties such as purchasing too much and poor storage. The cupboard will optimize food storage to prevent the food from spoilage and help to adapt better habits.

The good thing about the cupboard is that you can make it as big or small as you want, which allows it to be used for different quantities of food. This means that it can be used in households, but also in restaurants, so that food waste can be reduced even further.

Chapter 1: Literature Review

Twenty one summaries of meaningful publications on the general subject of disasters.

- A lot of cosmetics contain microplastics, but customers do most of the time not know this. This is because the list of ingredients is difficult to read and people do not know what all the ingredients on the list mean. Not only is this bad for the customer, but also for nature. Because when cosmetics are used and washed off the microplastics are very likely to end up rivers and oceans. These microplastics are so small that animals, like fish, don't even know they are eating them. What's even worse is that the plastics get absorbed into the body. When these fish are caught to be eaten the plastics end up in the body of the consumer without them noticing it. Beat The Microbead3 is an app you can download to scan the list of ingredients on cosmetics. When scanned the app tells you if the product contains microplastics. This brings awareness to this growing problem and the customer can decide if they want the product or not[14].

- Lots of illegal deforestation is happening and it is endangering the lives of many species. Deforestation happens on such a large scale that it is impossible to defend all the areas at once. When rangers know the illegal cutting is going on, they try to be there as fast as possible, but most of the time they are too late. To try to fight this problem the company Rainforest Connection[19] has been set up. This company uses old phones which are hidden through the forest and pick up sounds that are associated with illegal logging. The phones are connected to an app and if the sounds are picked up the local park ranger will be notified (if they have downloaded the app). This means that they can react way faster to stop the illegal logging[6].

- Earthquakes damage buildings every year. Not only do buildings get damaged, also a lot of people get killed, because of the collapsing buildings. To save more lives and prevent the buildings from collapsing earthquake resistant buildings are built. One country that leads in building these kinds of structures is Japan[12]. They make sure to separate the building from the ground. There are two different techniques that are mostly used. One method uses some kind of spring. These springs separate the building from the ground. When an earthquake happens the building moves way less, because of the springs. Another method used is with a sliding mechanism. With this method there are steel pucks that sit on top of steel saucers. When an earthquake happens the pucks slide across the saucers. This way the building doesn't move as much as it would with the precautionary measures. With these techniques lots of lives are saved and damages to buildings are reduced.

- There are a lot of natural disasters happening in the world and we as humans cannot prevent them from happening but we can reduce the severity from the disasters. Even without using technical infrastructure. Some natural risk reducers are forests and vegetation for landslides, coastal vegetation like sand dunes and mangroves for storms,

strong winds and cyclones, and healthy coral reefs to reduce the wave energy while coastal storms are happening. Implementing these prevention measures also helps with the unemployment in a country because they can set people to work on these measures[16].

- Technology is growing really fast. The prediction is that in only a few years most jobs are automated, but not only the normal, or boring jobs are automated also the warfare will be automated and since the technology will be growing so fast the most simple thing will be available for a few bucks even though combining some can lead to a murderous robot[1].

- The oak processionary caterpillar is becoming a real problem in western Europe. The caterpillar has little hairs that really itch when they land on your skin. Lately more and more caterpillars are alive in western Europe and they are becoming a danger to society. The RIVM[21] has left the caterpillar plague control up to the mayors of the Netherlands, but they have a risk management system. The places have to meet a certain condition before measurements will be taken against the caterpillars. They have a 3 step plan. 1. Risk inventory, are they really a risk in this situation? 2. Measurements and registration, collecting data. 3. Controlling, there are different ways of controlling depending on the outcomes of step 1 and 2, like doing nothing, using chemicals, warning the public, etc.

- Plastic waste is a severe issue occurring worldwide, causing 8.5 million metric tons of plastic to end up into the ocean every year. Several animals get trapped in the plastic and turtles often confuse the plastic bags for jellyfish and eat the plastic, causing them to asphyxiate. There are several prevention methods against the plastic pollution in which people are not being aware enough of. The whole world needs to come to terms and make a change which will become the new standard. Asian countries are not making the same effort as European[18]. (from experience, we were supposed to change to no more plastic by Jan 2020 but we still use plastic bags everywhere. It's bloody insane how much they're delaying the change just because of the inconvenience it brings people.)

- Pollution comes in several different forms affecting several different aspects of life, especially since the human population is increasing and their actions are what are causing this dent. Preventing pollution shouldn't focus on the aftermath but on where it originates from. The first step in getting everyone on the same page is making everyone aware of the situation and educating them of the value of our resources. This entails a cultural change and a change in the way people react[9].

- Bees are slowly disappearing and this is causing a domino effect on the world around us[5]. Some of the main reasons are habitat loss and invasive species, threatening bed diversity. Bees are important as they are the ones that are pollinating food crops (⅓ of the food people consume daily are pollinated by bees, alongside birds and bats). A way in which we can prevent the depletion of bees is by educating people in the different types of bees and informing them of ways in which to remove infestations safely in order not to harm them, as well as providing a safe place for them to breed but also maintain a

safe relationship between humans and bees.

- In Hong Kong landslides have been a big issue since the 1940s. In 1977 the government started taking precautionary measures against it. These measures were making man made slopes after taking into consideration the ground itself and aerial photos to decide if it needed upgrading. After 1994 it was realised that a lot of these slopes need better improvements so they function better. This also saw an increase in the number of slopes built and in better quality[8].

- Learning about how to react in a natural disaster is important, especially if you live in an area where it is frequent[23]. In most disaster education it is a traditional way of learning, which focuses on theoretical and conceptual knowledge and teaching. The goal of this study was to make a video game inspired by Tower Defense for disaster prevention. This would make it more engaging to learn about what to do in a natural disaster and also give students more motivation to learn about these things.

- Satellite data is used to aid in disaster prevention and preparation. The goal of this project is to be able to share this data with the largest group of people in the shortest possible time. For this to be possible, a system needs to be built which takes the data, turns it into a user friendly database and then shares it to people such as public administration, the scientific community and of course regular citizens[13].

- Tropical storms are on the rise. The damage caused by hurricanes is estimated in billions of dollars each year (11.5 billion in 2016). We have yet to find a way of stopping these storms, but how can we reduce the destruction? The biggest problem is damage in building foundations. It can affect every part of the building- this can even lead to it collapsing. Foundation repairs are very expensive, so how can we avoid them? An effective way to solve this problem is to install helical piles onto structures[22]. They are both attached to the foundation and secured into the ground. These piles can drastically increase storm protection and also cut down the cost of hurricane damage.

- The improvement of technology has led to a dramatic increase in obesity. How can we use technology to reverse this pandemic?[11] In-person meetings with a professional produce the best result in helping to reduce body weight but to many, that way is inconvenient or just unavailable. Video Conferencing allows people to have these meetings, even when they are not locally based. Exergames are a great motivation for exercise. Cameras, sensors and trackers allow to combine exercise with game reality. These games combine social, entertainment and competitiveness which are a great stimulation for exercise. Mobile phones are also equipped with sensors and trackers. They can now count your exercise, steps and even your calories burned. Smartphones can have apps that provide calorie counting, healthy recipes, exercise all in one place. There is still a lot that can be done with technology to help beat the obesity crisis.

- There are around 300 million people suffering from depression around the world and it is the leading cause of disability worldwide. While there are effective treatments out there, there aren't enough resources for the growing problem. While antidepressants can be lifesaving, only around 30% of patients respond well to the first drug they are prescribed. Almost 90% of users suffer from at least one side-effect. Antidepressants are effective but there need to be safer and more effective solutions people could choose from. Digital therapeutics use digital solutions to change the patients behaviour and lifestyle with an app. This technology[20] has been successful to treat illnesses like II type diabetes and obesity. Notifications on the phone can reach the patient anywhere, anytime. Thanks to the data collected by the user, their care can be adapted. Digital therapeutics can be a standalone app or an app with support from a remote professional. Clinicals can support their patients whenever help or a reminder is needed. There is no surprise that digital therapeutics are a quickly emerging solution in this digital era and there is no doubt that they will be part of the future of medicine.

- Every year wildfires destroy a lot of forests, despite already existing prevention methods. Fires are necessary for a healthy forest, but most of the fires are caused by humans. The fire-resistant treatments to avoid ignations at the source aren't yet possible with the technologies we have these days. So scientists are developing a fluid to use on vegetation in areas that burn easily. By making use of environmental exposure and weathering. High risk areas for wildfires can be protected and treated, during the peak fire season[24].

- Power outages are happening always everywhere. This is almost never convenient, because a lot of instances and people depend on electricity. It is especially important for hospitals and other important buildings. If there are power outages there, most of the time they have their own generators. But not in less developed countries, so there is a prevention method. By making use of intentional islanding, severe electric grid blackouts can be prevented[10].

- Landslides happen when big rocks, earth or pieces of rubbish move down a slope. Debris flows are also known as mudslides. A common type of fast moving landslides, that tends to flow in channels. Landslides happen due to the cause of disturbed natural stability of a slope. They most of the time go together with heavy rains or are followed by droughts, earthquakes or volcanic eruptions. Areas where wildfires or human modification of the land have destroyed vegetation on slopes are mostly vulnerable to landslides during and after heavy rains[7].
  The Center for Robot-Assisted Search and Rescue (CRASAR) provides rescue robots and expert operators. These are waterproof robots that tolerate wet conditions, but not yet densely packed rubble, vegetation, and soil. They are still working on improving their robots[17].

- E-waste, waste from electronics[15], is one of the fastest-growing waste streams worldwide. Because of this rapid growth, issues related to e-waste are a serious concern. Increasing amounts of e-waste can have very negative effects on the environment and public health because of improper recycling and disposal techniques. These unsustainable recycling practices are common in several developing countries, where recycling methods are underdeveloped, and a significant proportion of e-waste components end up in unsanitary landfill and open dump sites. The paper linked below proposes the hypothesis that an integrated approach can improve e-waste handling in developing countries by addressing region-specific issues simultaneously.

- Water shortage is one of the many consequences that need to be accounted for with the global increase in population. Because of this growth, stress on existing natural water supplies continues to increase. Many parts of the world are already having to deal with a supply unfit for human consumption, resulting in disease and death. Previously proposed solutions are often either dependent on a consistent climate or non-sustainable. For example, groundwater supplies are dependent on rainfall, which is greatly impacted by climate change. Another solution is the desalination of seawater, where the salt content is removed to make it drinkable. However, this solution has so far proved itself to be very energy intensive and thus not sustainable for future use. This doesn't mean that seawater is not a viable solution. Seawater supply is barely affected by climate change, so a sustainable desalination plant could in theory be a long term solution for keeping the supply of fresh water under control. This paper addresses the methodology adopted, based on sustainability principles, for the planning, design, construction and operation of the Adelaide Desalination Plant (ADP) in South Australia, one of the areas already affected by shortages in the supply of fresh water[4].

- Whenever a natural disaster takes place, quickly gathering information is crucial to reduce the number of victims and damage of such disasters. Deploying rescue teams allows for this, but it's a generally time-consuming process and not feasible for all conditions. Using drones[2] is a great way to gather lots of information and scout a large, and sometimes almost inaccessible area in a relatively small amount of time. However, controlling these drones is often not straight-forward, which negates the time saved by using them. This paper explores the possibility of autonomous drones. It discusses the different ways in which these drones can be utilized when it comes to natural disasters, and the technical challenges that present themselves with controlling drones autonomously.

Chapter 2: Identification of General Problems and Challenges

Eleven general problems and challenges from the former chapter with a small explanation.

General problems

- Pollution: There are many forms of pollution but all of them originate from humankind. There is plastic pollution, air pollution, field pollution, etc.

- Dying species: The red (endangered species) list is becoming larger and larger. This is because of (illegal) deforestation, wildfires, and also because of hunting which is mostly done illegally on these dying species.

- Electronic waste: In a world with more and more technology there will also be more electronic waste. This waste is just thrown away with the normal waste which can cause serious chemical disasters if not handled the right way.

- Water shortage: There are multiple countries where there is a shortage of water. Since we as humans exist mostly of water this causes a big problem in those countries.

- Wildfires: Wildfires produce a lot of CO2 and burn down a lot of trees also are most wildfires hard to control and are lethal for people if they aren't warned soon enough.

General challenges

- Education of Natural Disasters: The Education of Natural Disasters can help a lot of people with surviving natural disasters which makes the disasters less lethal and thus luss bad.

- Searching people: After natural disasters there are a lot of people lost during the disaster. Some of these people are still alive after the disaster but die because they aren't found in time. Improving the search for people can decrease these deaths.

- Public health: With a lot of different diseases in the world public health is an important issue. Having enough resources and knowledge can reduce the effects of these diseases and thus lead to less deaths.

- Getting electricity to people: Nowadays electricity is an important part of our lives but there are enough places that have no or bad electricity. Making sure electricity gets to the people safely and quickly can help with preventing deaths from all kinds of disasters.

- Providing data to people and instances: Knowledge is power is a well known sentence. This is true when it comes to disasters and preventing them. That is why it is very important to get data and knowledge to people and instances.

- Making data readable: Even though there is a lot of information in the world most is hard to understand for most people. Making this data readable can help with informating people on what to do in a disaster or what not to do to prevent such things.

Chapter 3: Identification of Relevant Problems

Five problems that we found relevant, urgent and interesting.

1. **Wildfires;** with the rising threat of wildfires due to global warming a solution is needed to prevent wildfires or detect wildfires sooner to decrease the damage.
2. **Food waste;** while we in first world countries throw food away as soon as a little part of the food has gone bad others in third world countries struggle to feed themselves. There is no good balance and the immense food waste needs to be reduced.
3. **Plastic waste;** this problem has been tried to be solved many times, but the plastic waste could still be way less. You could start very simple by bringing your own mug to a coffee machine instead of using a plastic cup, but that's only on the consumer's side. Big companies could also do way more to reduce the amount of plastic waste.
4. **Searching for people after a disaster;** searching for people after a disaster is urgent, because it's about a life or death situation. Making searching easier and/or faster is something that could be worked on.
5. **Greenhouse gas emissions;** how can we make clear to people how much CO_2 they really produce? Most people don't know this. Making people aware about greenhouse gas emissions could help the decrease of the emissions.

Chapter 4: Problem Selection and Motivation

The problem we are addressing and our reason why.

Food waste.
There is a lot of food waste in the world, depending on where you are there is more or less food waste compared to the rest of the world. In third world countries, people die from too little food while we in the Netherlands throw a good banana away because it has a small bruise. Also, the fact that people buy, make, and eat too much food is a motivation to look further into this problem. Food waste is a really simple problem, buy less food and you'll waste less. However this isn't happening, people are still wasting a lot of food each year and we think we can give a contribution to lessening the problem.

Food waste is a slow occurring disaster. The total produce wastage for edible parts is 1.3 billion tonnes. More and more food is being thrown out every day. But why is this such a big deal?
After the food has been thrown out, it ends up in landfills to rot. That's when it produces enormous amounts of methane gas. These emissions represent the largest source of GHG emissions from the waste sector. This gas contributes to the global warming crisis. The carbon footprint of food debris is counted to be 3.3 billion tons of CO_2 released into the atmosphere each year. Food waste alone causes 10% of greenhouse gasses.

Since more food is being produced and thrown out, more land is being used for all the waste. We are wasting land on decomposing produce. Instead, we could be planting more trees or building homes in those areas. Also, a lot of the time the land is not cared for and it can be useless in the future for other things. After fertilized products rot into the ground, the soil becomes acidic. This is also harming biodiversity. Agriculture is at fault for mass threats to animal and plant species. We are also wasting terrain before even throwing out the food. 28% of the world's agricultural soil is used to produce food that will be lost or wasted.

Unethical disposal is also a humanitarian problem. The enormous amounts of wasted food could feed millions of people. But instead, it ends up in landfills.

It is not only food. The whole process from the seed to getting dinner on your table produces tons of waste (water, fuel, plastic, etc).

Chapter 5: Potential Solutions

Seven possible solutions for our problem with a small explanation with it.

Food waste solutions:

1. A really big issue that people are facing on a day to day basis is purchasing too much food at once, leading to more food being thrown out and wasted as the stigma around over dated food is to throw away anything past the "consume by:" date.

   A way to solve this is by bringing light to educating people about the reality of the "consume by" dates through an app and allowing for people to sell/swap their food that they do not want or do not plan to eat. For example if you had a bunch of bananas that you don't plan to eat in the next few days, then someone who is willing to purchase or swap for those bruised bananas can go on the app and request for the specific food and amount they want and this will reduce the amount of waste that bananas could have produced. This can work with any other type of food and people could send their location or somewhere they would like to meet up in order to exchange food products. The app will have GPS location tracking (for delivery/pickup), a user friendly list of how they would like to browse through the types of food available, eg. food that is the oldest at the top, food that is the closest near your location, etc.

2. When people are deciding to throw out food or not, they often accidentally look at the sell by date instead of the expiry date, causing them to ultimately throw out food before it has gone bad. Also people often don't know how long different foods can last before actually going bad. This leads to an increased amount of food waste although it can be easily avoided with some simple information(expiration dates, amount of time it can last after being opened, etc.).

   A potential solution to this problem could be providing a database for food that consumers buy in a grocery store which provides the user with information about sell by dates vs expiration dates so people know which is which, give general statistics about how long the food can last after being opened so the user has an idea of what time span they have to consume all the food without accidentally wasting it and it could also suggest how long certain foods last after the expiration date. To make it more interactive for the user, they could enter when they buy the food so the app sends notifications in case the food is about to go bad to remind the user.

3. One place to look at to reduce the food waste is farms. You wouldn't immediately think of it, but a lot of food is thrown away at farms. This might be due to various reasons such as the food looking ugly (or just not looking right), having some damage or maybe being sick (having a disease). To tackle this problem we could optimize the growing conditions for the crops. This is being done a lot in greenhouses, but not really outside of greenhouses.

To get the optimal growing conditions for the crops you'll need a database with information about all the crops (so optimal growing conditions, but also diseases they are susceptible to). Then sensors are placed at different locations at the field (or in the ground), so that a large area is being covered. The sensors are able to detect diseases, but also the amount of sunlight, water and nutrients the plants need and will give a signal to a central point, if the optimal growing conditions are not being met. This way the farmer does not have to go on the field to inspect all the crops, but he can just check the central point. It saves the farmer a lot of time and it also helps to decrease the amount of food waste.

4. Food being thrown away because of expiration is a big contributor to the amount of food being wasted each year. Letting food get expired can have multiple causes. For example, groceries could be stored under the wrong conditions. Storing something that belongs in the fridge at room temperature can speed up the process of expiration drastically. Another reason for expiration is people forgetting about the food. Finally, people often throw away perfectly fine food because they think it's expired, when it's really not.

   A potential solution to this problem could be a smart cupboard. This would basically be a cupboard that houses an Arduino with a bunch of sensors (for example, a temperature sensor) within, and presents a screen on the cupboard's door. Whenever you put food in the cupboard, the device tells you whether the conditions in that cupboard are suited for the product and if there might be a better place to store it. It also tells you how long you can expect the product to last before it expires and reminds you with its screen to use the product if you haven't used it when it nears its expiration date.

5. Food waste is a big problem, this happens everywhere in the world and it has huge consequences. But if we all worked together, we might be able to find solutions. One of the branches this happens is in big organizations/company's. A lot of the food is wasted here. A good solution could be smart fridges to store their products.
   A fridge with a lot of smart sensors and software. One of these features could be a system for the fridge to recognize each product and be able to visualize what is inside of the fridge. That way you can monetize when the product has been put in there and all the important data about this product. So the perfect temperature can be set and a warning can be sent out if a product is about to expire. When you would put a product in the fridge, sensors can recognize the product and it will remember the date and time it has been put in there. Once the product is recognized, the fridge will automatically change settings for the best atmosphere. This will probably work the best for bigger fridges with a clear storage system. A cheaper application for smaller customers, like households and small restaurants, should also be possible.

6. Food waste is a large problem and there are different causes for food waste. Restaurants are one of the main problems of food waste especially in these corona times. The restaurants make too much food that the consumers don't eat. There are too many vegetables, or just some veggies they don't like. The sauce tastes weird, fries are

too much or just the entire meal is too much. There are so many possibilities of having food that isn't going to be eaten by the consumer that there must be room for possibilities.

Having some kind of measurement of what is eaten and what isn't can help with making the right amount of food and lessen the food waste. Also connecting this to an app could make it work better. For example having an app to specify how much veggies you want and in the end measuring if there are any veggies thrown away. This can also help with seeing if some amounts are still too large after putting them in the app and after people have ordered that food in an amount and still have leftovers.

7. Wasting food is unfortunately a part of everyday life for most people, especially with people that cook a lot or have gardens. I grew up with my grandma who loves freshly grown fruits and vegetables. What would she do after all the fruit we couldn't eat? She simply made jam that she stored and could be eaten all year. But making preserves for winter is rapidly declining in popularity.

   This simple solution for food waste isn't common for young people. How can we make it more popular? It seems like young adults use their phones for almost everything, so making an app would guarantee access to recipes right in the pocket. Put in what produce you have left and see what recipes pop up. You would be able to even combine different kinds of fruits and/or vegetables.

   We could also combine the app with a smart fridge that will give you a recipe when it senses that something is going to go bad. Sensors from the fridge pick up the chemicals released from the chemical reactions happening in aging fresh food. The sensors will send a signal to your phone and the app will notify you with a recipe.

Chapter 6: Solution Selection

The solution we chose and why we did this. Who is going to do what and what we need for this solution.

Motivation:

The solution we have chosen is the Smart Cupboard. We choose this idea, because there are many ways to make a cupboard 'smart' and it is easy to adjust the complexity of the project. We want to keep track of the buy and average expiration date. We also want to keep track of the temperature and humidity and based on that give a recommendation if the food is stored in the right place. We'd like to connect the cupboard to a simple app, where all the information is displayed neatly.
The cupboard is intended to be used in homes. This way the consumer can easily keep track of products and if they need to be consumed. Of course it is possible to expand this cupboard in such a way that it is also usable for restaurants, so that the food waste gets way less there.

The Institute of Food Technologist claims that the largest share of food loss and waste happens at consumer level. According to the Netherlands Nutrition Centre consumers are the biggest food wasters with a share of 33%. Seven out of ten people in the Netherlands are willing to decrease their food waste. Nevertheless, in reality shoppers face multiple difficulties with wasting less, including purchasing and preparing too much and incorrect storage habits. We want to help the consumer level (but also other levels) by making it easier with smart storage.

Smart cupboard

Features:

- Keep track of buy date
- Keep track of expiration date
- How fast does food go bad
- Suggest recipes (when food almost expires)
- Keep track of temperature/humidity
- Recommend storage place (based on temperature/humidity)
- App to monitor/gives notification
- Database with food

Modular Approach
Roles/functions:

Kevin:
- Circuits/Arduino
- Purchase of sensors and components
- Designing cupboard/product

Kimberley:
- Presentations
- Prepare demo
- Circuits/Arduino
- Purchase of sensors and components

Marleen:
- Research
- Data analysis
- Management/coordination
- Feedback

Max:
- Documentation
- Programming/making app
- Management/coordination

Natsu:
- Prepare demo
- Designing interface/app
- Designing cupboard/product
- Validation and testing

Sterre:
- Programming/making app
- Designing interface/app

Victoria:
- Research
- Data analysis

Chapter 7: Methodology

Equipment List:

- DHT22 temperature & humidity sensor
- Cupboard
- App for Android; product is put in by user
- Arduino
- Wires
- Light switch
- Lots of lights
- Raspberry Pi

Data Needed:

- How fast does food go bad
- Optimal temperature and humidity
- Average expiration time
- Average time food has been in a store
- At least 5 kinds of foods

The equipment we are going to use and the data we need is mentioned above. We can get most of the data we need from the internet. A lot of research has been done on the topic of expiration dates of food which we can use. The US government has even published research and results about it, so we will use that information.

The equipment we're going to use will be in a controlled environment, meaning that it does not need a special casing. The data that is going to be collected is the humidity and the temperature. This is needed to know if the food is in the right environment and if it needs to be replaced. We aim to get most of the project done by the 15th of January, so that we'll have enough time to test everything and to see if things need to be improved. These two weeks will give us enough time to test and validate all the gathered data.

To make sure the sensors work like they should, we'll have to calibrate them in some way. We only use one sensor, so we have to make sure it works. To test if the sensor works like it should we will test it in different rooms (for the humidity and temperature). We are also looking into getting maybe another sensor so that we can compare the results we get from them.

We use *Trello* to keep track of all the things that still need to be done. This app helps us to cut up all the tasks into small pieces and to keep track of what everyone is doing. It looks like this:
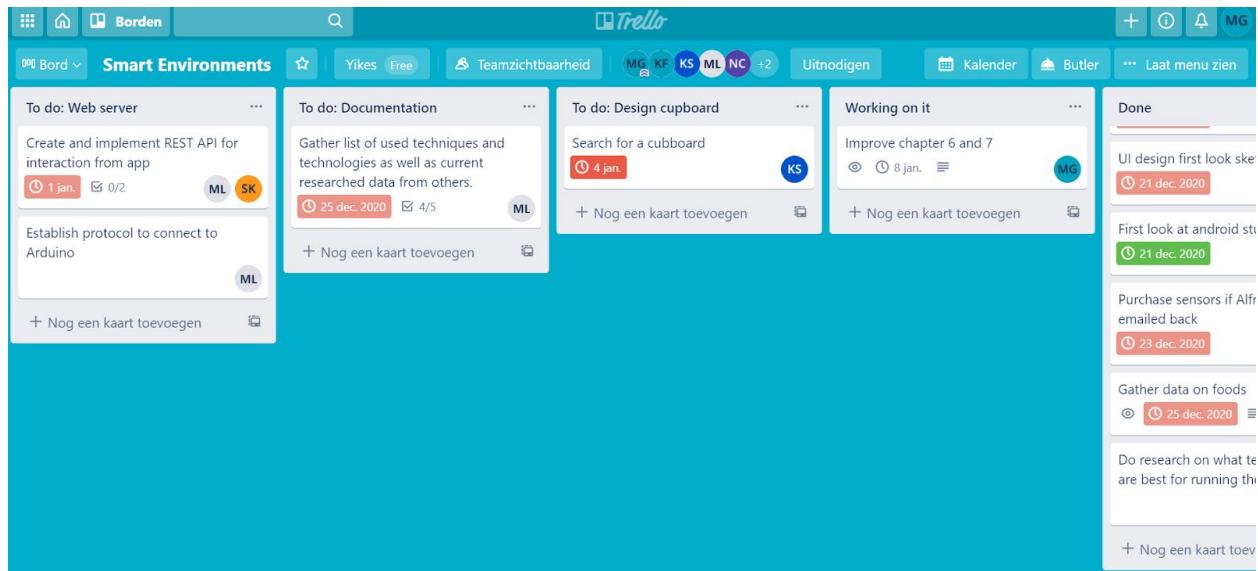

Figure 1. A overview of our Trello board during the research and development of our project.

Basic vs Ambitious scenario

Our goal for a basic scenario is to make a Smart Cupboard which keeps track of the humidity and the temperature. Based on that information it will give a recommendation where you can store your food the best, so that it won't expire. You'll have to fill in the food you put in the cupboard into an Android app. The app will allow the user to keep track of the expiration date and the conditions in the cupboard. You'll get a notification when the food almost expires, so that you consume the food in time.

In an Ambitious scenario we would like to do everything we do in the Basic scenario but add lights and a jingle. The light will be 5V RGB lights and different colours will indicate the state of the food. For example: Green: the food is still good, Orange: food almost reaches expiration date, Red: food has reached expiration date and isn't safe to consume anymore. We would also like to implement some recipes, so that when you get a notification that food almost expires you get a recipe with that food in it. This encourages consumers to use the food. In this scenario we would also like to add a jingle. This jingle will play every time you open the cupboard; it is just for fun.

Data Validation:

To ensure the quality of our data we will check multiple sources of the data (multiple websites). Thanks to that we will be able to have the most accurate data of the foods. To validate our app we will try the use of the app multiple times to see what the outcome is. To validate the working of the code of the arduino in combination with our sensor we will try it on two different arduino with each a different DHT22. To validate the work of the sensors we will use a thermometer to check the temperature to see if this sensor worked properly. Sadly we can't check the humidity

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sensor with an outside measurement device, but we will check if we got a reasonable percentage from the sensor with tests like blowing on the sensor to see if the humidity changes.

Data storage and communication

For storing the data, we are using a local JSON database that's stored on the Raspberry Pi.

The data in the table below is stored like in figure 2. This makes it easily readable and extendable should we want to. The static data, like the available products, optimal temperatures, optimal humidities etc. are stored separately from the user-specific data.

For communication, we are using a Node.js web server to bridge the communication between the app and the Arduino. The app communicates with the web server over HTTP, and the Arduino provides the sensor readings to the web server over a custom serial protocol.

To send a notification to the user, the server uses Google's Firebase Cloud Messaging services.

Figure 2. An example of how we stored our data on the web server using a JSON database.
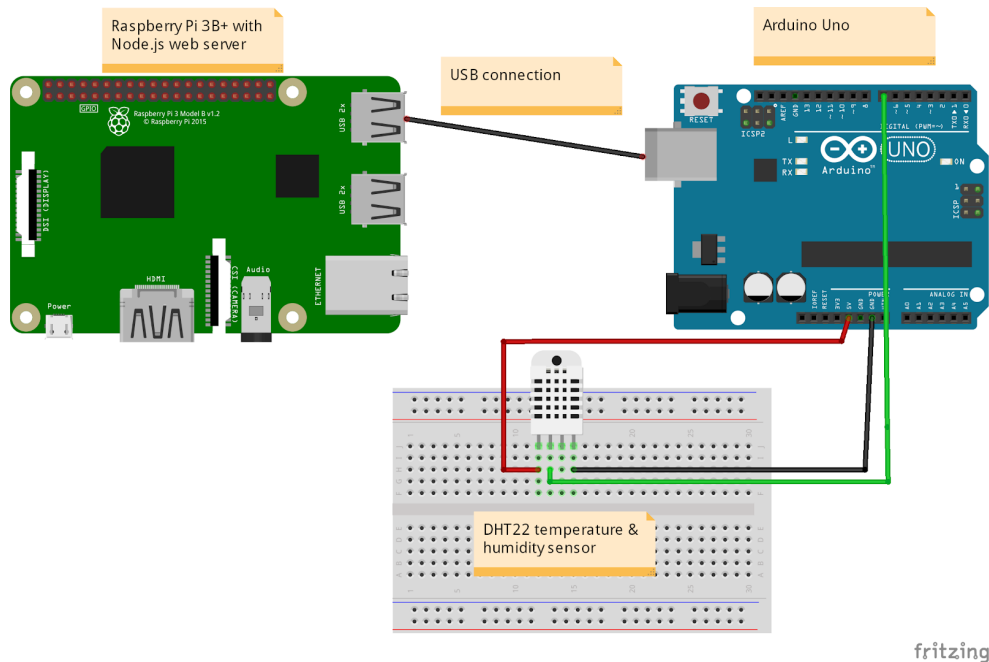
Setup demonstration

Figure 3. A rough overview of the physical setup.

Chapter 7a: Data and Research

Table with data of different fruits and vegetables.

Fruits/vegetables	Expiration date in cupboard[1* & 28]	Expiration date in refrigerator[2* & 28]	Best temperature (℃)	Best humidity (RH)
Apples[27]	7 days	1-2 months	-1-1.5	90-95%
Blueberries[37]	2-3 days	5-7 days	+- 0	90-95%
Cabbage[31]	1-2 days	1-2 weeks	0 – 4	90% or higher
Carrots[36]	+- 2 weeks	+- 4 weeks	0-3	+- 95%
Eggplant[33]	3-4 days	2-3 weeks	10-12	90-95%
Grapes[25]	3-5 days	5-7 days	+- 0	90-95%
Mushrooms[30]	2-3 days	4-7 days	2-4	85-90%
Raspberries[32]	1-2 days	2-3 days	0-2	90-95%
Strawberries[35]	1-2 days	3-5 days	0-2	90-95%
Tomato[29]	7 days	2 weeks	15-17	85-90%

Note: The average storing time till expiration in the cupboard and fridge are taken from the site 'StillTasty'[34]. This site gets their data from the American government, who did research[28] on how long food could be stored in certain environments. The superscripts on the fruits and vegetables will take you to the sites where the ideal humidity and temperatures of the foods are described.

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[1] Storage in a cupboard will have a temperature between 15.5-21 degrees Celsius[34].
[2] Storage in a fridge will have a temperature between 1.5-4 degrees Celsius[34].

Chapter 8: Results and Conclusion

The end result of our project is the basic scenario, meaning that you are able to fill in the app the foods you put into the cupboard. You will receive notifications when the food almost expires. A sensor that measures the humidity and temperature is connected to the Arduino. This information is displayed when you open the app. When you store your food you get to see the optimal storing humidity and temperature for the foods, so that you know if you have to store it somewhere else if you want the food to stay fresh longer.
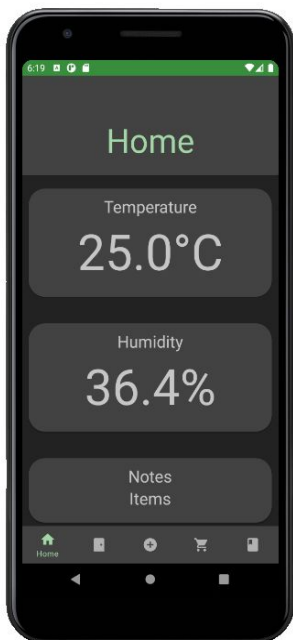

Figure 4 shows what our app looks like. Its home screen provides the user with up-to-date information about the conditions in the cupboard. As long as the Raspberry Pi is connected to power, and both the app and the Raspberry Pi are connected to WiFi, the app is able to retrieve information.

The user can add products to their virtual pantry, and the app will automatically calculate the expiry date. All information is stored on the web server, so in theory the app could be installed on multiple devices.
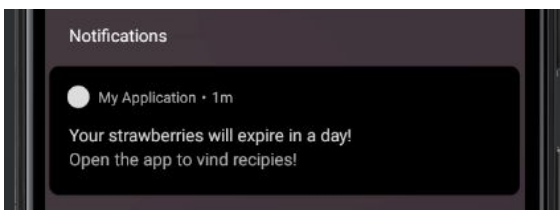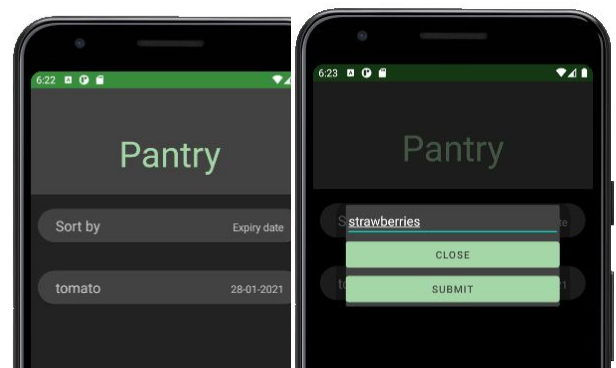
Once a product reaches its expiry date, the user will be sent a notification on their phone reminding them to use said product.

Figure 4 (top left). Our app's home screen. The data is directly requested from the web server.

Figure 5 (right). The user can add the products in the cupboard to their virtual pantry. Where they can keep track of what they have stored in their cupboard and when the products will expire.

Figure 6 (bottom left). An example of a notification the user will receive when a product nears its expiration date.

Conclusion

The goal of this project was to tackle the food waste problem, because it is a slow occurring disaster and if we do not do something about it now, we'll have big problems later. Food waste is not only a humanitarian problem but it is also contributing to the destruction of our planet. Enormous amounts of land on which the food rots are later unusable for other endeavours and releases a huge portion of methane to our atmosphere.We mainly focused on food waste in households, because they are very big contributors to this problem (according to the Netherlands Nutrition Centre[43] they are the biggest with 33%). The Smart Cupboard will help reduce waste, by notifying the consumer when the food will go bad. Humidity and temperature are measured by the sensors and sent to the app, which thanks to appropriate software and calculations based on extensive research will inform the user about the approximate shelf-life of the product. This will ensure that the user is storing the produce correctly and that the produce is eaten before going bad. With all of human responsibilities it's hard to keep track of everything, especially ones food- this is where our Smart Cupboard comes to help. Its scalability would make it an ideal market product. Even though this product was made in thought of households, it could be easily adapted to other environments such as restaurants, factories and workspaces. Overall, we are very pleased with the turnout of our project, especially in these times of the Coronavirus. We think we were able to cooperate even though it was a difficulty considering the current circumstances. We believe that our product could truly help in the food waste disaster.

Problems encountered

We haven't encountered that many problems, but the problems we did have were very small. At one point the sensors we purchased did not work, so we had to buy new ones. This caused some problems with the planning we had, because the planning was quite tight and did not leave much space for things like this to happen. This resulted in us getting behind on our schedule and not really being able to do the testing. Due to corona we also were not able to get our hand on a thermometer and a humidifier to validate our testings. That's also why we don't have any 'real' data collected.

Discussion

This project could be implemented in all kinds of different environments. We've designed this cupboard so that it can be used in households, but is it possible to use the same equipment in a fridge for example. It would also be possible for restaurants or hotels to use this project on a larger scale. If that were to happen the data base would have to expand a lot, so that much more food can be stored in the cupboards and fridges. This project can be implemented on many scales and in many different environments, meaning that lots of food waste can be stopped.

Of course, this project is just a prototype.The Smart Cupboard could easily become a market product. It is cost efficient but it could also be made for higher end consumers. The product could be sold in different kinds of styles and cost points (something for everyone- budget friendly and for trend setters). If you would bring this product to the market, you would have used smaller equipment. The current setup is quite bulky and might take up too much space in some cupboards. To make it appealing on the market to clients you would have to integrate the equipment in the cupboard itself. A solution to fix this would be to not use both a Raspberry Pi

and Arduino, but opt for something small like an ESP-8266 module. This is also more energy efficient and would allow the setup to function on battery power. The current implementation also only works on the premise that there is only one Smart Cupboard. For a real world implementation both the app and server would have to be altered to support multiple cupboards and users.

Literature list:

1. 2017, J. A. T. P. (2018, 10 juli). *Technologie zorgt voor rampspoed in de komende 20 jaar*. CIO. https://www2.cio.nl/markttrends/96186-technologie-zorgt-voor-rampspoed-in-de-komende-20-jaar

2. Apvrille, L., Tanzi, T., & Dugelay, J. L. (z.d.). *Autonomous Drones for Assisting Rescue Services within the context of Natural Disasters*. ursi. http://www.ursi.org/proceedings/procGA14/papers/ursi_paper2126.pdf

3. Beat the Microbead. (2020, 22 juni). *International Campaign Against Plastic in Cosmetics*. https://www.beatthemicrobead.org/

4. Blesing, J., & Pelekani, C. (2016). SEAWATER DESALINATION: A SUSTAINABLE SOLUTION TO WORLD WATER SHORTAGE. *Water e-Journal*, *1*(1), 1–8. https://doi.org/10.21139/wej.2016.003

5. Brown, M. J. F., & Paxton, R. J. (2009). The conservation of bees: a global perspective. *Apidologie*, *40*(3), 410–416. https://doi.org/10.1051/apido/2009019

6. Cavanaugh, R. (2018, 26 maart). *Cell phones in Amazon trees alert rangers to illegal logging, record wildlife*. Digital Trends. https://www.digitaltrends.com/outdoors/solar-powered-cell-phones-saving-amazon-rainforests/

7. Centers for Disease Control and Prevention. (z.d.). *Landslides and Mudslides|CDC*. https://www.cdc.gov/disasters/landslides.html

8. Choi, K. Y., & Cheung, R. W. M. (2013). Landslide disaster prevention and mitigation through works in Hong Kong. *Journal of Rock Mechanics and Geotechnical Engineering*, *5*(5), 354–365. https://doi.org/10.1016/j.jrmge.2013.07.007

9. Elleuch, B., Bouhamed, F., Elloussaief, M., & Jaghbir, M. (2018). Environmental sustainability and pollution prevention. *Environmental Science and Pollution Research*, *25*(19), 18223–18225. https://doi.org/10.1007/s11356-017-0619-5

10. Esmaeilian, A., & Kezunovic, M. (2017). Prevention of Power Grid Blackouts Using Intentional Islanding Scheme. *IEEE Transactions on Industry Applications*, *53*(1), 622–629. https://doi.org/10.1109/tia.2016.2614772

11. Forman, E. M., Evans, B. C., Flack, D., & Goldstein, S. P. (2016). Could technology help us tackle the obesity crisis? *Future Science OA*, *2*(4), FSO151. https://doi.org/10.4155/fsoa-2016-0061

12. Fuller, T., Singhvi, A., Gröndahl, M., & Watkins, D. (2019, 7 juni). *Buildings Can Be Designed to Withstand Earthquakes. Why Doesn't the U.S. Build More of Them?* The New York Times. https://www.nytimes.com/interactive/2019/06/03/us/earthquake-preparedness-usa-japan.html

13. Goniewicz, K., Magiera, M., Burkle, F. M., & Goniewicz, M. (2020). Prospective Study on the Potential Use of Satellite Data for Disaster Prevention, Preparedness, and Mitigation in Poland. *Prehospital and Disaster Medicine*, *35*(3), 331–334. https://doi.org/10.1017/s1049023x20000321

14. *Grote stijging downloads Beat the Microbead-app dankzij uitzending KVW*. (z.d.). npo3.nl. https://www.npo3.nl/grote-stijging-downloads-beat-the-microbead-app-dankzij-uitzending-kvw

15. Ikhlayel, M. (2018). An integrated approach to establish e-waste management systems for developing countries. *Journal of Cleaner Production*, *170*, 119–130. https://doi.org/10.1016/j.jclepro.2017.09.137

16. IUCN. (2017, november). *NATURE-BASED SOLUTIONS TO DISASTERS*. https://www.iucn.org/sites/dev/files/nbs_to_disasters_issues_brief_final.pdf

17. Murphy, R. R., & Stover, S. (2007). Rescue robots for mudslides: A descriptive study of the 2005 La Conchita mudslide response. *Journal of Field Robotics*, *25*(1–2), 3–16. https://doi.org/10.1002/rob.20207

18. Petruzzello, M. (z.d.). *Plastic Disaster: How Your Bags, Bottles, and Body Wash Pollute the Oceans*. Encyclopedia Britannica. https://www.britannica.com/story/plastic-disaster-how-your-bags-bottles-and-body-wash-pollute-the-oceans

19. Rainforest Connection. (z.d.). *Rainforest Connection | Protecting rainforests with real-time data*. https://www.rfcx.org/home

20. Ranta, K., & Laine, V. (z.d.). *Revolutionizing Depression Treatment with Digital Therapeutics*. Anxiety and Depression Association of America, ADAA. https://adaa.org/learn-from-us/from-the-experts/blog-posts/consumer/revolutionizing-depression-treatment-digital

21. RIVM. (2008, mei). *GGD-richtlijn medische milieukunde: de eikenprocessierups en gezondheid* (Nr. 609330007). https://www.rivm.nl/bibliotheek/rapporten/609330007.pdf

22. Seider, G. (z.d.). *A Common-Sense Solution to Hurricane Devastation | Smart Cities Dive*. Smart Cities Dive. https://www.smartcitiesdive.com/ex/sustainablecitiescollective/common-sense-solution-hurricane-devastation/1275376/

23. Tsai, M.-H., Wen, M.-C., Chang, Y.-L., & Kang, S.-C. (2014). Game-based education for disaster prevention. *AI & SOCIETY*, *30*(4), 463–475. https://doi.org/10.1007/s00146-014-0562-7

24. Yu, A. C., Lopez Hernandez, H., Kim, A. H., Stapleton, L. M., Brand, R. J., Mellor, E. T., Bauer, C. P., McCurdy, G. D., Wolff, A. J., Chan, D., Criddle, C. S., Acosta, J. D., & Appel, E. A. (2019). Wildfire prevention through prophylactic treatment of high-risk landscapes using viscoelastic retardant fluids. *Proceedings of the National Academy of Sciences*, *116*(42), 20820–20827. https://doi.org/10.1073/pnas.1907855116

25. Builder, M. (2018, 13 februari). *How to Store Grapes So They Last Longer*. MyRecipes. https://www.myrecipes.com/extracrispy/how-to-store-grapes#:%7E:text=As%20the%20experts%20from%20the,crisper%20drawer%20in%20your%20fridge.

26. CCE Cornell Vegetable Program, & Hadad, R. (2016). *Cold Storage Chart & Reference Guide*. https://rvpadmin.cce.cornell.edu/uploads/doc_500.pdf

27. Ferro, S. (2018, 11 september). *A Simple Trick for Keeping Your Apples Fresh for Longer*. Mental Floss. https://www.mentalfloss.com/article/556777/simple-trick-keeping-your-apples-fresh-longer#:%7E:text=Apples%20are%20one%20of%20those,of%2090%20to%2095%20percent.

28. FSIS. (2020, 21 februari). *FoodKeeper Data - English* [Dataset]. FSIS. https://catalog.data.gov/dataset/fsis-foodkeeper-data/resource/2ff1a3ce-4b4e-47d2-a7f4-e54b678ecae9?inner_span=True

29. Geers, J. (z.d.). *Transport & storage tips | Prominent*. Prominent. https://www.prominent-tomatoes.nl/en/de-tomaat/kwaliteit/transport-storage-tips/

30. Gulf Mushroom Products Co. (z.d.). *Gulf Mushroom*. Gulf Mushroom. https://www.gulfmushroom.com/mushrooms-storage-handling.html#:%7E:text=Optimum%20humidity%20%2D%2D%2085%2D90,This%20will%20hasten%20their%20decay.

31. Miller, L. (2020, 1 maart). *StackPath*. Gardening Know How. https://www.gardeningknowhow.com/edible/vegetables/cabbage/cabbage-storage-tips.htm

32. S. (2015, 2 december). *Strategies for Raspberry Cooling*. SEMCO.
   https://semcoice.com/facts-cooling-storing-raspberries/

33. Splawn, M. (2016, 23 juli). *The Best Way to Store Eggplant*. The Kitchn.
   https://www.thekitchn.com/the-best-way-to-store-eggplant-233530

34. StillTasty. (z.d.). *StillTasty: Your Ultimate Shelf Life Guide - Save Money, Eat Better,
   Help The Environment*. https://www.stilltasty.com/

35. Strawberry Plants. (2020, 8 juni). *How to Store Strawberries*.
   https://strawberryplants.org/how-to-store-strawberries/#:%7E:text=The%20optim
   al%20temperature%20for%20storing,loss%20and%20shriveling%20can%20occu
   r.

36. Thomsen, M. (z.d.). *Proper Humidity for Storing Fruits & Vegetables*. Hunker.
   https://www.hunker.com/13407037/proper-humidity-for-storing-fruits-vegetables

37. Van Amerongen CA Technology B.V. (z.d.). *Blueberries storage | Controlled
   atmosphere / Ultra low oxygen and Palliflex Pallet storage | Van Amerongen*.
   Van-Amerongen.
   https://www.van-amerongen.com/en/blueberry-storage#:%7E:text=Temperature
   %20should%20be%20around%20freezing,pre%2Dcooling%20is%20important!).

38. Depta, L. (2018, oktober). *Global Food Waste and its Environmental Impact*.
   RESET.to.
   https://en.reset.org/knowledge/global-food-waste-and-its-environmental-impact-0
   9122018

39. Food and Argiculture Organization of the United States. (z.d.). *Food wastage: Key
   facts and figures*. FAO. http://www.fao.org/news/story/en/item/196402/icode/

40. IFT. (2018, 2 april). *Most food waste occurs at the consumer level*.
   https://www.ift.org/news-and-publications/news/2018/april/02/most-food-waste-oc
   curs-at-the-consumer-level#:%7E:text=With%20notable%20differences%20betw
   een%20the,occurs%20at%20the%20consumer%20level

41. New Food. (2018, 21 mei). *5 Ways Food Waste is Destroying Our Beautiful Planet*.
   New Food Magazine.
   https://www.newfoodmagazine.com/article/43551/five-ways-food-waste-environm
   ent/

42. Payne, K. K. (2014, 1 april). *The Consequences of Food Waste*. Inquiries Journal.
   http://www.inquiriesjournal.com/articles/890/the-consequences-of-food-waste

43. van Dooren, C., & Mensink, F. (2014, december). *Consumer food waste*.
   Netherlands Nutrition Centre.

https://ec.europa.eu/food/sites/food/files/safety/docs/fw_lib_vc_sheet_voedselver spilling_en.pdf