A digital twin of food waste:

to understand the behavior of waste and to reduce it

Project work in Design of sustainable infrastructure and urban transformation

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Background

Our project team consist of three Chalmers master's students; Klaudia Mur, Oskar Rehnberg and Joline Kraemer. Oskar and Joline both have a bachelor's in civil engineering and are therefore experienced with the built environment. However, they are on different master programs; Oskar is majoring in geotechnics and environmental engineering, while Joline has focused on project management in the built environment, having insight in how to lead change and how to handle construction logistics in dense cities. Klaudia, our third member, has a bachelor's degree in physics and a completed master's degree in philosophy. In her current master studies here at Chalmers she studies complex systems and is especially interested in network algorithms and how to study urban cities as a network of flows.

We approach the subject of urban cities and transformation from different perspectives and prior backgrounds. One thing that we all have in common is however a drive for sustainability! A drive to come up with solutions that in some way can have a positive impact on the environment and spaces we live in. Something that we quickly learned during the first part of the course, the thematic blocks.

During the first weeks we covered five thematic blocks; Space, Flows, Information, Environment and Resources. From the space and flow segment we were able to practice our network analysis skills. Here Klaudia could bring her network analysis skills as well as Joline and Oskar could take advantage of their prior knowledge within traffic planning and infrastructure. However, we felt drawn to the network created by flow of information rather than of vehicles. Which was applied in the information section where we learned more about digital twin and simulation. We reused this idea in our project, however for a different purpose. In the environment segment we focus on stormwater and noise where both Joline and Oskar had prior knowledge but Oskar especially regarding stormwater. Lastly we cover the area resources. During this workshop we became aware of two problems at campus that would later lead us to our project idea, namely:

- it is not so easy to throw away food waste at campus, and:
- the reusable lunch box system at the campus restaurant SMAK failed,

These insights together with the interest in digital twins and information flow that sparked from information and flow workshops we came up with two focal point for our main project:

- Make food waste stations more accessible, and optimize the collection,
- Combine the reusable lunch box with the student union card and the information on it in a "Pant" system

Campus Johanneberg

While the workshops covered very broad topics applicable to many domains, an emphasis was to relate them, and the project, to Campus Johanneberg.
It is Chalmers' main Campus. It dates back to the 1920s, and has since then expanded as demand for space has increased. The biggest expansion phase was in the 60s. The campus Johanneberg is now approximately one kilometer long and houses many types of buildings. The future prospects are summarized in the "Campusplan" (Inobi AB & Probility AB, 2019), a document put together by the main stakeholders in the area. At the center of the plan are six goals and six strategies that give the aim of Chalmers' future urban planning, see Table 1. A key part of goal 6 and strategy 6 is better management of resource flows on campus. Since there are both many restaurants and people bringing lunch, food can be perceived as one of the main resources consumed on campus and food waste is therefore a big contributor to waste.

Table 1. Description of Chalmers' campus goals and strategies. (Inobi AB & Probility AB, 2019)

Goals	Strategies
International, cutting-edge knowledge environment	Clarify different areas and nodes
Integrated part of the city with distinct character	Define and develop main streets and meeting places
Attractive living environment that contributes to people's well-being	Meet the city
Good accessibility with sustainable transports	Create green and health-encouraging values
Green Campus that encourages ecological values	Develop and make building stock more efficient
Responsible and efficient use of real estate, land and other resources	Prioritise sustainable mobility and logistics

The strategies are agreed upon by the main stakeholders on campus: Akademiska Hus and Chalmersfastigheter, which own the properties on campus, and Chalmers and Chalmers Studentkår which stand for the education and services. There is a culture of cooperation between them, since they are closely connected. The management of restaurant food waste at Campus is connected to the owner of the six most popular restaurants at Campus: Chalmers Conference and Restaurants. They manage the restaurant experience at Campus Johanneberg, and together with the property owners manage the waste. This project connects to all of these stakeholders. How the project connects to the three chosen thematic areas (information, flow and resources) is briefly stated below:

- **Information**: Kårresturangen has information about the food waste they produce when cooking, and also information about the emission rate per sold dish. However there is little information known about food waste on an individual level on campus.
- **Flow**: To understand what kind of food waste we want and can impact we need to map out the food waste based on the flow of food on campus. We will therefore make a flow analysis on food and where food waste is produced.
- **Resource**: As stated above, food is one of the main resources that are consumed on campus. Food is a resource that cannot be eliminated or excluded but our consumption can be more streamlined. To make the food as a resource more sustanbile the food waste needs to be minimized.

Process

While we were functioning as a team quite efficiently during the workshops, where we had to spontaneously come up with ideas and work on them for a short amount of time, the project work, and the choosing of the project idea, presented us with different challenges. With more time and resources at hand, we did no longer have to take the first best idea and make the best out of it. We took our time to come up with project ideas and choose one.

The project idea combines the solution of two smaller problems that we became aware of during the workshops (food waste on campus, and a reusable lunchbox system connected to the student union card) with a tool that takes advantage of the situation on campus but goes further than just the solution of the two problems.

Those problems and solutions lead us to the actual project idea: Combine waste stations with sensors to measure how much food is wasted, and collect and gather that data, taking advantage of the (already broadly used) student union card, and the information system beyond it. In other words, create a digital twin of food waste behaviour on campus. The aim of the product goes beyond the solution of the initial problems. The process we went through is therefore not a classical engineering process, where a problem is identified, and a solution is found, but both the process and the result go beyond the boundaries, and is therefore quite creative, in our opinion.

Working on the project

When first starting with the project work we mapped out our competencies, interest and what we learned and found interesting in the workshops. With this as a starting point we choose three thematic areas; Information, Flow and Resources. After a couple of brainstorming sessions, we came up with several ideas each with its own distinct character. We pitched these ideas to the teachers and after their input and further consideration we decided to focus on the idea regarding food waste.

Firstly, we defined the boundaries and framework of the project, made an action plan and decided to split up responsibilities and parts of the work. We feel that we produce our best work when we can facilitate all our competences simultaneously by working together, however, due to the covid-19 situation, to make progress fast enough we felt that splitting up some of the work was necessary. Nevertheless, we stayed in close contact and had one to two weekly meetings to discuss, map out our progress, where we are, and to come up with solutions together in order to utilize all our qualities and knowledge. The seminars also helped us in our project work. It gave us great feedback and helped us comprehend where we were in our progress and what we needed to focus. The “Creative Work in High-Tech Environment” workshop also gave us new input regarding wider usage of the information and analysis that can be done by our digital twin.

Gathering information:

A big part of our individual work was to gather information, by researching and talking to external stakeholders. The information gathering was divided into three different segments:

- **Lunchboxes**; How they are used on campus, what reusable systems have been tried. What material would be preferable for a reusable lunch box.
- **Food waste**; How is it handled right now, what impact does it have. What research has been done on the subject.
- **Digital twin**; Information we had to gather was mostly about privacy issues and policies.

To gather the information needed on all three segments we read literature and articles online, talked to the teachers for inspiration, interviewed Chalmers students and contacted stakeholders at Kårrestiranger.

Bringing our idea into context

In order to bring our idea into context we first had to map out the food waste cycle and decide upon the bounders and framework of the project. This was a significant part of our process and enabled us to focus our results later on.

Mapping out the food waste cycle

Once we had the idea for the tool at hand, we had to put it into context. A first step was to map out the food production system and at what point food waste is produced. Figure 1 shows our findings: Raw food is produced, transported, processed, distributed to wholesales, bought, and finally processed, cooked and served at restaurants or in households. All those steps produce waste. It is important to distinguish between perfectly edible food that is thrown away because of overproduction, small flaws or bad planning, food that is thrown away because it is not edible anymore, for example processed food, food gone bad or expired, and so on and food waste produced when cooking. Strategies to avoid food waste should tackle all kinds of waste. One approach is to bring still edible food back into the cycle, another is to find ways of recycling food waste to produce e.g. energy or soil.

However, holistic solutions should try to optimize the whole production/distribution and result in avoiding food waste in the first place. Since the production/waste cycle is strongly interrelated, it is important to understand that this cannot just happen at one point in the cycle but needs better planning and communicating between parts of the cycle. Our idea comes in at the very last step of this process: when sold portions are not eaten up and part of it is thrown away. However, our main idea is that information about this part of the cycle can help optimize the other parts and avoid food waste on a larger scale.

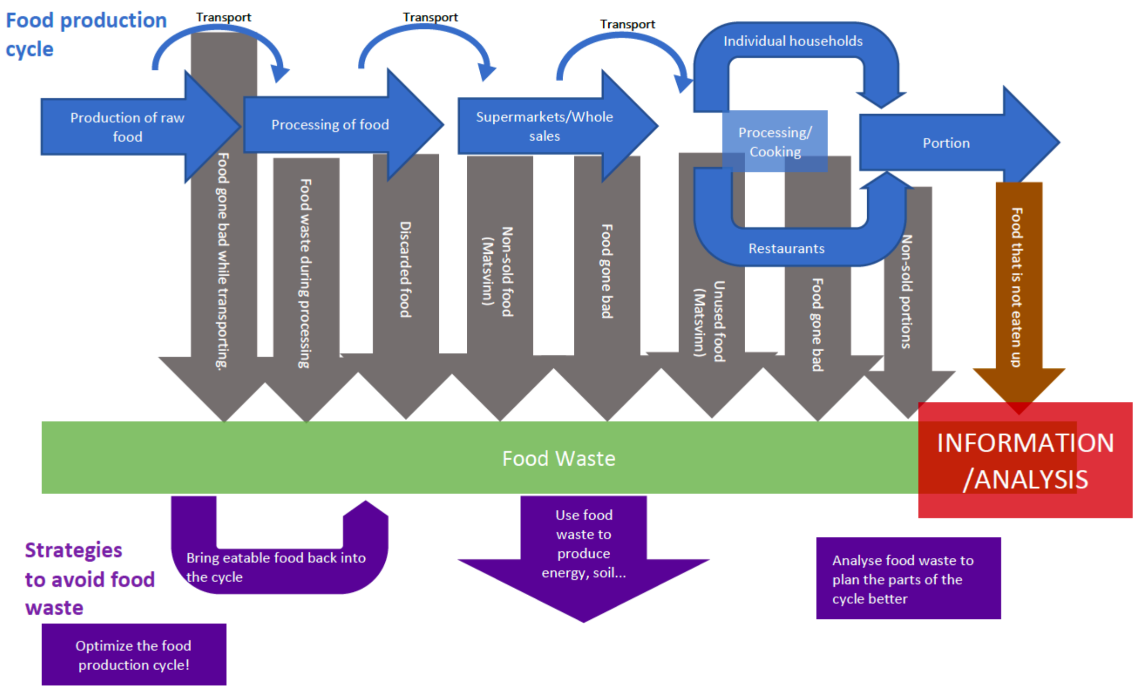

Figure 1: Food production and waste cycle

Boundaries

A very important part of our project work was the definition of boundaries. While raising and answering several questions, we constantly changed our understanding of the boundaries and the framework during the process. Some of them are:

- **What?** Defining both the "harder" parts of the project (Lunch box, waste station), and the "softer" ones (digital twin)

- **Where?** What makes Campus Johanneberg a good "experimentation ground" for the digital twin? Where should waste stations be positioned?

- **Who**? Who is in the systems, who's data is collected? Do we want to focus on students, or on the broader social sphere of Chalmers, including employees and guests?

A big obstacle we faced asking the question "who" was the question of privacy. Are we allowed to gather information about people? To face this, we defined several levels of data strategies, from progressive to conservative:

1. Progressive: data about bought and thrown away food is stored and linked to personal information
2. Semi-progressive: data is stored, but linked to (the same) anonymous ID and not personal information
3. Semi-conservative: Periodically reset ID information
4. Conservative: Only collect the data of the waste without any ID linkage

- **What for?** The purpose of the digital twin part of the project is to "Understand food waste behavior on an individual level". We believe that the results can be applied and useful beyond our testing space of Chalmers. However, this leads to another question:

- **For whom?** Who is going to use the waste station and lunch boxes? Who is going to use the information and analysis done by the digital twin?

- **What kind of impact?** Does our project help make Campus Johanneberg and the life of the people visiting it more sustainable? How can our very local solution have an impact on the efficiency of the food production cycle? How can the projects and its findings be scaled up?

Defining our boundaries was closely connected with defining which Sustainable Development Goals we target. The most noticeable goal that our project aligns with is number 12: *Ensure sustainable consumption and production patterns*. However, it is also closely connected to goal 11: *Make cities and human settlements inclusive, safe, resilient and sustainable*, and goal 9: *Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*, (United nations, 2015) since we want to use innovative tools to tackle the problems. How and if this project aligns with these Sustainable Development Goals will be further developed in the discussion.

Proposed solution

As learnt in the resources workshop, an effective way to improve sustainability at campus would be to reduce and streamline the usage of resources. Food is arguably one of the biggest resources consumed at campus and therefore our proposed solution is connected to improve how we sort, reduce the amount, and understand the human behaviours regarding food waste. Our solution consists of three main parts: Reusable lunch box system, waste stations and a digital twin tracking behavior, see figure 2.

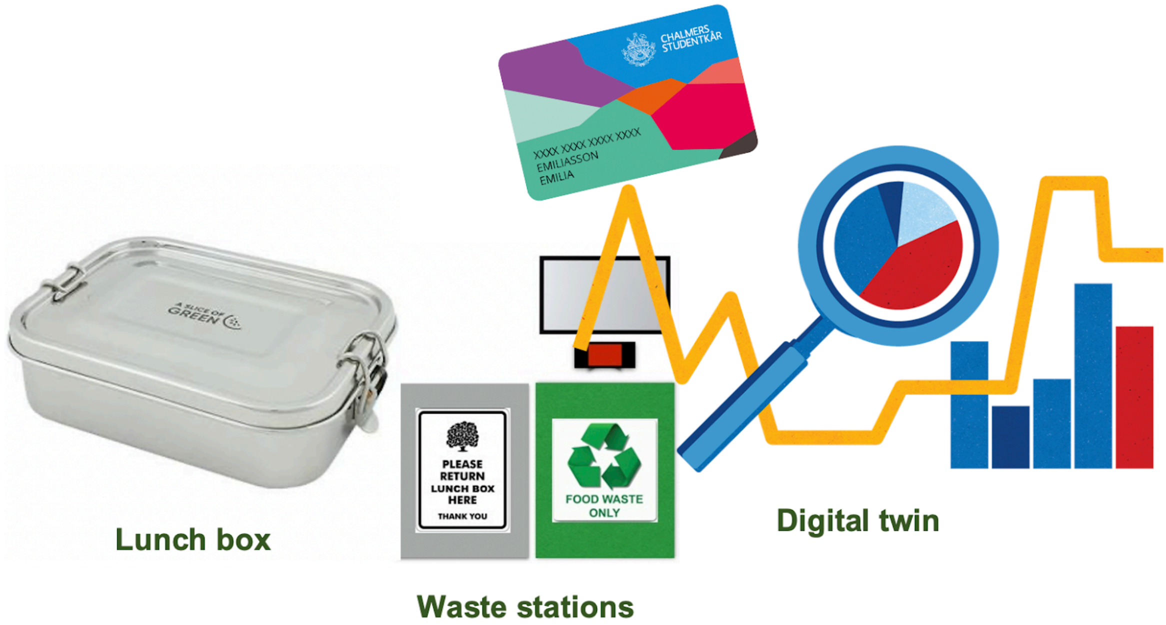

Figure 2. Schematic collage of proposed solutions.

The reusable lunch box concept would be accessible at all cafes and restaurants at campus that offer a take away lunch. The intelligent waste stations measure how much food is thrown away. Both the reusable lunch box system and the weighing are connected to the student union card. They all allow the collection of information about individual's behaviour, which is the backbone of the digital twin.

This chapter will explain the concept in further detail starting with the lunch box and moving on to the waste station and the digital twin. We then describe the expected areas of usage and what kind of impact the solution will have. Key challenges and limitations form the last part of this section.

The Lunchbox

The reusable lunch box serves two main purposes, to reduce the amount of non-renewable plastics usage and to assist in the data collection. The take-away boxes at campus are mostly made out of plastic, which is a non-renewable resource. There have been some attempts to shift the boxes from plastic to biodegradable paper but so far the test trials of Chalmers Conference & Restaurants have failed. Expressen, a take away filial part of the Chalmers Conference & Restaurants, business revolves around selling warm healthy lunchboxes prefillied at a low price and at a fast and convenient way for their customers.The lunchboxes have to endure high temperatures and moist filling at a longer period of time without soaking through, something that the biodegradable boxes have failed at. SMAK, a smaller restaurant at Campus, has transitioned to using only biodegradable lunch boxes, however they pack their food at demand and at a higher price. A reusable lunch box concept is another alternative. It has also been tried at SMAK, but never gained popularity, likely because it didn't give the consumers enough incentive.

"A coworker at expressen said that they have tried everything, but there is no product on the market that could replace the plastic lunch box at the moment." - worker at Chalmers Conference and Restaurants

We propose a reusable lunch box, but in a different concept than what has previously been tried. The consumer can purchase a reusable box, that they can hand in dirty the next time they buy food. In order to make the lunch boxes more sustainable but still preserve the required characteristics of the take away box we therefore propose a reusable lunch box, for all the restaurants and cafes that offer a take away lunch. To decide on a suitable lunch box some important aspects were overall sustainability, endurance, sanitariness, and durability. After a discussion, a metal lunchbox was agreed to be an appropriate container. It is durable, sanitary, contains few parts, and a complete watertight seal is required.

During the SMAK pilot test of reusable lunch boxes, an interviewed user pointed out an important issue. Since the user is responsible for the lunch box they have to bring the box home, and then back again when he/she wishes to buy lunch. This means the user has to plan ahead and if they are to buy food spontaneously they have to buy a non-reusable box. Our system would therefore collect the box directly after being eaten, thus improving user friendliness. It would also mean less boxes since the user is not appointed a personal lunch box. Implementing a recollection of the reusable lunch box directly also enables analysis to be made of the food waste in the lunch boxes.

To summarize the user experience, the consumer enters the system by buying a reusable box. The information about enrolment is stored on the student union card and a corresponding database. The box can be returned the same day, and by blipping the student union card, the database notices that this person has bought and brought back the lunch box. The next (or any other) day, the person can buy food in a reusable lunchbox without paying for the lunchbox again. When graduating or leaving Chalmers, the person can withdraw from the system and get the money back by giving back a box. The system does not only work for students, but for everybody with a student union card.

The Waste Station

In order to make analyses of the food waste the recollecting of the boxes and waste station needs to be joined, see figure 3. At the stations the union card will be scanned. Then the leftovers in the lunch box can be emptied and the lunch box handed in. The food waste bin will have a weight scale installed that enables the information of the union card and the amount of food waste to be analysed. More on that in the next section *Data collection*.

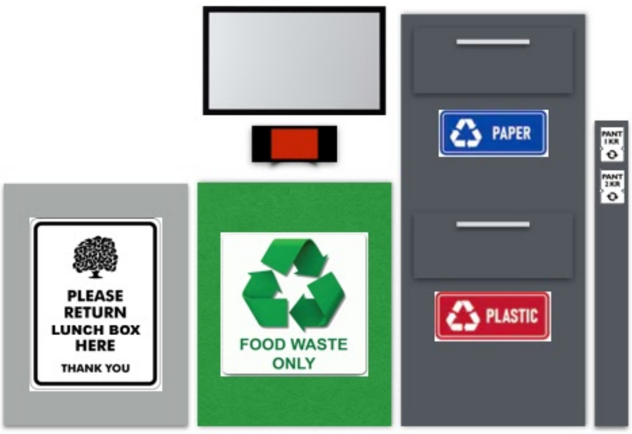

Figure 3: The waste station

Figure 4: Betweenness centrality of nodes on campus

Where the stations should be placed is based on the flow of people to an from the restaurants, and to and from eating places. This flow is both inside and outside buildings. Since we do not have access to that data we cannot replicate that flow in this project. However, it could be based on a betweenness centrality of nodes on the network of paths on campus, as we did in the workshop “Spaces” (see blog, and figure 4).

The Digital Twin

The last part of our solution is the digital twin, it ties everything together and is at the center of our project. As is shown in figure 5, it will collect information about food waste. The data will be analyzed to produce insights and improve upon itself. More specifically, the information will be about the connection between what food is being purchased, by whom and how much is being wasted to create a better understanding on the matter. As said, the digital twin will access the student union card and the information that it acquires, like buying patterns, age and gender. For example, an analysis could be made on how much food waste a person throws over time and on average. The personal insights will provide the user with awareness over its habits, and can be used for *nudging* purposes, e.g. to encourage the user when they are improving and provide information on the impact so far. The system-wide analyses could also be used by the restaurants, e.g. to enable them to portion the food more efficiently, resulting in both individual and systemic insights about food waste.

Because of the novelty of digital twins, and the nature of the campus as an academic area, the digital twin is best developed in collaboration with Chalmers. Akademiska Hus, Chalmersfastigheter, or Chalmers Conference and Restaurants are potential owners of the project. It needs to be further looked into who should have ownership of the digital twin, but since the input data needed is owned by different stakeholders, collaboration will be necessary.

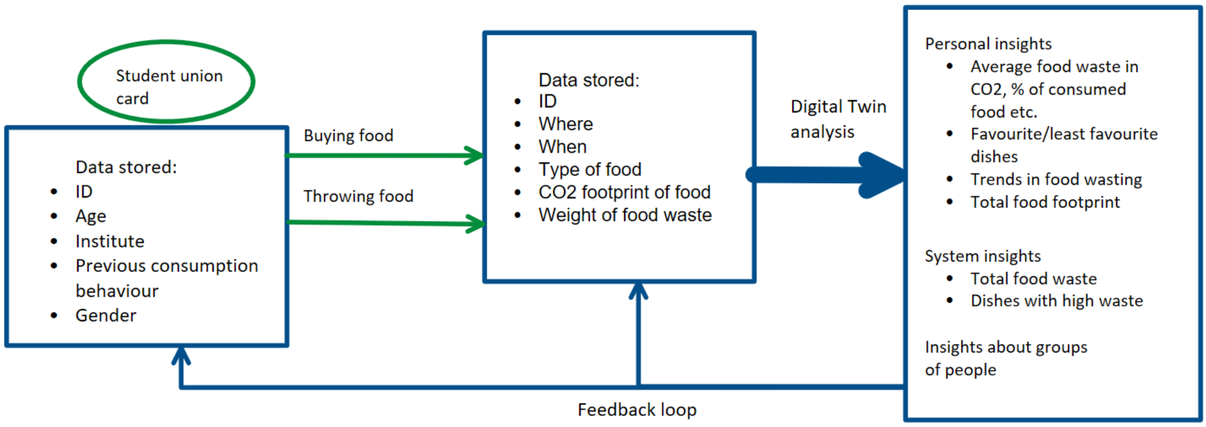

Figure 5: Schematic diagram of the digital twin.

Data Integrity

When it comes to collecting and analyzing data, data integrity and safety is of most importance. Oot of the four integrity approaches stated in Boundaries we chose to use the progressive approach on data integrity, since that allows for the highest impact of our project. That is, as long as we are mindful of data integrity. Since the data is clearly personal, according to GDPR an agreement and consent from the users is needed (Regeringskansliet, 2018). Furthermore, we are only allowed to collect data that can be of use to the project, and it can only be stored for the time it is useful. The project will have to be designed after these principles, which means; When entering the system by buying the reusable lunch box, users can choose between different privacy options and thereby sign a form of consent.

It will be communicated clearly what data is collected and what it will be used for, much like the cookie settings on a web page.

Data Collection and Analysis

In the progressive data collection approach, when buying lunch with the student union card, information is collected and stored into a database, where it can be connected with purchases/waste of previous days, and with personal information. The same happens when the person throws away food and returns the lunch box. They have to blip their card to correctly register their returning of the box, and so even the information about the food waste can be tracked. A more conservative approach would be to store the information without connection to personal ID/information. However, this does not allow to track the behaviour of a specific person through time, but just for an average.

Analysis is done on different levels. Since we get information about what kind of food people bought before throwing the leftovers away, we can make an analysis of how that is interrelated, e.g. what percentage of a specific food is usually thrown away. However, the interesting thing about our digital twin is that it allows us to make analyses on a personal level. We can get trajectories through space and time of the persons' behaviour. With that, individual behaviour can be understood more deeply than by just looking at one point in time. For example, we can see if there are patterns: if the amount of food that is thrown away is correlated with the time of the day, the week, the month, the year; with what kind of food is bought, and so on. We can give the people an individualised analysis of their behaviour.

By comparing the patterns of behaviour of all users, we can further (using Machine Learning for example) extract different ”personas”: user groups that behave in similar ways. We can analyse if those behaviours correlate with personal information, like age, gender, institution. Those personas, or groups of users, can then be specifically targeted. For example, if there is a large group of users that never eats up their meal, the restaurants could think about offering portions of different sizes. Our analysis can help them determine the ideal size of the portion.

Expected areas of usage

To understand the impact and expected areas of usage, we have to again look into the boundaries and where on the food production/waste cycle we are located. Figure 6 shows the expected areas of impact. It is explained in the following paragraphs.

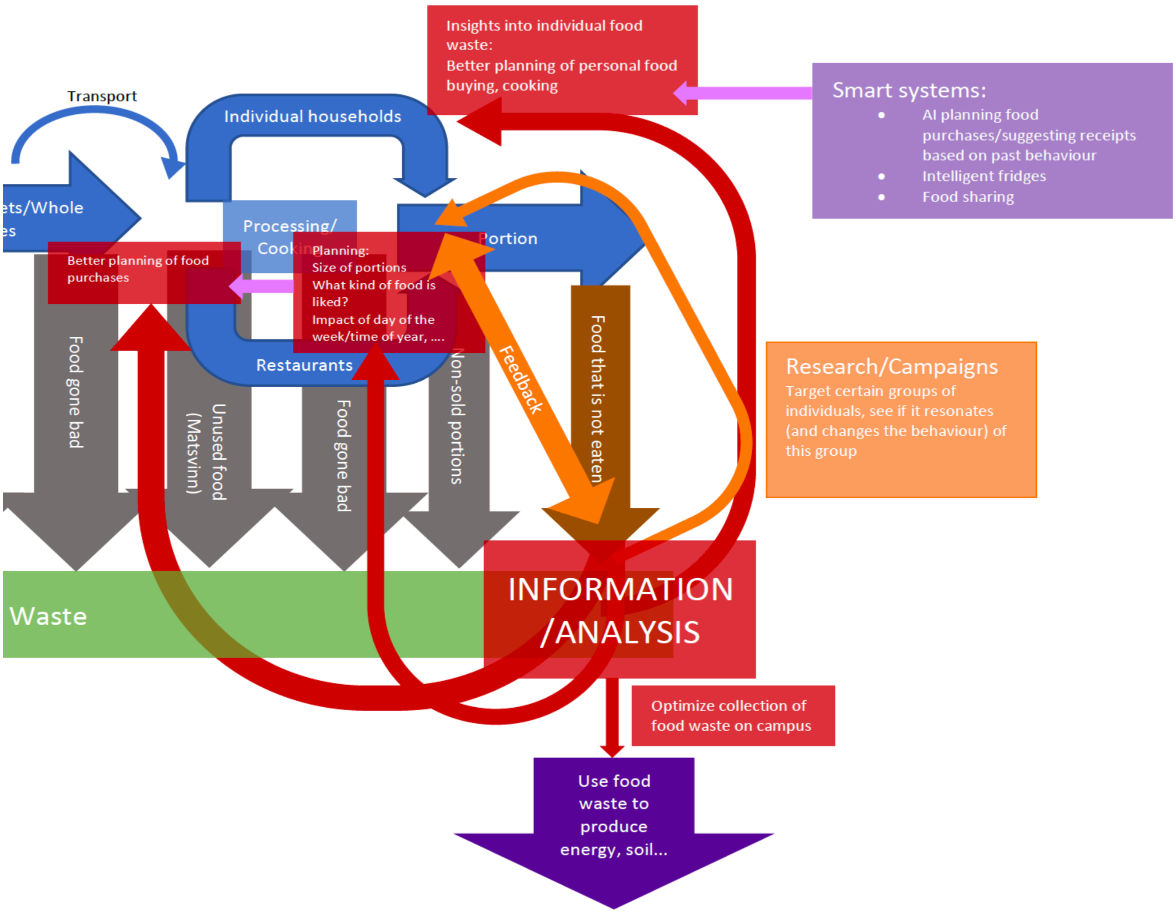

Figure 6: Mapping the impact of food waste

We can distinguish between two levels of stakeholders/impacts. The local level is Campus Johanneberg. On the one hand, this means the physical spaces there, and the restaurants and cafés connected to the student union. However, it also means the social space “Chalmers”, and the information that flows between its parts. The lunchbox and waste station system, since being concentrated on campus, mainly impacts the local stakeholders. However, the digital twin and the analyses coming from it can have an impact outside those boundaries as well.

To comprehend the extent of the expected area of usage we have divided it into two parts; local level and universal level. Where the universal level concerns impact on stakeholders outside the project's boundaries and global within its boundaries.

Local level

On a local level we have distinguished three stakeholders that will be directly in contact with the project. The users (on an individual level), Chalmers Conference & Restaurants and Chalmers fastigheter.

On the individual level the user (people connected to Chalmers, with a student union card) can participate in both the lunchbox system and the digital twin. Buying a reusable lunch box and participating in the "pant" system helps them save resources. They can experience the space on campus differently, by knowing where to recycle food. They can choose to access the data and analysis collected by the digital twin. This gives information about their food waste behaviour i.e. the flow of the food waste, and suggestions on how to improve it. It can also help them plan better, for example how much food to buy and cook at home (maybe in combination with other smart tools), which in the end will lead to less food wasting and a better usage of resources. With a reusable lunch box system, Chalmers Conference & Restaurants do not have to purchase one way plastic boxes anymore. Also they do not need to purchase as many reusable lunch boxes as SMAK did, in comparison to the amount of users, during their trial period since the user does not hold on to their lunch box, instead handing it in after every use. With that said, the reusable ones have to be collected, cleaned and distributed accordingly. The information about the waste can help the restaurants at campus to plan better, both when it comes to e.g meal proportions and optimize purchase procedures which can help reduce the resource consumption. The information about where, when and how much food is thrown away can help to optimize the flow and collection of waste on campus for Chalmers fastigheter. This can lead to a more efficient waste management which impacts the environment on campus, by keeping it clean and preventing unwelcomed smells. The waste stations are nudging users to use the food waste bin instead of throwing plastic boxes and food waste into the residual waste. This increases therefore the ratio of correctly separated food waste, and helps to effectively reuse it as part of Gothenburg City biogas initiative.

Universal level

Restaurants and food providers outside of Chalmers could also make use of the findings. The analysis of the behavior can help them plan strategically as for Chalmers Conference & Restaurants. How to plan strategically for food waste can also apply to housing communities, public buildings and work spaces, especially where there are break and lunch rooms designated for eating. Our digital twin can also be used in combination with smart systems that use information about food and eating behaviour to optimize individuals' and organisations' food consumption. These systems can use the information that we gather, in combination with other data.

Key Challenges and Limitations

Key challenges with this project are data integrity and motivation. However, we see these challenges as intertwined. If the user is sufficiently informed of the personal gains and impact from one's own behavior it will motivate the user to participate, and if the user is informed it will also motivate it to agree to the privacy terms. Good marketing material that effectively communicates its science-based message in a way that it is easily understood will therefore be needed. The possibility that the data can present the user custom and price-adjusted meal portion could be another incetie for the user. For the project to have as big impact as possible it is important with a big user base, since the project relies on data collection, which makes the motivation of the user a central challenge.

Since the project stretches over multidisciplinary areas another key challenge is the fact that there are many stakeholders that need to be involved. To get different stakeholders to agree on direction, cost distribution and responsibility take time and effort. However since these stakeholders are used to cooperating in other research projects we think this challenge can be overcome.

A limitation of the project is the base of users. Since the users will be connected to Chalmers the data will be based on academics and mostly younger adults (the student). This might constrain the applicability of the analysis to other parts of society. The possibilities of the digital twin is only fully utilized when the users have bought the food at campus furthermore the digital twin is designed to solley weigh the food waste. Different foods have different masses and therefore cannot be fully comparable, which limits out data reliance.

Conclusion and Discussion

Our project is situated in the food production and supply sector, which has a huge impact on the environment and, seen on a worldwide scale, is going in the wrong direction. Enough food is produced, but not equally distributed, and a huge part of produced food is thrown away (Holt-Giménez et. al, 2012). In some parts of the world, others do not have enough.

We are focusing on a very local part of this chain. However, our findings could be used across those boundaries, to understand and optimize food production and distribution on different levels.

The information about individuals makes it possible to target certain user groups that share characteristics in their food waste behaviour, and to see if e.g. campaigns have an impact on their behaviour. In other words, the way the data is collected and the analysis is conducted allows us to understand feedback loops. This is a way of using information on a local level to understand systems and the mechanism affecting them on a higher level. But would offering a smaller portion to people that are always throwing away leftovers, prevent them from wasting food? In the same way, those groups who never threw any food away might not change their behavior even if the portion was bigger. From childhood some might have learned to never throw away food, and it is seen as something highly unethical. While others might have learned to always leave food on the plate to show satisfaction and content, to not be perceived as greedy. Values like this can be unconscious, underlying and deeply rooted creating behaviors that are shown to be very hard to change.

The digital twin is today designed to solely weigh the food waste which risks to limit our data reliance. If the lunch box was scanned before emptying as well measuring the weight of the waste this problem could be solved. However this would lead to two problems. The first one would be that it would make the digital twin far more complex regarding joining the data but also more expensive to purchase the waste stations. This could lead to the stakeholders viewing it as too big of an investment and to back out completely or buy fewer stations. Which ultimately would lead to less data and less valuable results. The second problem would be a decreased probability of usage. The less effort for the user, the better. To scan the lunch box would require more effort by the user and the motivation for doing so might fade, especially over time. This would lead the user to return to the old habits of throwing everything in the residual waste which would also mean less to no results.

Our digital twin can be used in combination with other smart systems that use information about food and eating behaviour to optimize individuals' and organisations' consumptions. One interesting possibility is to connect our digital twin with smart fridges. Smart fridges can propose receipts and purchases based on the food that already is in the fridge. They could use data about food waste to know what the person actually likes to eat, and how big the proportions would ideally be to calculate the optimal recipe and portions, so that the wastage is reduced both of the prepared and unprepared food.

We find that our project connects well to the Sustainable Development Goals (United nations, 2015) as well as sustainability goals in the “Campusplan”. Food is essential and exists in both shortage and abundance as a resource. So to create a better understanding of our behavior patterns around it and to minimize unnecessary waste is in direct alignment with goal number 12, “Ensure sustainable consumption and production patterns”. If we understand the patterns and behaviours we can scale up this project and apply it on a societal level. By for example redesign the waste stations in the cities today to enable food waste and even reuse (one man’s waste is another man’s treasure, is particularly true for food). This could then have the possibility to benefit both the environment and the people in as well as create an inclusive community. This correlates to goal 11: “*Make cities and human settlements inclusive, safe, resilient and sustainable”* and goal 9: “*Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”*. Since the project is scalable in different parts of the society, user digital twins in a new way, and can be used in combination with other smart systems we believe that it also correlates with goal 9 on the fact that it fosters innovation.

Ethical aspects regarding data integrity have been part of every step of the project forming the framework, boundaries and end result. The data utilized in the digital twin is of sensitive nature and must be respected. However, we do not see how this would actually hinder this project. Today we are so used to sharing data, clicking in every box of “in agreement with the cookie setting” not bothering changing it to only the necessities. Or the fact that you do not have control, in Sweden, over which web pages post your home address and birthdate in a search engine, you can only request them to kindly take it down, hoping they will do the ethical thing. So in theory ethics and sharing personal data is, and must remain, in focus and be debated. However, in practice, there is rarely an obstacle.

On a personal level, writing blog posts, the report, making presentations and participating in the midterm seminars and the workshops took more time than anticipated, so we had less room to actually develop our idea than anticipated. Nonetheless, the journey is sometimes more important than the destination, and we have gained a lot of skills regarding the novel learning process in the related tracks course.

References

Inobi AB & Probility AB. *Chalmers 2019-2050: Campusplan*. Mars 2019.

Holt-Giménez, Eric & Shattuck, Annie & Altieri, Miguel & Herren, Hans & Gliessman, Steve. (2012). *We Already Grow Enough Food for 10 Billion People … and Still Can't End Hunger.* Journal of Sustainable Agriculture - J SUSTAINABLE AGR. 36. 595-598. 10.1080/10440046.2012.695331.

Regeringskansliet, (2018). Lagförslag som kompletterar EU:s dataskyddsförordning. Retrieved from: https://www.regeringen.se/regeringens-politik/grundlagar-och-integritet/lagforslag-som-kompletterar-eus-dataskyddsforordning/

United nations. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved from https://sdgs.un.org/goals