UWCSEA, East 2023

The Bin Project

Primary Aim : Using AI algorithms to classify and minimise food waste

Written by: Hanming Ye, Aditya Agrawal, Anika Sharma, Antoine Lee

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Section A: About the Project

Summary

We aim to minimise food waste in Singapore's 180 schools and 115 hawkers through data analytics and behavioural economics. Our solution is to:

1. **Track and classify consumer plate waste** by stationing cameras with AI object recognition on bins.
2. Use **data analysis** to find **underlying causes** behind **behavioural patterns** and **wastage trends.**
3. Work with kitchens to **implement changes** that address these underlying causes. Drawing from behavioural economics, we create nudges that change consumer choices.
4. Publish findings to consumers via reports and interactive platforms.

By reducing costs for food vendors and educating consumers about their underlying habits, we **tie key stakeholders together**, and work together to solve the multifaceted issue of food waste. And by designing our system to be replicable, we seek to create a **network** of bin systems across cafeterias islandwide. This way, we can tackle food waste one bin at a time.

About the Issue

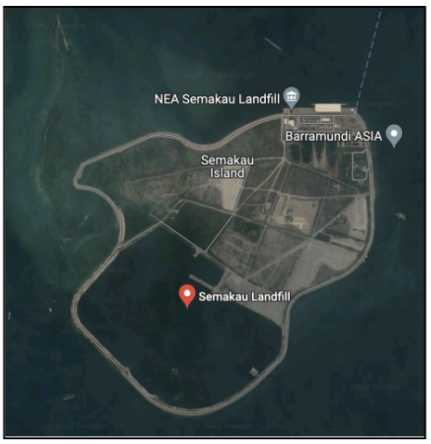
In 2021, Singapore generated 817 million kilograms of food waste - a figure that is increasing each year. This creates consequential impacts for our community.

Ecological harm:

Eighty-five percent of food waste [NEA, 2016] is sent to one of Singapore's 4 **incineration plants**. There, air pollutants along with toxic residue are released [NEA, 2020]. These chemicals, such as PFAS and dioxins, cause cancer and other health problems [Rosenberg et al. 2019].

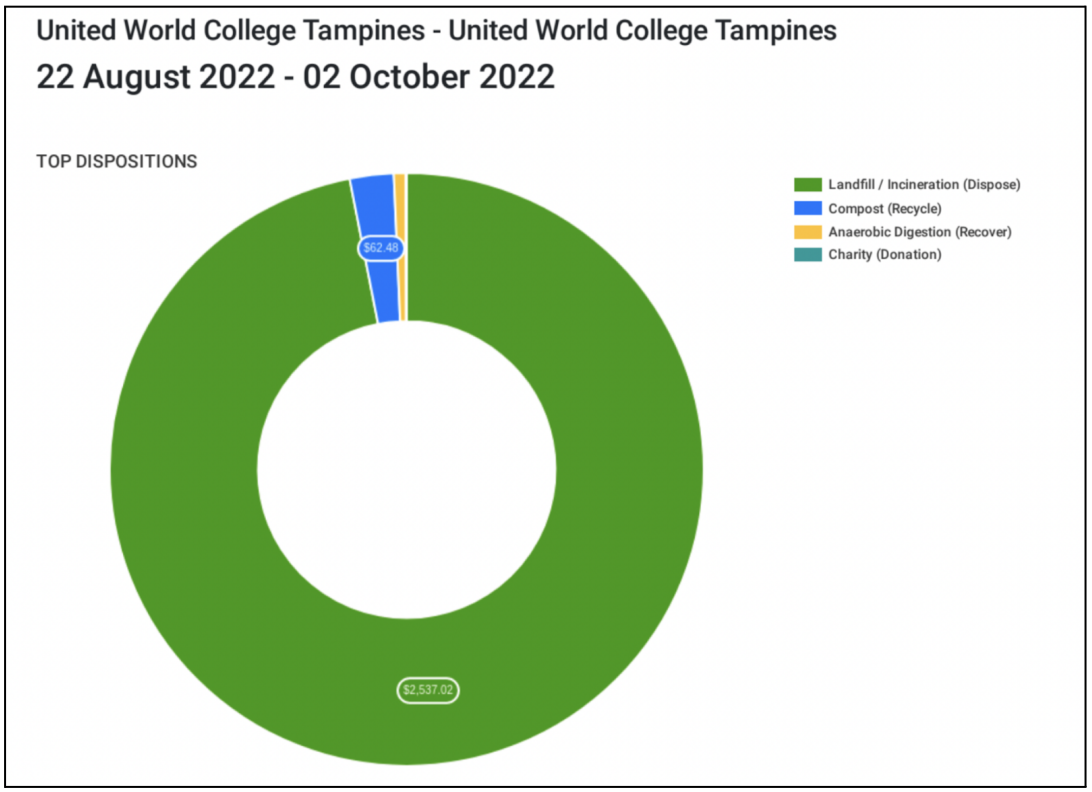
Senoko Incineration Plant, 11 miles north of our school.[Anon, 2022]

Other food waste is transported to Semakau Landfill. There, the waste releases methane into the air and leaches chemicals into the surrounding area. These rapidly filling pits are expected to be full by 2035.



There are composting facilities in SG. But a very insignificant portion of waste is processed there due to *cost, accessibility,* and *contamination*. In UWCSEA, even with our own composting centre, a microscopic amount of waste is disposed of sustainably.

Sodexo data:



Economic & social harm:

Over 90% of food in SG is imported [CNBC, 2022], making food a scarce resource. Devastating floods in Pakistan, global supply chain struggles, and Malaysia's increasingly protectionist food export policies have exacerbated this scarcity. Thus, food waste caused by excessive purchasing **worsens the existing strain on food security**.

Therefore, food waste is an insidious humanitarian crisis, **amplified locally by Singapore's unique geographic and economic characteristics.** We plan to address this growing issue by constructing a social initiative that works with **both consumers and producers** to reduce waste, powered by **innovation and data**.

Impact and Measurement:

Food waste can be classified into **three different types**:

1) **Preparation waste**
    a) Also known as "unavoidable waste", such as fruit peels and bones.
2) **Catering waste**

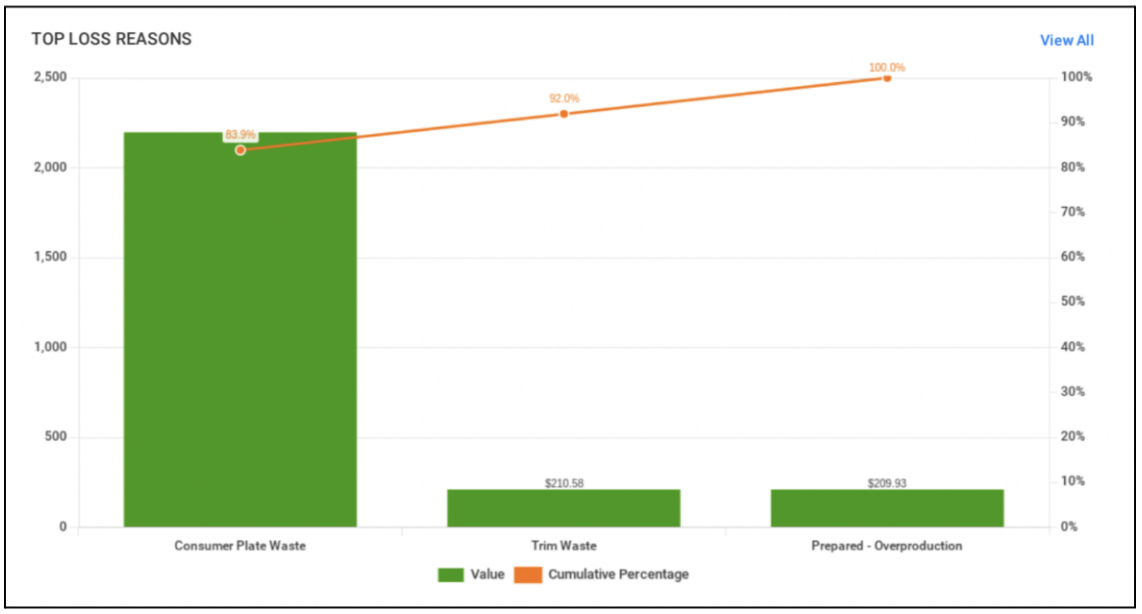
a) Overprovision by the producer/retailer.

3) Plate waste

a) The uneaten food consumers scrape into bins. This comprises the largest portion of food waste.

In our school:

This is the bar graph showing food waste recorded in UWCSEA East's canteen in October (provided by the Sodexo - the food catering provider in school):



This demonstrates that **plate waste** is by far the **predominant cause of food waste**. There are two main reasons for this disparity:

1) The catering provider (Sodexo) has expertise in accurately estimating the quantity of food that will be consumed daily, especially as the kitchen employs a scale that records catering waste.

2) There exists no viable method to measure and analyse consumer plate waste.

In SG:

We expect this distribution of food waste to be true in general, and government figures support this conclusion [EEA., 2010]. But why are consumers wasting so much food in Singapore? Our chain of analysis leads to several key factors:

- **Phenomenon**
  - Plate waste is the largest cause of food waste
- **Patterns/trends**
  - The 2019 NEA survey found that 40% of respondents over-catered for gatherings.
  - Over 50% of food waste originates from public dining locations.
- **Mental models**
  - **Cultural**
    - In Singapore (and other Asian cultures), there is a prevalent mindset that "excess food should be prepared to prevent the embarrassment of guests and family members going hungry" [Ramakrishna, 2021].
  - **Geographic**
    - The majority of waste processing facilities are hidden from consumers (eg. on Semakau island or at Tuas). This means that there is a **disconnect between consumers and their food waste**, and hence a lack of awareness.
  - **Technological**

- There is a lack of adequate data to inform action on food waste, because waste is hard to measure beyond weight with current tools.
    - Food waste statistics from Singapore have been classified as having "very low confidence" by the UN Environment Programme.

Other projects addressing this concern:

- The National Environment Agency (NEA), has set up numerous resources (such as funds for innovative sustainability projects) to help suppliers adopt sustainable production models. [NEA, 2017]
- Local organisations such as Uglyfood and the FoodBank reduce catering waste through reallocation.
- UWCSEA East's 0 Waste Service (0Wes) spreads awareness to students around the 3Rs: reduce, reuse, recycle.

How our project is different:

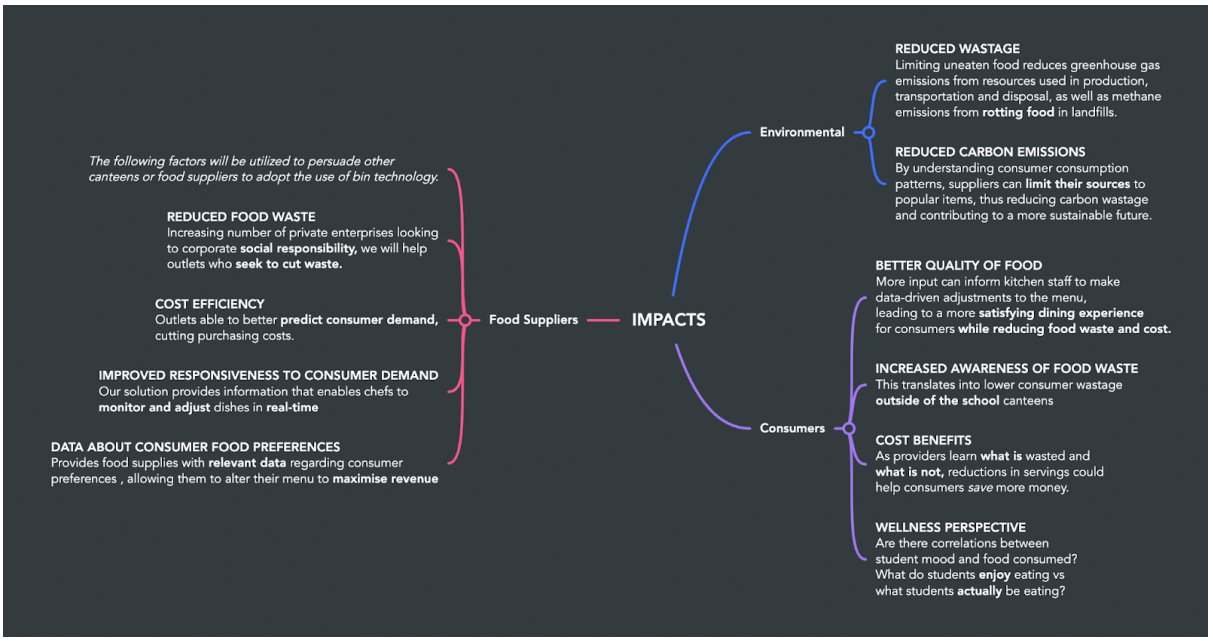
1. **AI & Data:** The vast amounts of data we collect & analyse enable us to be **precise** when making decisions, **quantitative** when measuring impact, and **clear** when communicating our results.
2. Rather than just a campaign, our solution is a **tool** that empowers kitchens and consumers to be sustainable, rather than urging them to be.
3. The system taps into the **private incentives** of food suppliers of cutting costs and catering to consumer preferences, helping them achieve **both** sustainability and profitability.
4. Our system is **replicable**: like a franchise, we aim to create a **network** of bin systems by engaging students in other schools (see timeline).

How we will join forces with other projects:

- We will collaborate with environmental awareness groups in each school with the Bin system to **share our data** and promote a **considerate culture around consumption** (see "FWAW" in timeline). For example, the 0Wes team at UWCSEA.
- We plan to work with the **NEA** to develop a certification that recognizes food outlets with exceptional food waste reduction efforts, with the undertaking of our solution as one way to

achieve this certification.

Who the project will impact:



Challenges	How they were addressed
We were unsure how receptive food suppliers would be to our system and our data.	We interviewed the director of Sodexo at UWCSEA East Mr Arun, and identified concrete ways that data would help solve shortfalls of the existing system. By learning from him, we decided to create weekly reports (see timeline) that will communicate our findings in a way empathetic to suppliers' perspectives.
In developing our prototype, we could face difficulties, particularly around ensuring the accuracy of our camera.	By collaborating with alumni and industry professionals (eg. from A*star), we have been improving the performance of our image recognition algorithm. We also plan on adapting open-source research to match our needs.

Role of Alumni advisors:

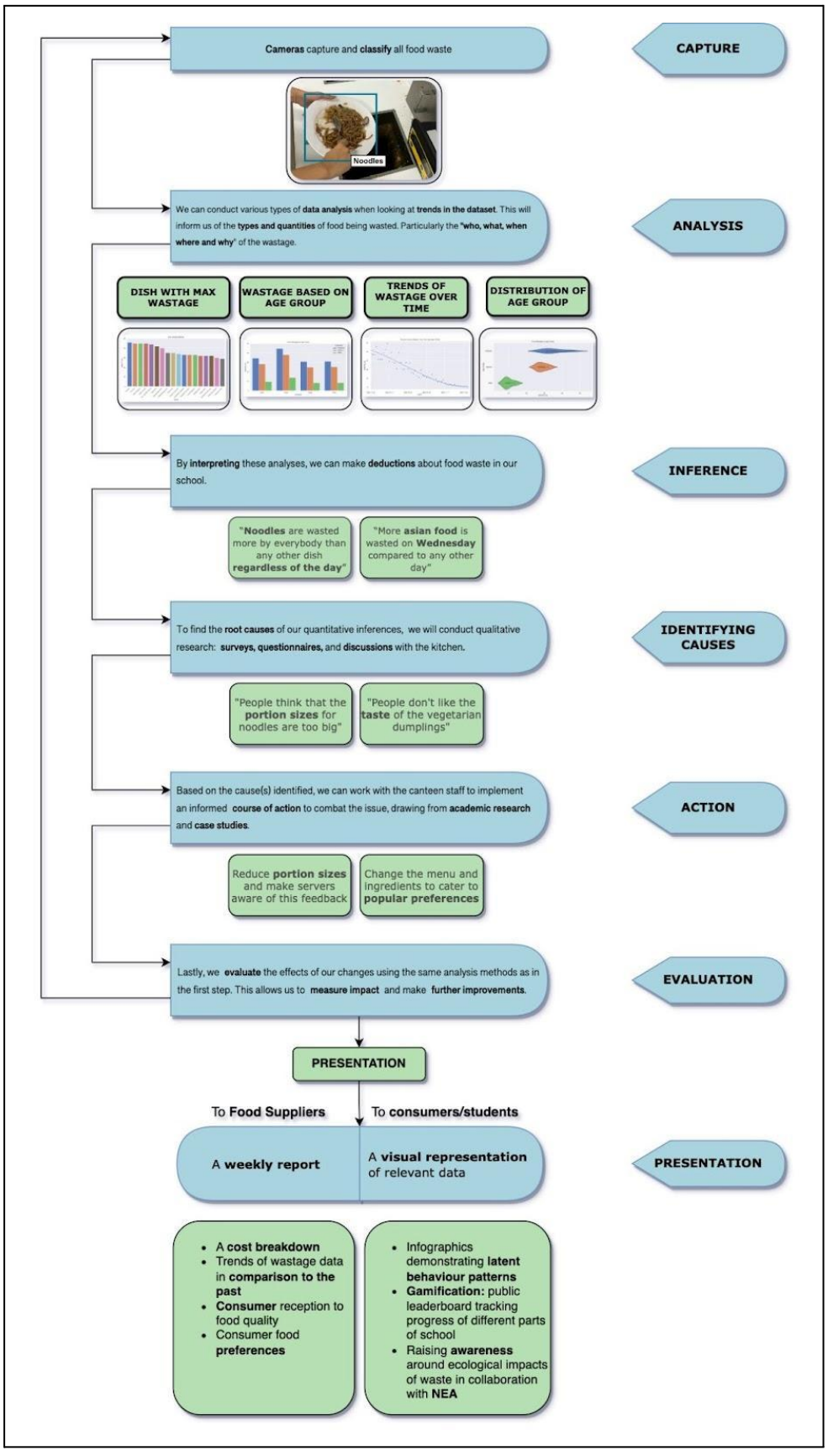
Our current alumni are studying in fields closely related with our proposed project, such as engineering at UCB. They will lend expertise on incorporating technology into our project and connect us with industry professionals.

Success indicators for 1 year:

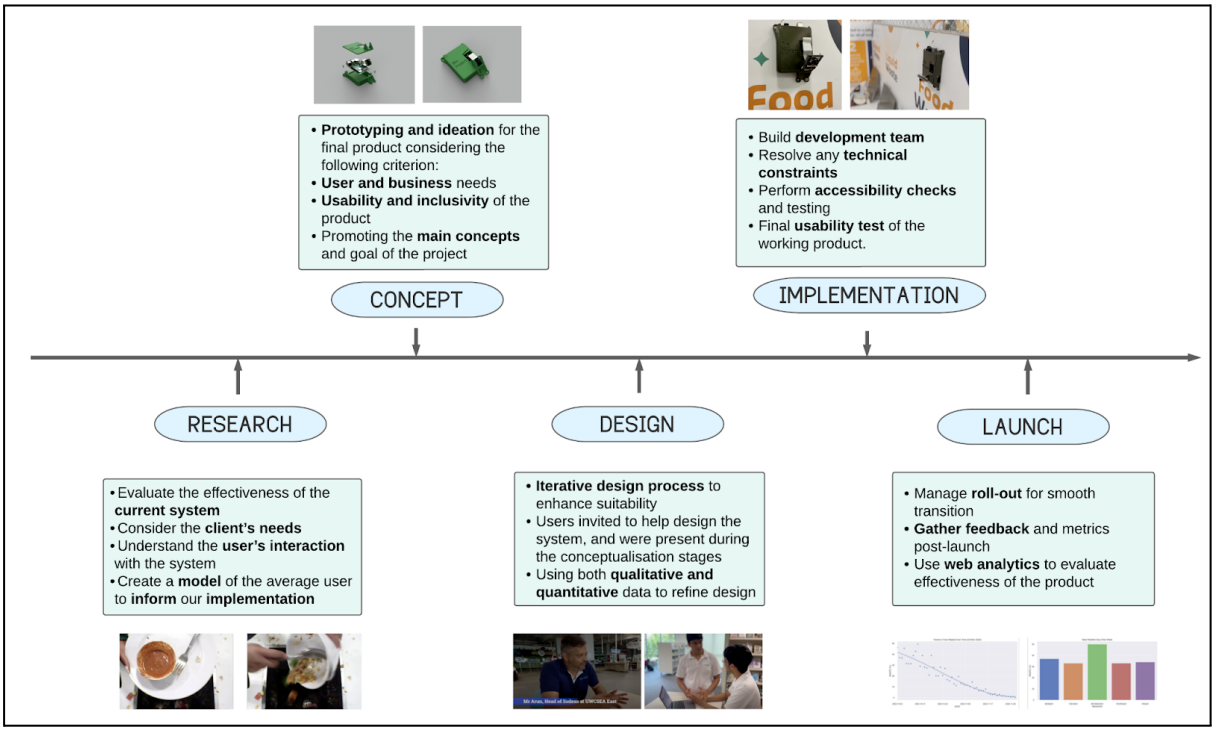
- The project is implemented in all Sodexo school canteens in Singapore, with student Bin groups established in each.
- Over 1 million plates of food waste are captured, classified, and stored in an online database.
- The report shows a decrease of at least 30% in consumer plate waste compared to the previous year.

Section B: Project Plan

Core *Bin System* flowchart:



Proposed Timeline

3 Months	We have created and installed a minimum viable prototype:  Although it automatically captures food waste, it's not yet able to classify the waste accurately independently. Thus, in the next three months, we will collect thousands of photos from this bin to **train our algorithm** to classify the types and volumes of wasted food, as well as upgrade it (see budget). At the core of all this, we are following a user-oriented design process [Weaver, 2022] 

In 3 months, we expect to have to created a **complete system** that is able to categorise and analyse food waste data.

To formally initiate our system, we plan to run a week-long campus campaign—**Food Waste Action Week (FWAW)**—aiming to establish the Bin System for all stakeholders. During this full-operation period, we plan to

- **Educate** consumers, and **change underlying habits** even when they are away from the Bin System.
    - Publish our **findings** to consumers through interactive infographics to make them aware of their **latent behaviours and food preferences.**
    - Use gamification and leaderboards (eg. primary school vs high school) to involve the community in a collective waste reduction effort, which has been shown to be an effective means of behaviour-nudging [Hu, 2023]
    - Spread awareness around the impacts of food waste through major media platforms in collaboration with **student service groups** (see partners, section A)
- **Establish feedback routine** with suppliers:
    - Working with Sodexo to interpret and reflect upon the **first batch of data** produced (see previous "core flowchart"). From this, we will produce the first **weekly report**: a summary of data, customer reception, and suggestions **catered to the canteen's private incentives** (eg. reducing costs).
    - Implement the first data-driven changes (eg. switch to smaller plates for the noodles section).

Creating the fully functioning system is the crux of the next 3 months. To do this, the **resources** we need include:

- **Hardware**
    - Camera (with better quality and frame rate than current to capture food waste) - **$35**
    - Other electronics (eg. printed circuit board, HDD) - **$90**
    - Casing & other hardware (3D printed, made of bioplastic) - **$10**
    -
- **Software**
    - Matlab (computing platform used to analyse data using algorithms and models) **- $940** annually

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AWS (a developer's software to run applications and perform unsupervised learning) - about $360 annually
Server space - approx. $80 annually

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<tr><td rowspan="2">6 Months</td><td>
After implementing the system in our own campus, we will expand and introduce the system to more canteens in Singapore.

To upscale sustainably, we have the following procedure:

1. Spend 1-2 months ensuring smooth operation at UWCSEA East through iterative improvements based upon feedback.
2. Create a Bin handbook that details our implementation and operation process, including our challenges and reflections.
3. Collaborate with 2 other schools with Sodexo canteens (eg. UWC Dover), ensuring the replicability of our system. At each school, we will engage a group of students passionate about reducing food waste, and work with them to implement Bin by communicating our learnings through the handbook, and understanding the particulars of their canteen that the Bin system should adapt to.
a. To get other cafeterias on board, we will work with these groups of students to present the arguments in the "Who the Project will Impact" section to vendors.
4. The new student group will install the system and go through the same pilot periods we went through, with much more established technology.
5. As "graduated teams", the student group will organise a FWAW for their own school. Now, they will be in charge of operating and maintaining the Bin system at their school, while maintaining regular contact with other Bin groups.
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Now, to support the expansion of Bin groups, our budget will include the resources needed for two more Bin system kits, which previously totalled up to around $100 of hardware, and $950 of software. However, due to the developmental components being complete and the centralisation of many aspects of the system, the software required can contain less features, and costs will reduce to around $120 yearly.

Because the process of communicating with and upskilling other student groups is quite labour-intensive, we plan to train "outreach teams" composed of students from our school who will serve as links between the core team and the other Bin group.
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<tr><td>12 Months</td><td>
In one year we hope to achieve two main goals:

1. Implementing the system around SEA in 20 - 30 like-minded schools(eg. FOBISIA,IASAS).
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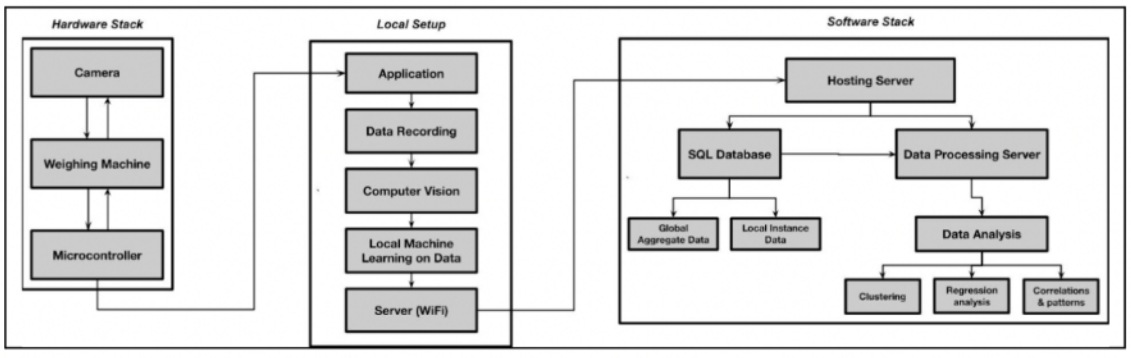
	2. Partnering with NEA to change food waste handling and explore opportunities for implementation in hawkers. We will continue our previously established routine of realising Bin in like-minded schools, including in canteens not operated by Sodexo. To achieve this, we will need to make our system more adaptable—into a **turnkey project**. For instance, we plan to make the system require lower maintenance and more automatic by creating an interface from which data and analyses are shared in real time. Later on, this will also allow cafeterias where it is not possible to organise a specific "Bin Team" to be involved in the network of Bin Systems. After the first year, we will host a **conference** for all bin groups, to discuss our collective vision for the future of Bin.
	Resources required: As the amount of data we collect starts to provide insight into collective food waste in Singapore, we plan to publicise the information we obtain at hawkers with the Bin system, with the ultimate goal of creating a **National FWAW.** This entails advertisements and extensive media campaigns that necessitate funds.

About the System



Under the hood, data collection will be performed by an array of **small internet-enabled computers** that will use **cameras and sensors** to measure the food waste. Then, these individual modules will send the information to a local device (a computer or phone) which will amalgamate the incoming data into a database.

In the chart below, we list some data analysis methods that have proven to be viable, with support from alumni and Dr Zhang, from the department of biostatistics, Indiana University.

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