Food Sustainability at The National University of Singapore

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Abstract

The National University of Singapore (NUS) is committed to promoting sustainability on its campus as food insecurity is on the rise in Singapore. Our sponsor, Professor Veera Sekaran from the Regenerative Agritech Centre, tasked us with decreasing the food consumption carbon footprint by reducing food waste at the source to address food sustainability on campus. Through data collection and analysis, we identified findings that posed barriers and benefits to our goal. To address this concern, we developed and proposed behavior interventions to combat food waste on campus. Our recommendations include rice bowl portion displays, eco-friendly labels on menus, food samples of eco-friendly foods, and launching an educational poster campaign to bolster our recommended behavior interventions. These recommendations will serve NUS to reduce food waste and the carbon footprint, ultimately contributing to an overall improved campus food sustainability.

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Authorship Table

Section	Primary Author(s)	Primary Editor(s)
Title Page	Ian Sullivan	David Pham
Abstract	All Authors	All Authors
Acknowledgments	David Pham, Ian Sullivan	Katlyne Mio
Executive Summary	All Authors	All Authors
1. Introduction	Katlyne Mio, Marshall Wo	David Pham
2.1 Sustainability	Marshall Wo	Ian Sullivan
2.2 Food Sustainability	Marshall Wo	David Pham
2.3 Food Sustainability in Singapore	Ian Sullivan	Marshall Wo
2.4 A Less Traditional Approach to Food Sustainability	David Pham	Ian Sullivan
2.5 Impact of Cultural Diversity on Consumption Habits	David Pham	Katlyne Mio
2.5.1 Religious Considerations	David Pham	Katlyne Mio
2.5.2 Cultural Influence of Rice	Katlyne Mio, Ian Sullivan	Marshall Wo
2.6 Healthy Consumption Habits	David Pham, Marshall Wo	Ian Sullivan
2.6.1 Singaporean Health Initiatives	David Pham, Ian Sullivan, Marshall Wo	All Authors
2.7 Food Waste on NUS Campus	David Pham	Katlyne Mio
2.7.1 Carbon Footprint of NUS	Ian Sullivan	David Pham
2.8 Sustainable Behavior Change	Katlyne Mio	Ian Sullivan
2.8.1 Make Sustainable Behavior the Social Default	Katlyne Mio	Marshall Wo
2.8.2 Emphasizing Personal Relevance	Katlyne Mio	David Pham
2.8.3 Make Hidden Information Visible	Katlyne Mio	Ian Sullivan
2.8.4 Fostering Mindfulness	Katlyne Mio	Marshall Wo
2.8.5 Create Opportunities for Competence, Skills, and Knowledge	Katlyne Mio	David Pham
2.8.6 Make Change a Byproduct of Other Events & Balance Urgency with Realistic Hope	Katlyne Mio	Ian Sullivan
2.9 Fostering Sustainable Food Consumption Behavior Change	Katlyne Mio	Marshall Wo

2.9.1 Food Samples	**Katlyne Mio**	**David Pham**
2.9.2 Eco-labels	**Katlyne Mio, Marshall Wo**	**David Pham**
2.8.3 Community Gardens	**Katlyne Mio**	**Marshall Wo**
2.9.4 Educational Posters	**Marshall Wo**	**David Pham**
3.1 Establish Baseline Consumption Habits on the NUS Campus	**Marshall Wo**	**Katlyne Mio**
3.1.1 Existing Quantitative Data from NUS	**Katlyne Mio, Marshall Wo**	**Ian Sullivan, David Pham**
3.1.2 Observations	**Ian Sullivan, Marshall Wo**	**Katlyne Mio, David Pham**
3.1.3 Survey	**All Authors**	**All Authors**
3.1.4 Interviews	**David Pham, Ian Sullivan**	**Marshall Wo**
3.1.5 Focus Groups	**Marshall Wo**	**David Pham**
3.2 Ethical Considerations and the Institutional Review Board	**David Pham**	**Ian Sullivan**
3.2.1 Risks to Study Participants	**David Pham**	**Marshall Wo**
3.2.2 Benefits to Study Participants	**David Pham**	**Katlyne Mio**
3.2.3 Record Keeping	**David Pham**	**Ian Sullivan**
4. Findings and Analysis	**Marshall Wo**	**David Pham, Ian Sullivan**
4.1 Community-Based Social Marketing Method (CBSM)	**Katlyne Mio**	**David Pham**
4.2 Challenges and Opportunities	**Katlyne Mio**	**Ian Sullivan**
4.2.1 Portion Sizing Contributes to Food Waste	**Ian Sullivan**	**Katlyne Mio**
4.2.2 Major Contributors to Food Wasted: Carbohydrates and Vegetables	**Marshall Wo**	**David Pham**
4.3 Food Choice Influencers	**Ian Sullivan**	**David Pham, Marshall Wo**
4.3.1 Price	**Katlyne Mio**	**Ian Sullivan**
4.3.2 Convenience	**Katlyne Mio, David Pham**	**David Pham**
4.3.3 Taste	**David Pham**	**Katlyne Mio**
4.4 Assessing Existing Sustainability Initiatives at NUS	**Marshall Wo**	**Ian Sullivan**
4.4.1 Posters	**Marshall Wo**	**David Pham**
4.4.2 Rice	**Katlyne Mio**	**Marshall Wo**
4.4.3 Community Gardens	**Katlyne Mio**	**Marshall Wo**
4.4.4 Bin Design: Recycle Right	**Katlyne Mio**	**Ian Sullivan**

5. Recommendations for Sustainable Behavior Change	**Katlyne Mio**	**Marshall Wo**
5.1 Considering Tools from Psychology	**Katlyne Mio**	**Marshall Wo**
5.2 Rice Bowl Portion Displays	**Katlyne Mio**	**David Pham**
5.3 Eco-labels in Stall Menus	**Marshall Wo**	**David Pham**
5.4 Food Samples at Canteens and Food Courts	**David Pham**	**Katlyne Mio**
5.5 Educational Poster Campaign at Canteens and Food Courts	**Marshall Wo**	**Ian Sullivan**
6. Conclusion	**David Pham, Ian Sullivan**	**Katlyne Mio, Marshall Wo**
6.1 Future Work	**David Pham, Marshall Wo**	**Katlyne Mio, Ian Sullivan**
Appendices	**All Authors**	**All Authors**

Table of Contents

Table of Figures

Executive Summary

Growing Global Risks of Food Security

In 2019, Singapore was ranked as one of the most food secure nations in the world. However, growing trends across the world are beginning to threaten every nation's food security. With the expanding global population, demand for food is expected to increase 50% by 2050 (SFA, 2024). Countries are increasingly looking inward, prioritizing their own needs over international trade. Singapore heavily relies on imported food as the country imports over 90% of the nation's food. As countries prioritize their own needs, this puts Singapore's food security at risk and in 2022, Singapore's ranking dropped to 28th for food security (Economist Impact, 2023). Singapore's heavy reliance on imported foods has prompted the government to initiate a 30 by 30 goal for the country to produce 30% of its food by 2030 (SG Green Plan, 2022).

NUS Food Waste Increase

The Regenerative Agritech Centre (RAC) at The National University of Singapore (NUS) is tackling food sustainability for the nation and the campus by developing technological solutions for sustainable agricultural practices. RAC Director Professor Veera Sekaran, recognizing the complexity of sustainability, desires to explore how to increase food sustainability through technological solutions and behavioral practices. Professor Veera Sekaran serves as the sponsor of this project and has charged this team with proposing interventions to foster sustainable food consumption behaviors at NUS by reducing waste at the source. Highlighting the issue, from fiscal year (FY) 2019 to FY 2022, there was a food waste increase at NUS of approximately 158 tonnes resulting in 367 tonnes of food waste in FY 2022. As food

waste increases, the demand for food production and the number of waste disposal facilities grows, affecting food security (Ministry of Sustainability and the Environment, 2024). Thus, reducing food waste at the source decreases the demand on the food supply, helping NUS improve food sustainability.

Project Goal

Our project's goal was to decrease the consumption carbon footprint on campus by reducing food waste at the source. To achieve our goal, our first objective was to establish a baseline of consumption habits on campus which we achieved through observations, surveys, interviews, and focus groups. Observations consisted of categorizing dishes returned at dining locations on campus to determine what foods were contributing to food waste the most. Additionally, we collected 597 survey responses, this sample size provides a 95% confidence level with a 4% error of tolerance. Finally, we conducted eight interviews and three focus groups to help supplement the data collected from observations and surveys. Our second objective was to analyze this data to identify challenges and advantages in achieving our goal. Our final objective was to use this data to develop proposal behavior interventions for NUS to reduce food waste at the source, and as a result decrease the food consumption carbon footprint on campus.

Best Practices for Sustainable Behavior Change

To achieve our objectives, we first conducted research on sustainable behavior change best practices. We came across many trends across various methods for behavior change and noted the Community-Based Social Marketing (CBSM) method in Doug Makenzie Mohr's *Fostering Sustainable Behavior Change*, encompassed the structure of most successful behavior

change methods. The CBSM method has had thousands of successful case studies worldwide and served as the structure of our project. CBSM consists of 5 steps, define target behavior and audience, identify barriers and benefits, develop strategies, implement strategies, evaluate and assess. We aimed to target sustainable food consumption behavior of our NUS stakeholders. Our first objective was to establish a baseline of consumption behavior on campus through data collection and analysis to then identify challenges and advantages our behavior change interventions will face. To develop strategies, or what we refer to as behavior interventions, we considered our main findings in conjunction with tools from psychology in a sustained effort to reduce food waste.

Research of Successful Food Sustainability Behavior Change Strategies

Food samples can be effective in sustainable behavior change by allowing people to try new foods. Studies have shown that food samples effectively reduce food waste of consumers. Food vendors can also use food close to expiration as sampling options before it spoils, reducing unsold food waste (HelloFresh Group, 2023). Food samples also prove to be successful in reducing waste when implemented on university campuses (Gunders, 2021).

The production and transportation of different foods emit different levels of greenhouse gas (GHG) emissions. To help make this information transparent, eco-labels display how environmentally friendly food dishes are. The University of Massachusetts Amherst, a school that the Princeton Review has recognized for the past seven years as having the best food system of a university or college in the United States (Blaguszewski, 2023), was the first school to implement them on campus in 2022. They ranked eco-labels on an A-E scale with A being the

most environmentally friendly (UMass Dining, 2022). These eco-labels are part of a larger dining initiative on campus to improve sustainability.

Educational posters have been proven to be an effective method in transferring knowledge. One study at The University of Ostrava tested the educational effect of posters for students aged 10 to 15 years old. They sampled about 1,000 students from ten elementary schools in the Czech Republic and placed various posters in common places at school. These results showed a significant increase in the level of knowledge after the yearlong application of the posters, particularly the ones that had the least amount of text (Dostal et al, 2021). Posters, when done right, are an effective educational tool.

Results

Our survey data showed that 67% of respondents are interested in learning more about food sustainability. This is indicative that transparency about campus food sustainability and educational campaigns would be received well. Throughout our research, we established challenges and advantages the NUS community faces when trying to reduce food waste. 52% of survey respondents reported that portion sizing was a major challenge they faced when trying to reduce food waste on campus. NUS FY food waste data was useful in determining annual amounts of food waste but had limitations in that it did not specify what foods contributed most to the waste. After conducting our tray return observations, we determined that on average 42% of plates were returned with food waste, the majority of which consisted of carbohydrates, specifically rice, followed by vegetables. This was corroborated by survey comments, with one respondent stating, “If it is too much food, I focus on eating the greens and protein, and if I cannot finish, [I] just leave the rice.” We also found through interviews that rice is valued less,

and students were less likely to reduce portion sizing because there was no price reduction that followed. From survey data, supported by interview and focus group responses, we found that price, convenience, and taste are the leading influences of food choices on campus in that order. Throughout NUS there are various existing sustainability initiatives. We interviewed students about awareness of these initiatives to assess if they were having an impact on the community. We found that many students were unaware of poster campaigns encouraging healthier consumption habits that had only been present at UTown. We also found the existing rice level choice initiative is not working effectively and community gardens on campus are not receiving sufficient student care due to lack of student time and interest. However, a student initiative for recycling bin design has proven to be effective. Upon further investigation, the bin design initiative has attributed its efficacy to its 3-D visual display, whereas the rice level choice initiative relied primarily on 2-D visuals.

Recommendations

Based on our findings, we recommend NUS implement rice bowl portion displays at stalls that primarily serve rice on campus. Currently, there is an initiative at the mixed rice food stalls on campus where students can ask for less rice verbally. However, dining locations on campus are loud making communication difficult and vendors are often in a rush. We recommend having rice bowl sizes set at small (100 g), regular (200 g), and large (300 g) where students can point to indicating how much rice they want, effectively eliminating the communication barrier.

Another recommendation we suggest NUS implements is the use of eco-labels on the menus at food stalls on campus. These eco-labels would rate each dish on an A-D scale with A

being the most environmentally friendly. We recommend stalls only implement A-B eco-labels as they may be resistant in putting C-D eco-labels on their menus as they can drive customers away. Eco-labels help students make more educated decisions when choosing food as most survey responses claimed they want to learn how to make more sustainable food choices.

Our next recommendation would be the implementation of food samples at dining locations on campus that connect to our previous initiative of eco-labels. From survey data and interview responses we found taste is highly valued when making food choices. We asked survey respondents on a Likert scale if food samples would help them try new foods without the risk of wasting food in case the taste does not meet expectations. The resulting mean of this Likert scale question was four out of five, the agree option, indicating a demand for food samples from the NUS community. We suggest that stalls on campus begin providing food samples for eco-labeled dishes to encourage students to try environmentally friendly food without the risk of wasting food.

Our final recommendation is for NUS to launch an educational poster campaign to bring awareness to each of our other interventions. The posters should provide information about food waste and GHG emissions and encourage students to take advantage of our other interventions. These should be located at all dining locations to ensure a wide audience is reached. Future groups carrying on this research would focus on implementing these solutions on campus with the hope to reduce food waste and improve food sustainability on campus.

Conclusion

Our interventions are designed to address this projects' goal: reduce the carbon footprint of NUS through the reduction of food waste at the consumption level. During our project we laid the foundation for sustainable behavior change interventions. Effective sustainable behavior change takes time to achieve and be adopted by communities. Since our project had a time constraint of seven weeks, we did not complete implementing evaluating and testing of our proposed interventions. We started the prototype design for our interventions so future researchers could follow by continuously designing, testing, and researching each intervention for the highest chance of success.

1. Introduction

Currently Singapore grows approximately 10% of its food locally and imports 90% (Singapore Food Agency, 2022). With Singapore's Green Plan 2030, or simply Green Plan, the government aims to drive the nation's sustainable development agenda. Singapore's 30 by 30 is a Green Plan initiative that bolsters the capability and capacity of the agri-food industry to produce locally and sustainably 30% of the country's nutritional needs by 2030 (SG Green Plan, 2022). Achieving this target requires ramping up local food production, improving consumer food consumption habits, and reducing food waste.

The National University of Singapore (NUS), a globally renowned institution, has committed to advancing sustainability. NUS has set a goal to reduce its total waste on campus by 30% compared to its Fiscal Year (FY) 2021 baseline by 2030 (NUS, 2022). However, from FY 2019 to FY 2022, NUS has increased its food waste from 209 tonnes annually to 367 tonnes per year (NUS, 2022). We concluded that FY 2019 be the baseline for NUS food waste, as 2019 was prior to the global pandemic, Covid 19.

The Regenerative Agritech Centre (RAC) at NUS is tackling food sustainability for the nation and the campus by developing innovative technological solutions for sustainable agricultural practices. In partnership with NUS College of Engineering's Design and Innovation Centre, the RAC works on optimizing harvesting environments using high-tech equipment to produce analytics that suggest new innovative urban farming strategies. The RAC also wants to tackle sustainability in the food sector more generally by investigating ways to mitigate food waste and reduce the carbon footprint associated with food consumption.

RAC Director Professor Veera Sekaran, recognizing the complexity of sustainability, desires to explore how to increase sustainability through technological solutions and behavioral practices. He serves as the sponsor of this project and has charged this team with proposing interventions to foster sustainable food consumption behaviors at NUS to tackle reducing waste at the source---in other words, before it happens---and thus generate less waste. This approach tackles sustainability at the front end of food consumption by encouraging NUS students and faculty to develop habits that prevent waste and become more conscious of sustainability. The sponsor recognizes that more sustainable food consumption behaviors offer another approach to Singapore's Green Plan goals and NUS's sustainability targets.

The primary goal for this project was to reduce the consumption carbon footprint on campus by reducing food waste at the source. To achieve this goal, our first objective was to determine a baseline for behavioral consumption habits on the NUS campus through qualitative data via observations, surveys, interviews, and focus groups. Our next objective was to then analyze this data to establish benefits and barriers that will help us in achieving our goal. Finally, our last objective was to use our findings to create proposal interventions for NUS to reduce food waste at the source, decreasing the consumption carbon footprint. Our interventions include customizable rice bowl sizes, eco-labels, food samples for eco-friendly dishes, and an educational poster campaign to launch all our interventions off. The efficacy of these interventions can be tested by repeating data collection methods that we used to measure the baseline after implementation.

2. Background Literature

2.1 Sustainability

Sustainability, or sustainable development, has received much attention in recent years. The term originated in the 1987 United Nations (UN) *Report of the World Commission on Environment and Development: Our Common Future*, also known as the Brundtland Commission Report, which defined it as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). In other words, sustainable development helps improve life and existence in today's world, without compromising it in the future. It involves practices that can occur repeatedly and do not deplete the natural resources of the planet. This means sustainable development emphasizes the actions and behaviors of people because they matter for humanity's collective future.

The role one plays in promoting sustainability and the planet is important in solving looming environmental crises. A survey by the Pew Research Center in 2022 analyzed what the people across 19 UN-member countries thought was the world's greatest threat. About 75% of respondents named climate change (Poushter et al., 2022), demonstrating that most people have a general understanding that this is an important issue in today's world. Notably, it does not necessarily show a popular awareness of the link between human behaviors, sustainability and climate change. Fostering that link is a first step for sustainability efforts.

The combination of the need for greater sustainability and increased public awareness of the issues has resulted in change. For example, there has been a major increase in environmental laws worldwide over the last 50 years. Over 1,000 environmental agreements have been made between UN-member countries since 1970 that focus on pollution, carbon emissions, and plastic

waste (Berelashvili et al., 2022). This is a recognition that many countries know that creating a more sustainable planet poses a necessary central challenge for today's world, and work toward sustainability must be both broadly conceived and directly targeted. Environmental laws tackle pollution and waste through government action, but sustainability can and must be approached from grassroots and educational angles as well.

2.2 Food Sustainability

While many aspects contribute to global sustainability, food plays a vital role, as it is fundamental to human existence. However, its centrality has an unintended consequence: food production contributes to about 30% of global greenhouse gas (GHG) emissions. The livestock sector alone contributes about half of that (Harvard 2019). Greenhouse gases, which trap heat in the atmosphere, are the leading cause of climate change and are one of the biggest threats that the world is facing. This means that food has devastating impacts on the environment and sustainability. Emissions that are caused through global warming also make the environmental conditions for food production more tenuous, thereby further exacerbating food sustainability.

A proper term to describe the amount of greenhouse gases emitted is carbon footprint, which The Nature Conservancy defines as "The total amount of greenhouse gases that are generated by our actions" (The Nature Conservancy, 2022). Many stages in the food process contribute to the generation of greenhouse gases including food production, transportation, and food waste disposal. While food production can have a significant carbon footprint, not all foods contribute equally. Most food-related greenhouse gases come from meat-based foods and, more

specifically, red meat, which has the highest food production carbon footprint. As illustrated in Figure 1, beef produces 70.6 kilograms (kg) of greenhouse gas emissions per kilogram of food produced. The least amount of food-related greenhouse gases comes from vegetables and plant-based foods, which average around 0.7 kg of greenhouse gas emissions per kilogram (United Nations, 2022). This means that vegetables have a much lower carbon footprint than meats; therefore, based on emissions alone, they are better for the environment.

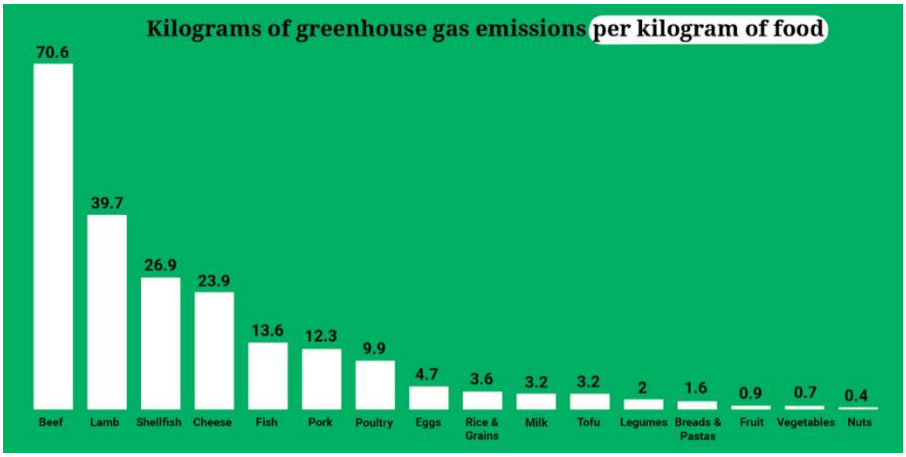

Figure 1. Greenhouse Gas Emissions in 2022 (United Nations, 2022)

As established by Figure 1, different foods have different greenhouse gas emission rates, which can help determine if they contribute to food sustainability efforts. Foods, though, also have different protein values. The nutritional value of food also factors into sustainability. Meat has higher protein content than plant-based foods, which means somebody must consume more of a plant-based food to reach the same level of protein as meat. This might mean that although meat has a higher carbon footprint, its nutritional value could offset its carbon emissions. However, this is not the case. When comparing the greenhouse gases emitted per 100 grams of protein, as illustrated in Figure 2, meat-based foods still produce the most amount of greenhouse

gases. Red meat is the biggest offender with 35.5 kg of greenhouse gas emissions. In comparison, foods such as legumes emit only about 0.9 kg of greenhouse gases per 100 grams of protein. In terms of both overall emissions and emissions per unit of protein, red meat does not score well.

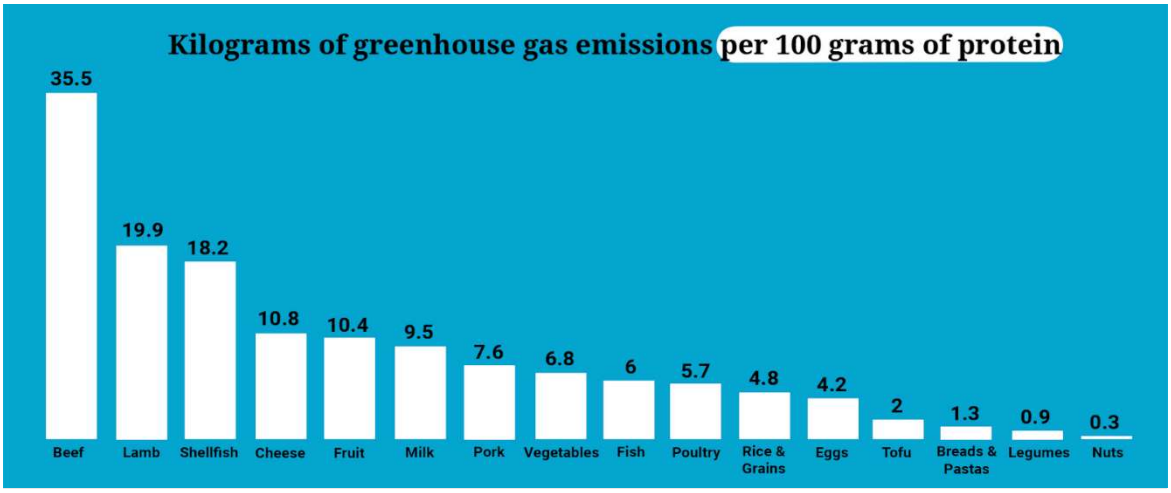

Figure 2. Greenhouse Gas Emissions per 100 Grams of Protein in 2022 (United Nations, 2022)

Along with its production, food transportation challenges a sustainable food model. The fuel needed to transport food emits greenhouse gases, with longer transport routes producing more emissions (EPA, 2022). Locally grown food does not need to be transported as far, which makes it more environmentally friendly and sustainable. When considering these factors, local diets that are plant-based and accessible to the market are the best for the environment and are important when creating food sustainability.

A sustainable food system consistently delivers food to its community, meets their nutritional needs, and ensures that the environmental, social, and economic aspects of current and future generations aren't compromised (Food and Agriculture Organization, 2018). This

means that to be sustainable, the food system must limit or control its impact on the environment or improve the environment. Therefore, to have food sustainability, food production must support healthy dietary needs and the environment.

2.3 Food Sustainability in Singapore

A small, highly urbanized country, Singapore has little space for farming or agriculture. Singapore devotes only 1% of its land to agricultural use and because of this, Singapore imports 90% of its food (Biswas, 2015). Imported food, with its more involved transport, has a higher carbon footprint than locally grown food. Distance matters in this calculation, meaning foods from neighboring countries will have a lower carbon footprint than imports from farther countries. Malaysia, for instance, has close proximity to the entire Singapore food market. Nonetheless, reliance on foods from food supply chains not controlled by Singapore lowers the country's overall food sustainability and food security.

Tourism, too, is a factor that typically lowers food sustainability. Singapore has doubled its international visitor rate in 2023 alone, reaching 13.6 million visitors, dwarfing the local population of 5.9 million (Singapore Tourism Board, 2024). Granted, tourists typically stay for only a short time. Nonetheless, with its high tourist rate, Singapore's food system must support more than the local population. With an increase in population, especially a temporary one staying primarily in hotels comes an increase in unsustainable food consumption habits. Many tourists visit new countries intending to try new foods and go to various restaurants. Moreover, when in different food environments many tourists demonstrate an increase in unsustainable food consumption habits compared to at home. A study in Lhasa, a popular tourist destination in

China, showed that tourists generate 1.7 times more food waste compared to when they reside at their homes (Wang, Filimonau, & Li, (2020). Given Singapore's culinary profile, with its famous hawker centers as well as its abundant restaurants, we can surmise that Singapore's tourism may be another negative contributing factor to food sustainability.

In recognition that high food imports contribute to global greenhouse gas emissions, the Singaporean government understands that reducing them is required to improve environmental sustainability (Ecosperity 2019). As a result, in 2019, Singapore's Environment and Water Resources Minister Masagos Zulkifli announced a goal known as '30 by 30', a sub-goal of Singapore's Green Plan 2030. Singapore plans to improve its agricultural practices to produce 30% of its own nutritional needs by 2030. Currently, the country is only at about 10% of the goal and is developing agricultural strategies to bring that number up to the target 30%. With Singapore's limited land, agricultural strategies focus on making limited space highly efficient in terms of food production (Singapore Food Agency, 2023).

Figure 3 allows us to understand how certain categories of food consumed contribute more greenhouse gas emissions compared to others in Singapore specifically. Although Singaporeans consume more chicken than pork on a per capita basis, pork emits significantly more greenhouse gases than chicken. Additionally red meats represent about 11% of annual per capita consumption by weight, but contribute to approximately 40% of GHG emissions (Ecosperity, 2019). Understanding how different types and amounts of food consumed affect Singapore's GHG emissions allows for the development of Singapore-specific interventions for changing food consumption behavior. The population's green consumption choices can complement and further accelerate progress towards Singapore's 30 by 30 plan, if locally grown

foods present an alternative to high GHG emission foods, thus leading to a decrease in the country's overall carbon footprint.

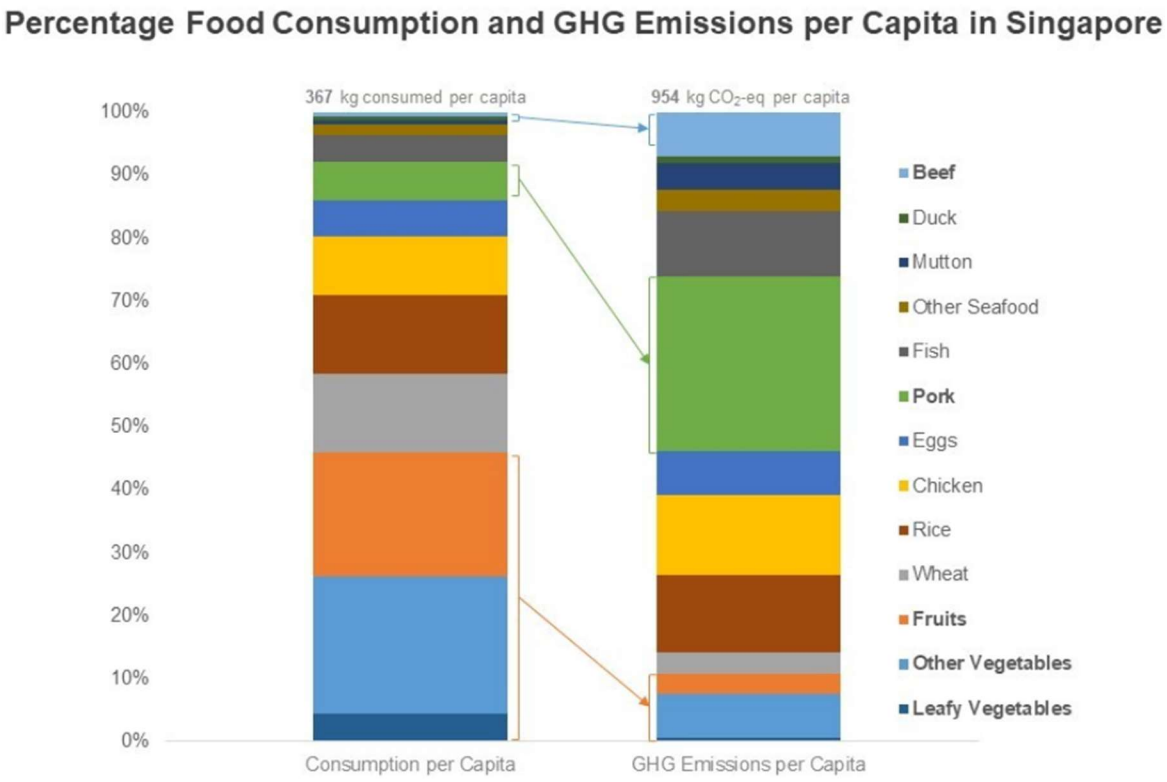

Figure 3. Percentage Food Consumption and GHG Emissions Per Capita in Singapore

Along with the 30 by 30 goal, Singapore acknowledges the need to improve food security to reduce risk factors that disrupt the general global environment. Food security refers to the availability of food within a country and the population's ability to access, acquire, and afford sufficient food; food security is an imperative factor in food sustainability. The Economist Intelligence Unit ranked Singapore as the most food secure nation in the world in 2019. However, in 2022, Singapore dropped to rank 28 in the Global Food Security Index (Economist Impact, 2022). The Singapore Food Agency (SFA) recognizes the risks to food security associated with global trends, including the depletion of natural resources, climate change,

disease outbreaks, and the increasing global competition for food. To reduce these risks, the SFA is employing strategies such as diversifying food import sources, growing locally, and growing in other countries through Singaporean companies (Ministry of Sustainability and the Environment, 2024). Locally produced eggs, for example, constitute 29% of eggs sold in Singapore, with this number increasing toward the 30 by 30 goal. Strategies such as these will minimize the growing risk food insecurity in Singapore.

An area of concern for food sustainability is food waste, both in terms of the amount produced and what is done with it. According to The National Environment Agency of Singapore, food waste accounted for 11% of Singapore's total waste in 2022. Along with this, only about 18% of Singapore's food waste was recycled even though utilizing waste management strategies is important when trying to improve food sustainability (National Environment Agency, 2023). The "Food Recovery Hierarchy" in Figure 4, illustrates sustainable prioritization of the different ways of handling food waste. The most-preferred to least-preferred methods of waste management are source reduction, industrial uses, renewable energy, and lastly, incineration. This hierarchy is useful when deciding how to tackle waste management. Source reduction, which is reducing the amount of waste that is generated to begin with, is most preferred because it eliminates the need to deal with waste later.

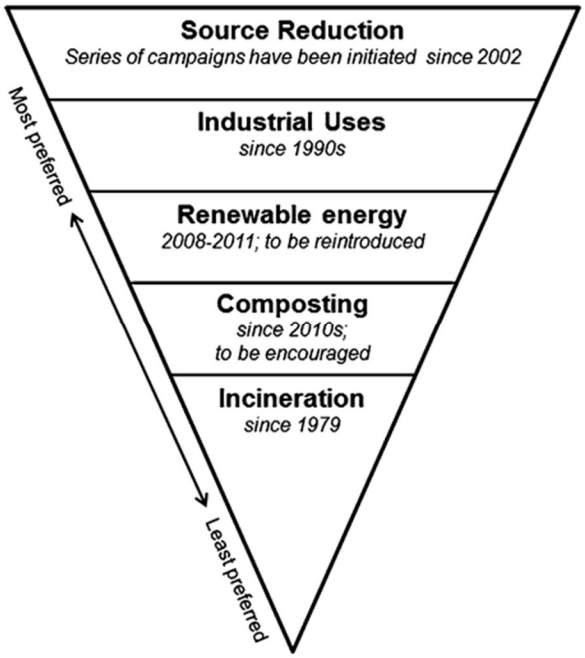

Figure 4. Proposed Food Waste Management Hierarchy for Singapore (Han Ng, et al., Journal of Material Cycles and Waste Management, 2015)

The Food Recovery Hierarchy is connected to food sustainability in Singapore in general because its various strategies can be used to contribute towards the 30 by 30 goal. Source reduction in particular shows promise because it potentially changes how the people of Singapore act regarding food consumption, making it a proactive rather than reactive strategy.

As food waste increases, the demand for food production and the number of waste disposal facilities increases, affecting food security (Ministry of Sustainability and the Environment, 2024). Food waste reduction also has a connection to carbon footprint. When food is wasted, the energy used for that food's production process is also wasted. It takes energy to grow, harvest, transport, and dispose of food. These food systems emit one-third of global GHG emissions, and with the world's increasing population discarding about 30% of their food, those

GHG emissions from food production will be going to waste (National University of Singapore College of Design and Engineering, 2024). Thus, the reduction of food waste would decrease the demand on Singapore's food supply meaning less food needs to be sourced, helping the nation achieve 30 by 30 while also decreasing the nation's carbon footprint.

2.4 A Less Traditional Approach to Food Sustainability

Food sustainability, with its emphasis on environmentally friendly options for both food production and waste, also involves societal consumption habits. Traditional approaches to improving food sustainability involving food waste often focus on reusing and recycling food waste. Unlike these traditional approaches, emphasizing consumption habits can serve as an alternative method to addressing food sustainability. The term "consumption habits" refers to a range of behaviors, not just specifically food. Many studies on consumer and purchasing behaviors articulate a similar broad answer to "What are consumption habits?" They are "behaviors in daily life often… repetitive and performed in customary places, leading to developed habits" (Maheswaran, 2007). This definition implies that habits tend to be formed through consistent and repetitive actions over a specific period, typically within a designated setting that triggers the behavior. Analyzing and assessing the consumption habits of its citizens can provide Singapore with a tool for guiding sustainability forward. Research shows that working with younger groups in a society, specifically children and young adults, aids in the building of healthy habit formation (Whitebeard et al., 2013). People absorb the most knowledge at an adolescent age, and young adults absorb knowledge through observations and experiences

(Whitebeard et al., 2013). Young adults and children, then, are target groups for building better awareness of healthy habits.

2.5 Impact of Cultural Diversity on Consumption Habits

Singaporeans love food, and for good reason, Singapore has a rich cultural background and history that all contribute to its famous food scene. Pew Research suggests that Singapore is one of the most religiously diverse nations on the planet (Miner, 2023). Additionally, Singapore is diverse in terms of ethnic and cultural demographics, with four main ethnicities: Chinese, Malay, Indian, and Eurasian (CIA, 2023). These main ethnic groups have had the biggest influences on Singaporean food and helped shape the cuisine many enjoy today.

2.5.1 Religious Considerations

Singaporeans have many ethnic backgrounds; and religions that may impact an individuals' consumption habits. For instance, Hinduism, Buddhism, and Islam; all include specific dietary restrictions or practices that affect consumption. Nearly half of Hindus, for instance, adhere to a lacto-vegetarian diet, and another third restrict eating all meats to some degree and all refrain from beef consumption. Many, though not all, Buddhists adhere to vegetarian diets. Observant Muslims cannot consume alcohol, pork or anything made with pork or alcohol products, maintaining a halal diet. Moreover, during the month of Ramadan, Muslims fast from dawn to sunset, breaking the fast with iftar, a heavy meal after sunset. Followers of these religions comprise 15% of Singaporeans; therefore, food restrictions play an important role in consumption habits. Additionally, national holidays, cultural, and religious celebrations can also play a role in Singaporean consumption habits. Chinese New Year, for instance, is widely

celebrated in Singapore beyond the 2-day national holiday. It leads to higher consumption of many foods as families celebrate the 10-day period with traditional feasts. Additionally, the national holiday Holi, observed by many Singaporeans involves the celebration of colors, renewal, and spring including the consumption of traditional sweet and savory foods. Thus, culture in Singapore is deeply rooted in people's food behaviors values, beliefs, and norms. These cultural and religious celebrations are important to consider since they occurred during our project center.

2.5.2 Cultural Influence of Rice

In many Asian cultures, rice has major cultural significance because it is a symbol of life and fertility, often signifying prosperity, health, and wealth (United Dumplings, 2024). A study done in 2020 by Diabetes Care studied the rice intake of 21 countries. This study found that Asian countries, consumed significantly more rice compared to other regions of the world (Bhavadharini Balaji, et al., 2020). As shown in Figure 5, South and Southeast Asia consume the most rice compared to different geographical regions.

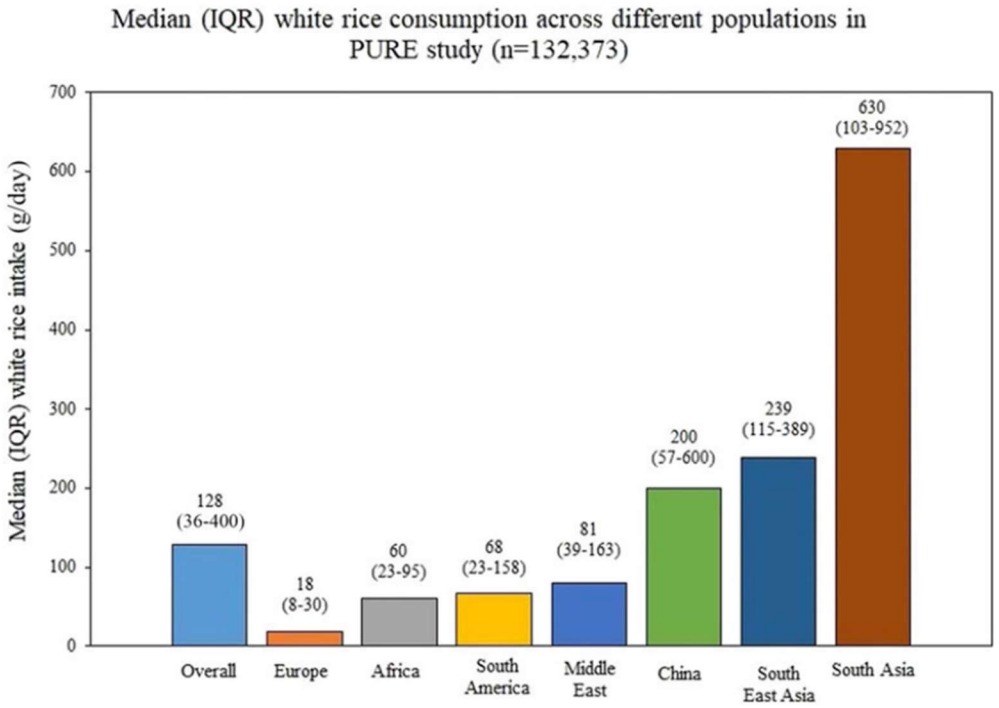

Figure 5. Consumption of White Rice (g/day) in Different Geographic Regions (Bhavadharini Balaji, et al., 2020)

Knowledge about healthy consumption habits can be gained from this study. This indicates the importance of considering rice consumption when conducting Singapore.

2.6 Healthy Consumption Habits

In the context of consumption habits related to food sustainability, the Oslo Symposium defines healthy consumption habits as “the use of food products that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle” (Oslo Roundtable on Sustainable Production and Consumption, 1994). This definition is forward-looking, just as sustainability is

forward-looking. Healthy consumption habits encompass effective practices now and in the future.

Societies, regardless of how developed they are, all benefit from transitioning from poor consumption habits to healthy consumption habits. Healthier consumption habits can help combat food waste and obesity, which are among the many problems countries face in the twenty-first century (University of Illinois College of Agriculture, 2021).

2.6.1 Singaporean Health Initiatives

The Singaporean government is proactive in assessing the country's food-related challenges. For instance, it identifies high sugar intake as a health risk because of its link to increasing obesity and diabetes and is the leading cause of kidney failure (Ministry of Health, 2023). About one in twelve Singaporeans have diabetes, and about six per day are diagnosed with kidney failure (Ministry of Health, 2023). The Ministry of Health (MOH) outlined sugar sweetened beverages as the biggest source of dietary sugar. Due to this, the government implemented a Nutri-Grade system on December 30, 2022. The Nutri-Grade system impacts beverages sold in prepackaged form that are ready to consume, powders or concentrates, and non-customizable beverages sold in beverage dispensers (Health Promotion Board, 2023). As illustrated in Figure 6, the grading system is based on the sugar and saturated fat content per 100ml (about 3.38 oz), with ratings from A to D, with A being most environmentally friendly. The Healthier Choice Symbol appearing next to the letters A and B, can appear on packages in place of an A or B rating. In another effort also enacted in December 2023, the MOH required

freshly prepared beverages in retail and non-retail settings to adopt the rating system (Health Promotion Board, 2023).

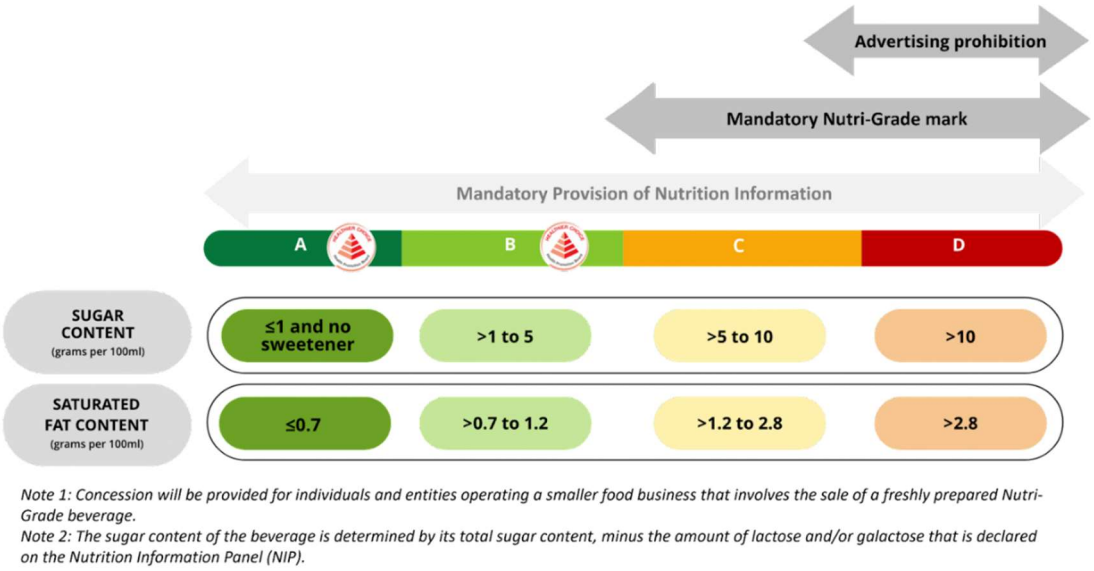

Figure 6. Nutri-Grade Rating System

The Nutri-Grade rating system illustrates an interest in cultivating healthy consumption habits among Singaporeans in general. Its implementation on the NUS campus in dining venues demonstrates efforts to influence young adults. Along with this, there are posters throughout the NUS campus to promote healthy consumption habits. The poster shown in Figure 7, displayed at the NUS Kent Ridge Campus outside a dining spot encourages NUS students and faculty to eat more fruits and vegetables to fight food cravings.

Figure 7. NUS Fruits and Vegetables Poster

Another poster displayed in Figure 8, at NUS encourages students and faculty to eat less deep-fried food and fatty dishes. NUS, in other words, has adopted a poster campaign to encourage students to choose healthier food options. The implementation of these posters on campus shows that NUS believes they are an effective way to influence food consumption behavior.

Knowledge about healthy consumption habits can be gained from this study. However, we can also connect this study to food waste because the prominence of rice in these regions tells us that rice may be wasted more compared to other foods.

Figure 8. NUS Fried Food Poster

NUS has seven major dining locations as listed on the NUSMART Dining App. These dining locations consist of 5 canteens and 2 food courts that are distributed throughout campus and each provide various types of cuisines. This is important to note as NUS and Singapore are very diverse culturally and religiously. Although there are many options, the majority consist of Asian cuisines. Canteen and food court vendors offer Malay, Indian, Chinese, and Japanese dishes. Currently, there are multiple labels for certain dishes on the menus at the NUS canteens. Almost every stall's menu at the dining locations includes at least one dish with health promotion board symbols for lower-calorie options and chef's recommended symbols. Different people require different amounts of calories, so NUS provides students with the option to opt for lower-calorie meals. Additionally, some menus include icons meant to point out healthier food

choices. These indicators include low-calorie options, protein sources, fiber sources, low saturated fat, and low sodium options. This is shown in Figure 9, for the Western stall menu in Techno Edge, a canteen at NUS. These labels help provide information to customers to help them make the most informed decision when ordering food.

Figure 9. Techno Edge Canteen Western Stall Menu

2.7 Food Waste on NUS Campus

Food waste is one of Singapore's most significant contributors to total waste, reflected on the NUS campus. Mr. Loo Deliang, the Head of the Sustainability Strategy Unit at NUS, which supports programs to establish long-term sustainability, such as reducing carbon footprint and mitigating waste, provided our team with key data on food waste at NUS. As shown in Figure 10, food waste has been on the rise since FY 2019 excluding FY 2020 due to the global

pandemic causing worldwide shutdowns. The pandemic caused NUS to shut down in person to go completely remote for its students and faculty starting in April 2020. Despite COVID-19 lockdowns food waste was still generated on campus. In the following years, NUS appeared to recoup its low waste. FY 2022 brought a high of 367 tons, significantly higher than pre-pandemic figures. Currently, total waste data is only available up to FY 2022. The trajectory of NUS food waste before 2020 suggests that food waste at NUS is on the rise.

ZERO WASTE NUS	FY 2019	2020	2021	2022
Total Waste Generated (tonnes)	5,920	5,077	3,995	5,024
(i) Incinerated / Waste directed to disposal by disposal operation	4,416	3,535	2,925	3,426
(ii) Recycled / Waste diverted from disposal by recycling operation	1,420	1,506	1,070	1,598
Paper, Plastic, Metal, Glass	81	81	109	134
Food	209	165	282	367
Horticulture	1,130	1,260	633	1,043
Electronic Waste (E-waste)	-	-	46	54
Recycling Rate	24%	30%	27%	32%
Daily Waste Disposed per Capita (kg/day/capita)	0.22	0.17	0.14	0.16

Figure 1100. NUS Waste Chart from FY 2019 to FY 2022

2.7.1 Carbon Footprint of NUS

NUS has a program called Carbon Neutral NUS which aims to advance the campus towards carbon neutrality. As shown in Figure 11, NUS has integrated this goal into its

infrastructure by incorporating redesigns, increasing solar capacity, and optimizing chiller plants and LEDs (NUS, 2024).

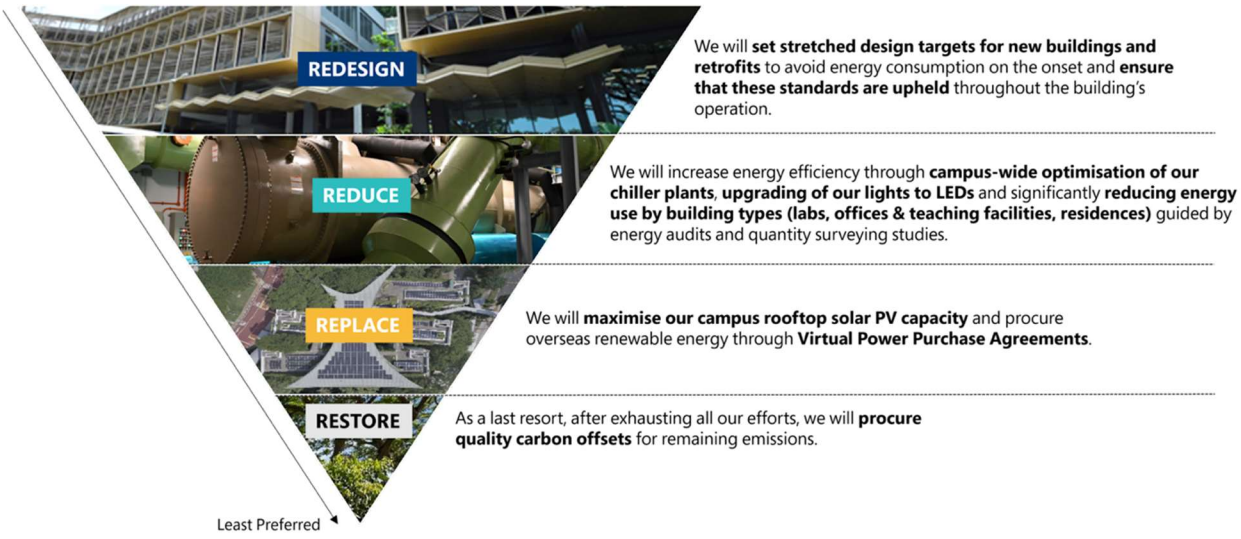

Figure 11. Model for Carbon Neutral NUS (NUS, 2023)

While NUS has committed to carbon neutrality, currently, data exists on the carbon footprint of specific foods in Singapore, but it is difficult to determine the GHG emissions of the specific dishes at NUS, making it difficult to estimate how much food contributes to the overall carbon footprint output from the NUS campus compared to other sources. The carbon footprint of food however is integral to the NUS campus' sustainability given the role of food production in overall carbon emissions. Determining the food carbon footprint on campus can help NUS assess whether food consumption is a major adverse factor for achieving sustainability on campus or if other sources like energy or plastic waste contribute a more significant amount to the carbon footprint.

2.8 Sustainable Behavior Change

There is complexity when motivating people to engage in environmentally sustainable actions around food consumption habits. Literature on sustainable behavior changes, complex change at scale, and institutional models provides insights into how to foster change.

Christie Manning, the author of "The Psychology of Sustainable Behavior", highlights seven key areas that empower people to take environmentally positive action: make sustainable behavior the social default, emphasize personal relevance, make hidden information visible, foster mindfulness, create opportunities for competence, skills, and knowledge, make change a byproduct of other events, and balance urgency with realistic hope (Manning, 2009).

2.8.1 Make Sustainable Behavior the Social Default

Social norms play a crucial role in shaping individual behavior within a community. Humans naturally conform to the norms and expectations of the groups they belong to. This desire to fit in stems from various psychological and evolutionary factors, including the need for social acceptance, belongingness, and cooperation for survival and success. By leveraging social norms and creating a culture that values sustainability, individuals are more likely to adopt environmentally friendly practices. This can lead to a ripple effect within the community, ultimately driving widespread change towards a more sustainable future (Manning, 2009).

Providing opportunities for individuals to demonstrate sustainability is also key to this process of norm-building. By showcasing dedication to environmental stewardship through substantial actions or public commitments, individuals inspire others to follow suit (James

Madison University, 2023). Creating and supporting networks that spread sustainable examples facilitates peer-to-peer learning and the social diffusion of sustainable norms (Manning, 2009).

2.8.2 Emphasizing Personal Relevance

Emphasizing personal relevance is critical in sustainability communication efforts, as messages that directly impact individuals' lives are more likely to capture their attention and elicit action. Research shows that highlighting the implications of environmental issues for human health and well-being can be particularly effective in motivating sustainable behavior change. By shifting the focus from abstract environmental concerns to tangible health outcomes, sustainability initiatives will be more relatable and engaging to the target audience (Manning, 2009).

Furthermore, the language used in sustainability messaging plays a critical role in shaping perceptions and attitudes. Labels or terminology associated with environmentalism or sustainability can sometimes carry a stigma. Therefore, using broad, neutral terms that are descriptive and inclusive can help to mitigate these barriers and ensure that the message resonates with a diverse audience (American Psychological Association, 2021).

Understanding the worldview of the target audience is another essential consideration in effective communication strategies. People are more receptive to information that aligns with their existing beliefs and values (Casad & Luebering, 2023). Therefore, tailoring messages to address local issues and concerns, as well as framing them within the context of the audience's values and priorities, can enhance relevance and credibility.

2.8.3 Make Hidden Information Visible

Information transparency plays a vital role in promoting sustainable behavior by providing individuals with clear, accessible information about environmental issues. When people have access to transparent information, they are better equipped to understand the environmental impacts of their actions and make informed choices. Clear, accessible information allows individuals to grasp the consequences of their behavior on the environment, motivating them to adopt more sustainable practices (Manning, 2009).

Overall, information transparency plays a crucial role in promoting sustainable behavior by empowering individuals to make informed choices that align with environmental values. Eco labeling is an example of information transparency, it raises awareness about environmental issues and influences consumer choices toward more sustainable alternatives. By leveraging these mechanisms, society can foster a culture of sustainability and contribute to the transition towards a more environmentally conscious future.

2.8.4 Fostering Mindfulness

Fostering mindfulness is another key aspect of promoting sustainable behavior. Mindfulness involves cultivating awareness, attention, and intentionality about environmental issues. By encouraging individuals to be present and conscious of their actions, mindfulness can lead to more thoughtful and environmentally friendly choices and holds promise as a catalyst for sustainable behavior change (Thiermann & Sheate, 2020).

One way to foster mindfulness is through practices such as meditation, reflection, and mindfulness-based interventions. These practices help individuals develop a deeper connection with the natural world and recognize the interconnectedness of all living beings (Ackerman, 2017). By cultivating a sense of gratitude and reverence for the environment, mindfulness can motivate people to adopt behaviors that minimize harm and promote sustainability.

In “Cultivating Sustainability Consciousness Through Mindfulness: An Application of Theory of Mindful-Consumption,” Parul Manchanda et al. explore how mindfulness practices can influence an individual’s awareness of sustainability. Drawing on the theory of mindful consumption, the study explains why and how mindfulness impacts sustainability consciousness. It emphasizes that mindfulness encourages individuals to be present, attentive, and intentional in their consumption choices, leading to greater awareness of their actions' impact on the environment, economy, and society (Manchanda et al., 2023).

Furthermore, promoting mindful consumption habits, such as mindful eating and conscious consumerism, can also contribute to sustainability efforts. By encouraging individuals to pause and consider the environmental impact of their purchases, mindfulness can lead to more sustainable consumption patterns and reduce waste.

2.8.5 Create Opportunities for Competence, Skills, and Knowledge

Creating opportunities for competence, skills, and knowledge is essential for promoting sustainable behavior. By empowering individuals with the necessary tools and resources, they can effectively engage in environmentally friendly practices and contribute to sustainability efforts (Manning, 2009). This approach involves providing education, training, and access to information about sustainable practices and fostering hands-on learning experiences and

collaboration within communities. Through these initiatives, individuals can develop the skills and knowledge needed to make informed decisions and take meaningful action toward a more sustainable future.

2.8.6 Make Change a Byproduct of Other Events & Balance Urgency with Realistic Hope

Making change a byproduct of other events and balancing urgency with realistic hope are also crucial aspects of fostering sustainability. By integrating sustainability initiatives into existing events or activities, such as community gatherings or workplace events, individuals can incorporate sustainable behaviors into their daily lives more seamlessly. Additionally, by maintaining a balance between the urgency of addressing environmental challenges and instilling realistic hope for positive outcomes, individuals are more likely to remain motivated and engaged in sustainability efforts over the long term (Manning 2009).

2.9 Fostering Sustainable Food Consumption Behavior Change

A powerful model for explaining and promoting change is Community-Based Social Marketing (CBSM). The CBSM method is based on social psychology and draws from the idea that sustainable behavior change is most effective when it involves direct contact with people and is carried out at the community level (McKenzie-Mohr, 2000). Over the last two decades, the method has been widely adopted by organizations and communities looking to influence behavior change. Environmental psychologist Doug McKenzie-Mohr developed the system and

has trained over 70,000 practitioners in its use, and presumably thousands of others have become familiar with the methods through his books (Fries, et al, 2020).

McKenzie-Mohr's *Fostering Sustainable Behavior* provides a guide for his CBSM method which can be broken down into 5 essential steps. Step one involves selecting the target behavior(s) and defining the audience(s). In this step, the researcher measures the baseline behavior. Step two requires identifying barriers and benefits; by doing so, the obstacles and advantages related to the chosen behavior can be better understood. Step three develops a strategy to create an approach that reduces barriers and enhances perceived benefits. Step four pilots the strategy, testing it in real-world settings through broad-scale implementation. Lastly, step five evaluates and assesses the effectiveness of the implemented strategy. Creating a sustainable future involves inspiring others to make positive changes, and CBMS provides a valuable framework to achieve this goal (McKenzie-Mohr, 2000).

2.9.1 Food Samples

Food samples are an effective tool for mitigating food waste and gaining more customer interest. This is a tool that not only benefits consumers and reduces risk of food waste but is useful for any food business model. Food samples allow customers to discover new foods they enjoy and offer immediate feedback ensuring that food with proven demand is produced in larger quantities to satisfy consumer demand, thus reducing unsold food waste (HelloFresh Group, 2023).

Food spoilage presents a challenge when considering food waste reduction. By using foods near expiration as a marketing tool through food samples companies such as HelloFresh are combating food spoilage. HelloFresh utilized cold storage perishable food items, such as

dairy products, close to expiration as sampling options and have had great success in reducing food waste and improved customer base (HelloFresh Group, 2023).

A contributing factor to food waste, especially among university students, is a matter of taste. When the taste is not up to par, university students are more likely to waste. Case studies have proven that food samples provide a significant reduction in food waste and have been effective when implemented on university campuses (Gunders, 2021). Food samples are one way to both encourage trying new foods, especially sustainable options, while mitigating waste on campus environments.

2.9.2 Eco-labels

Improved marketing of local produce through specialized local produce identifying stickers and organized displays can allow locals to make informed decisions when choosing what produce to buy (Nakajima, 2022). Tools such as eco-labeling are effective mechanisms for enhancing information transparency and raising awareness about environmental issues. Eco-labeling involves labeling products with information about their environmental attributes, such as energy efficiency, recyclability, or sustainable sourcing. These labels provide consumers with easily understandable information about the environmental impact of the products they purchase, enabling them to make environmentally conscious choices (Wojnarowska et al., 2021). Figure 12 provides an example of eco-labeling already in use in Singapore. These labels help display if spaces or buildings created are environmentally friendly.

Figure 12. Eco-label (Home Guide, 2018)

Buildings are one use of eco-labels. On a more individual level, putting an eco-label on foods helps give people an understanding of the environmental impact of their food. The University of Massachusetts, Amherst in the United States (UMass Amherst), which the Princeton Review has recognized for the past seven years as having the best food system of a university or college in the United States (Blaguszewski, 2023), began introducing eco-labels for individual dishes on campus in 2022 (UMass Dining, 2022). This effort to improve food sustainability and reduce the carbon footprint of food is part of a larger sustainability effort on campus. Each entry in the dining halls receives a label, ranging from A to E, with A being the best for the environment. The scale is based on the carbon footprint of the foods throughout the production phase, and the image of a footprint makes it easy for students to understand its meaning. Figure 13 includes the five possible labels for a UMass Amherst dining hall food selection.

Figure 13. UMass Amherst Eco-labels (UMass Dining, 2022)

Along with its eco-labels, UMass Amherst has launched an educational campaign on "Dining for a Cooler Planet" and five permaculture gardens to create edible and local landscapes that the school uses for dining hall foods. These gardens are made by converting underused grass lawns on campus into edible gardens, providing hands-on gardening opportunities for students, and teaching them about healthy and local food systems (UMass Dining, 2022).

2.9.3 Community Gardens

In a study that aimed to reduce the food-related carbon footprint by encouraging environmentally friendly consumption behaviors, researchers collected data from ninety-five community gardens in London through online surveys and interviews. As with the UMass Amherst campus gardens, they found that London's community gardens play a vital role in fostering low-carbon food consumption and contributing to climate change mitigation. Community gardens serve as valuable spaces for promoting sustainable food practices and raising awareness of the environmental impact of our dietary choices (Kim, 2017).

Edible landscapes are the use of food-producing plants in the residential landscape. Zheng and Chou (2023) conducted a systematic review of the literature on edible landscapes and their impact on sustainable urban development shedding light on the potential impact and prospects of edible landscapes in promoting sustainable urban development. The integration of food production within urban green spaces not only enhances environmental quality but also fosters community engagement and well-being (Zheng & Chou, 2023).

Healing gardens have many benefits including creating a sense of community, enriching lives, and developing skills, health, and self-confidence; their positive outcomes greatly uplift local communities. They are often found near hospitals, assisted living centers, and other community centers (Young et al., 2020). When found on a university campus, the benefits of healing gardens have great potential for positive effects during a transitional stage in life. Healing gardens can offer a place of mental repose and escape from the many stressors of university life. Further studying the healing effects of these gardens on campus could be valuable to sustainable campus design (Lau & Yang, 2009).

2.9.4 Educational Posters

Posters with text and images can be used to grab attention and educate. A study by the National Library of Medicine distributed 88 delegates who presented academic posters at two conferences at Bournemouth University in June 2007, and 2008. The results of the study showed that 94% of respondents agreed that powerful poster imagery is more likely to draw the reader's attention (Rowe & Ilic, 2009). The University of Ostrava conducted a study to test the educational effect of posters for students aged 10 to 15 years old. They sampled about 1,000

students from ten elementary schools in the Czech Republic and placed various posters in common places at school. These results showed a significant increase in the level of knowledge after the yearlong application of the posters, particularly the ones that had the least amount of text (Dostal et al, 2021). Studies such as these indicate that posters, especially ones with minimal text, are an effective way of capturing attention and educating people.

3. Methodology

The purpose of this project is to improve food sustainability on the NUS campus. Our primary objectives to accomplish this goal are:

Objective 1: Establish a baseline for understanding current consumption habits on the NUS campus;

Objective 2: Conduct data collection and analysis to identify challenges and opportunities that will aid sustainable behavior change.

Objective 3: Develop interventions based on best practices to positively influence behavioral consumption habits on campus to increase sustainability while also reducing the overall carbon footprint of the NUS campus.

3.1 Establish Baseline Consumption Habits on the NUS Campus

We established a baseline of current consumption habits on the NUS campus by using existing quantitative data from NUS and collecting qualitative data in the form of observations, surveys, interviews, and focus groups. Data was collected from students aged 18 and older, and faculty and vendors aged 21 and older. The surveys, interviews, and focus groups required consent and the data collected was privately stored in the WPI and NUS data servers behind two Factor authentication. This data helped us determine the current consumption habits and patterns on the NUS campus and provided a basis for analysis to recommend interventions tailored to the NUS community's needs for food waste reduction. These methods can be repeated and evaluated

after the broad-scale implementation of recommended interventions to test the efficacy on behavior change and its success in decreasing food waste.

3.1.1 Existing Quantitative Data from NUS

The secondary quantitative fiscal year food waste data from NUS mentioned in section 2.7 was helpful in assisting us to see the growing trends in food waste on campus. However, the composition of the food waste at NUS was a gap in the data provided to us. It was important that we supported the food waste data through further data collection and analysis to establish a baseline of consumption habits on campus.

3.1.2 Observations

As mentioned previously, we acquired data on the total amount of NUS food waste per fiscal year from 2019-2022. However, we wanted to understand which food items were contributing most to the waste. To determine this, we first observed various canteen environments at different times of the day and found peak hours to be 12:00-1:00 PM across every canteen. We then began observations from approximately 12:00-1:00 PM at the following canteens: Techno Edge, Frontier, The Terrace, and PGP, as well as Flavours@UTown food court, conducting observations 4 times for each dining location, between March 27, 2024 and April 22, 2024. The canteens and food court have halal and non-halal tray return stations. Our observations consisted of counting every dish returned and taking note of which were returned empty, with only carbs, vegetables, meat, or a combination of these food categories. Collecting

this data allowed us to determine which food items were the biggest contributors to food waste on campus. We noticed that few students were ordering halal and there were only one to two halal stalls at each canteen and food court. Techno Edge observations were done during Ramadan and has non-halal and halal tray return stations on opposing sides of the canteen. For the Techno Edge canteen, we only accounted for the non-halal tray return station as the halal tray returns did not have a significant number of trays being returned. This meant that our observations at Techno Edge were non-inclusive of the population that normally eats at that canteen that observes Ramadan.

In addition to students and faculty, we also observed food vendors at the canteens. We took note of the most popular food vendors and observed their interactions during orders. We observed communication between food vendor and customer, portion sizes, and the turnaround time of orders. Our findings helped us develop possible strategies that could be implemented during peak hours that'll reduce food waste when queues are growing, and demand is high. Knowledge of vendor-student interactions and turnaround time of orders serves as a baseline for determining feasibility of interventions for food vendors. Observation protocols and recording methods can be found in Appendix C.

3.1.3 Survey

Observations helped determine the baseline of consumption habits, but we further needed to understand why those habits existed. To determine this, we developed surveys to collect qualitative data for consumption habits on the NUS campus. We distributed surveys to NUS professors referred to us by our sponsor and by the NUS College of Engineering Centre for

Design and Innovation. We asked to reserve 5-10 minutes of class time and had each professor display a brief one-slide PowerPoint highlighting the project objectives and a link to the survey via QR code. Figure 14 shows the PowerPoint we used to disseminate surveys in professor course lectures.

Figure 14. Survey PowerPoint

This slide allowed for the survey to be deployed in a class with or without a team member present. The survey took 2-4 minutes to complete and included collection of consent to participate. We determined the sample size by using the finite sample size formula, widely used by statisticians from around the world. The formula is as follows:

$$N' = \frac{n}{1 + \frac{Z^2 \cdot p(1-p)}{\varepsilon^2 N}}$$

Where z is the Z-score

ε is the margin of error

N is the population size

P is the population proportion

Our Z-score is determined based on our confidence level. We ultimately chose to use a confidence level of 95% as this is regarded as the industry standard for research projects (Chan, 2022). With a 95% confidence level, our Z-score would be 1.96. Our margin of error is 4%, as industry standards range from 4-8%. The population size was found to be 50,000 students and faculty members. Our population proportion is 50%. With this formula, we set 594 responses as the minimum number of survey completions required for meaningful results (Glen, 2023).

To collect a response size of at least 594 students/faculty, the team targeted lecture classes with at least 100 students. Group members also spent time at separate canteens distributing surveys during peak hours to maximize survey responses. We additionally targeted sustainability student organizations through telegram group chats.

These surveys asked for demographic information, how often the students dine on campus, what factors affect food choice, and what factors affect food waste. This gave us a better idea of what influences are affecting the NUS community's consumption habits. Our surveys helped notice any trends, and challenges and advantages when trying to improve food sustainability on campus. The survey also listed our various preliminary strategies for improving consumption habits on campus for feedback to help gauge what may work.

We created our survey using Microsoft 365 Forms and automated it so that the data collected generated charts automatically for each question and populated an Excel sheet where we further sorted our data into pivot tables. This made our collected survey data sorting and analysis more efficient as we anticipated at least 594 survey participants. We first ran multiple trials with friends and small groups of NUS students to ensure the survey and data collection ran smoothly prior to widely disseminating it. The survey guide can be found in Appendix B.

3.1.4 Interviews

To further strengthen our knowledge of food consumption habits on the NUS campus, we conducted eight interviews (two professors, a staff member, two graduate students, and three undergraduate students). We interviewed Professor Veera Sekaran, our sponsor, and Professor Prakash Kumar, a professor in the Biological Sciences department. Interviews with professors provided our group with insight from previous years, as professors tend to stay and work longer than students and have a high level of knowledge in the subject. We interviewed Mr. Deliang Loo, the Head of the Sustainability Strategy Unit at the Office of University Campus Infrastructure, who provided information about food waste on campus and other sustainability initiatives. Observations and surveys are great for gathering data, but do not provide a different level of personal reasoning and perspective that interviews achieve. To further support our interviews, we used data and responses from surveys and observations to tailor our interview questions.

Most interviews were conducted by two team members. One member led the interview, asking the questions, while the other member audio recorded, took notes, and took track of time. In most cases, interviews took around 15 to 20 minutes, while interviews with professors ranged from 45 minutes to an hour as they had more to speak about the subject.

We used two options to conduct data recording and management for the interviews. We used smartphones equipped with the AI software Otter for transcription. One team member was also charged with traditional note taking for cross-referencing and data validation. The interview questions can be found in Appendix A.

3.1.5 Focus Groups

Focus groups can help make more meaningful sense of data by having open conversations in group settings. The surveys included a section for participants to state if they would be willing to participate in a focus group by indicating their name, email, and preferred time slot. For our focus groups, we aimed for six to eight participants but due to the approach of finals week during our project, and the busy schedules of NUS students, we had two to three participants per group. Procedures used by the University of Mississippi guided the structure of this team's focus group process (University of Mississippi, 2016). Our focus groups were divided by undergraduate and graduate student demographics. We divided these groups because insight can vary based on these descriptions.

Focus groups allowed for more in-depth questions and answers, and the team could capture emotions that could not be captured through a survey. For instance, we asked what they

felt could be improved about food sustainability at NUS. These questions informed participants of our interventions and how well each performed in our survey results. Participants gave their opinions on our interventions which allowed us to gather information that helped us in the development process. A list of focus group questions can be found in Appendix D.

3.2. Ethical Considerations and the Institutional Review Board

The research conducted at NUS abides by legal and ethical guidelines. Because it involved human subjects, data collection methods were submitted to and approved by the Institutional Review Board (IRB) from Worcester Polytechnic Institute (WPI). In addition, this research team completed WPI's required Collaborative Institutional Training Initiative Program (CITI) certifications. The team also completed an expedited IRB review through the NUS College of Engineering, submitting the WPI IRB approval and data collection tools.

3.2.1 Risks to Study Participants

Our research methods consist of surveys, interviews, observations, and focus groups and present minimal risk to participants. The research team has taken precautions in this regard; however, we cannot eliminate risk. Data collection methods like surveys, interviews, and focus groups confirm that participants are NUS students aged 18 and older, and faculty, or staff aged 21 and older. A foreseeable risk that our participants may have faced during our research could be discomfort regarding answers they might perceive as criticizing their country and university.

Knowing this, our research group implemented surveys, interviews, and focus group questions that do not require participants to provide their name or any identifying personal information. Our research protocols ensure anonymity to elicit honest responses not jeopardized by perceived discomfort and to facilitate sufficient data collection with integrity.

3.2.2 Benefits to Study Participants

By contributing to data collection, participants in this study help improve food sustainability on the NUS campus. Interventions based on analysis of participant data will ultimately assist NUS to reduce food waste and the food consumption carbon footprint on campus.

3.2.3 Record Keeping

The team uploaded collected data onto Worcester Polytechnic Institute's secure multi-factor authenticated web servers. Additional precautions from NUS have required us to also upload our obtainable data to NUS secure servers through our NUS emails. The data is uploaded to advisors and IT (Information Technology) administrators on the web servers. Advisors, and IT (Information Technology) administrators at the web servers. These precautions ensure that our research participants' information is protected by multiple levels.

4. Findings and Analysis

Within the NUS student population, awareness of sustainability and practice of sustainability in terms of food consumption and waste diverge. We calculated that about 42% of plates returned at canteens have food waste. We observed that carbohydrates such as rice and noodles comprised most of the wasted food, followed by vegetables. A common reason for this was inconsistent rice portions, as well as it being valued less when compared to meats and vegetables. From our surveys, 20% of respondents are unaware of food waste, while 67% of respondents are interested in learning how to improve their diets to be more sustainable. This shows a need for increasing the awareness of sustainable consumption habits.

4.1 Community-Based Social Marketing (CBSM) Method

Since the CBSM method has been successfully used in thousands of case studies, we modeled our sustainable behavior change approach at NUS based on the 5 steps outlined in *Fostering Sustainable Behavior* by Doug McKenzie-Mohr. The five steps are

1. Selecting the target behavior(s) defining the audience(s)
2. Identifying barriers and benefits
3. Developing a strategy
4. Piloting the strategy
5. Evaluation and Assessment

We have determined our audience to be NUS stakeholders, in order of influence, NUS administration, faculty and staff, food vendors, and students. In this section, we will focus on the

continuation of step 2 by establishing a baseline of our target behavior through data collection and identifying barriers and benefits through data analysis.

4.2 Challenges and Opportunities

NUS has many challenges and opportunities to influence sustainable change in food consumption behavior on campus. Major challenges faced by the NUS community include limited awareness of food sustainability issues, busy schedules, portion sizing, low value of rice, and communication barriers. On the other hand, some advantages to consider are NUSs' transient community, dedication to sustainable development, access to funding, large customer base, and existing sustainability initiatives on campus. Findings that overlap both challenges and opportunities include the reported top three factors that influence food choice on campus which are price, convenience, and taste. Another overlapping challenge and opportunity are that food vendors have a consistent customer base; this means there is less incentive to improve their business model but offers an opportunity to reach many consumers. When examined, these elements create a challenging environment but still offer many opportunities for encouraging sustainable food consumption practices at NUS.

4.2.1 Portion Sizing Contributes to Food Waste

Portion sizing is a major factor affecting the resulting food waste at NUS. As shown in Figure 15, 295 survey respondents identified portion sizes as the most common challenge they face when trying to reduce their individual food waste on campus.

19. **What factors do you face when trying to reduce food waste on campus? (Choose all that apply)**

More Details

Take out options	115
Portion sizes	295
Menu Customizability	112
Appetite towards the food	258
Smell	89
Appearance	66
Level of hunger	253
Taste of food	241
I don't have any factors	65
Other	8

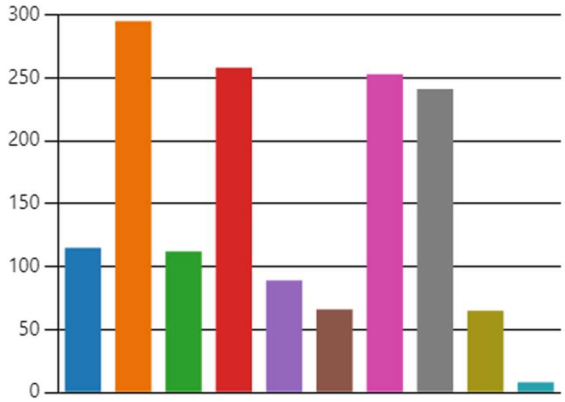

Figure 15. Survey Question about Food Waste Reduction

An open-ended follow-up question in the survey solicited individual comments about portion size. Although many students indicated a desire to request smaller portions of rice, they encountered difficulties doing so. One student noted that no financial incentive accompanies requesting less rice; small or large portions cost the same price, while another noted that portion size varies from vendor to vendor. Unless a customer spends the time to learn each vendors' portion sizing, there's no way to know how much food a customer will receive. Another respondent commented that any communication with a food vendor requires shouting.

Observations at the canteens support survey data, revealing many students want to request smaller portions of rice but need help communicating with the food vendors. The high-volume level at peak canteen hours makes any communication difficult, especially because there is usually some sort of physical divider between the vendors and students. Along with this communication barrier, the necessity for speedy transactions and communications challenges

creates an atmosphere that makes verbal student requests for altering portion sizes extremely difficult to convey to vendors, especially when there's no standard portion size across vendors.

Self-reporting in the survey and observations from canteens also revealed that when it comes to food waste, gender matters. We used our survey data shown in Figure 16, to find that 51% of female respondents indicate their plates still hold up to 25% of their food that they throw away at the end of their meal, and an additional 6% of women's plates contain up to 100%. Women on average eat less than men due to their smaller size, but at the canteens, there isn't much room for customization, since food is sold by standard serving size varying by food stall. We found that inconsistent and current portion sizing especially of rice is often too much not just for females, but some males have reported the same concerns. The overwhelming self-reported waste from females, and data from observations and interviews, suggests that the lack of customizable portion sizing plays a significant part in contributing to food waste.

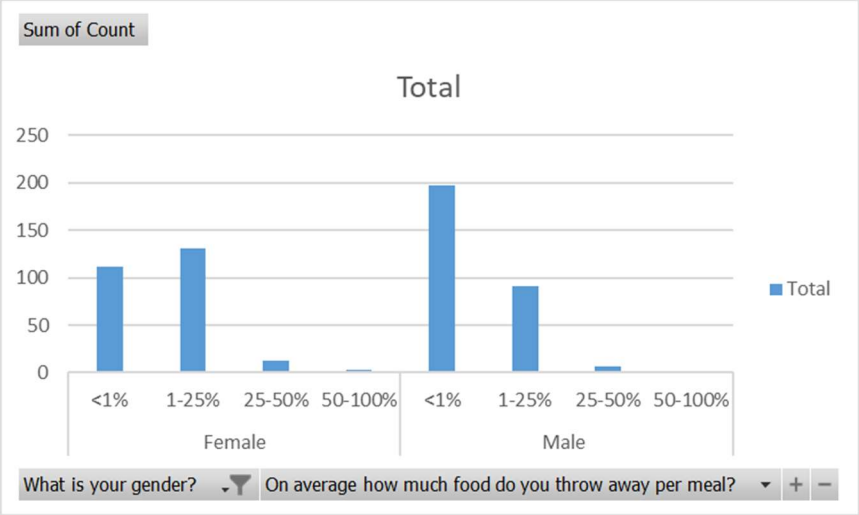

Figure 16. Gender Vs Amount of Food Wasted

4.2.2 Major Contributors to Food Wasted: Carbohydrates and Vegetables

Through observations, we calculated that about 42% of people returned their dishes with food waste, noting three categories: carbohydrates, vegetables, and meats. We marked plates as "mixed" that contained a combination of any of the three food groups. As illustrated in Figure 17, carbohydrates and vegetables constituted the majority of the food wasted, with a combined total of 50%. The mixed category ended up consisting of mainly carbohydrates, which, if it had been possible to count them separately, would further increase the carbohydrate percentage.

Figure 17. Average Food Waste Distribution from Observed NUS Canteens and Food Courts

This is corroborated by survey comments, with one person stating, "If it is too much food, I focus on eating the greens and protein, and if I cannot finish [I] just leave the rice." This supports our observations, as we noticed that most food wasted consists of carbohydrates, such as rice. Since portion sizes are often too much for some individuals, rice being valued less puts it at higher risk for disposal. That same person also noted that if they have "many leftovers I ask for takeaway and eat it later at home." In addition, when we asked all our focus groups why

carbohydrates and vegetables made up most of the waste, they all believed it was due to rice being valued less compared to other foods.

4.3 Food Choice Influences

There are a variety of factors that influence food choice. We addressed these factors in our survey, interviews, focus groups, and observations to evaluate which to prioritize when developing strategies to recommend that NUS implements on campus. Food choice influences play an important role in consumption habits because the food one chooses may not be environmentally friendly, worsening their carbon footprint, and food sustainability in general. Therefore, when changing consumption habits behaviors, it is necessary to take food choice influences into account. This section will go into detail about the three key food choice influences that NUS members experience on campus: price, convenience, and taste.

4.3.1 Price

As shown in Figure 18, the NUS community's food choice on campus is most influenced by price which has been supported by student interview and focus group responses. Survey statements also suggest that pricing indirectly affects food waste through the perception of value. When requesting smaller portions of rice, the price is not reduced, and respondents indicated less willingness to order less rice, even when the perceived portion received is beyond what they can eat and is likely to result in waste. In other words, value is lost, and respondents want to maximize their money by receiving the quantity they paid. This desire for value runs counter to

efforts to avoid food waste. This suggests that when the price drops for a reduced portion, people's value perception of the smaller portion will also change. Canteen food vendors are independently owned; it is beyond this project's scope to propose price changes, but the data indicates that portion-based pricing might benefit both food vendors and consumers and simultaneously reduce waste.

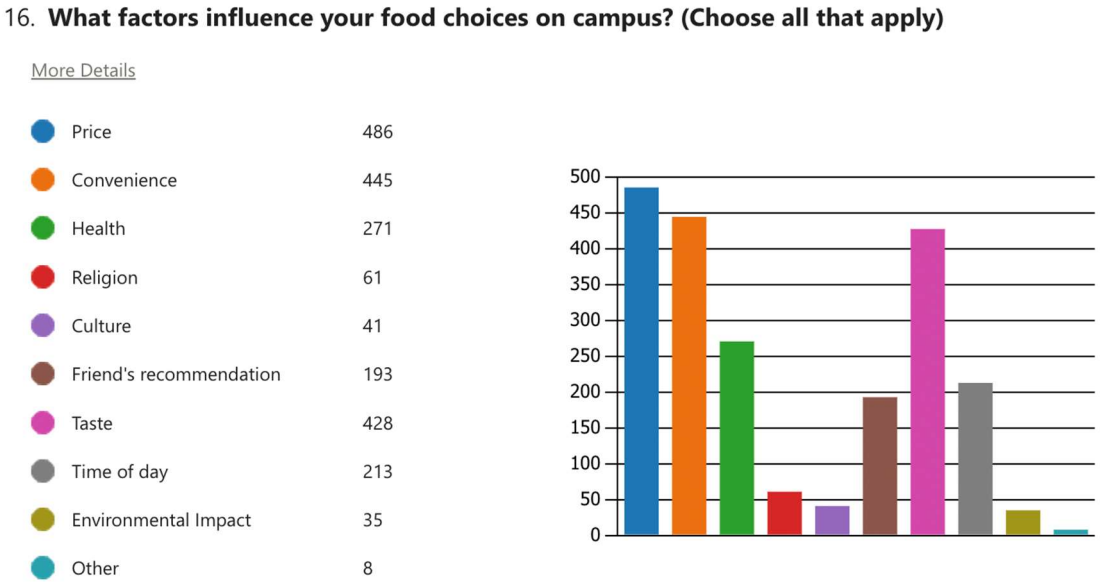

Figure 18. What Influences Your Food Choices on Campus? Survey Data

4.3.2 Convenience

Convenience significantly influences NUS community members' food choices. As seen in Figure 18, convenience ranks only behind price as a factor in food selections. Price and convenience being the top factors considered for food choice suggests that people who regularly

eat at NUS canteens prefer not to go out of their way to indulge in healthy consumption habits; they would much rather pick food choices that easily fit into their personal activities. Structuring canteen procedures to allow for seamless fulfillment of multiple factors including healthy consumption, convenience, and taste would not only make for a better dining experience, but it would also work towards food sustainability on campus.

4.3.3 Taste

The NUS community highly values taste when making food choices. This is no surprise. As shown in Figure 18, from our survey data, the NUS community reported that taste is the third most influential factor in food choice following price, and convenience. During our interviews, numerous participants reported that when they try a new food or meal on campus, they dispose of it if the taste does not meet their expectations. Focus groups further support that taste is a big factor that plays into the consumption habits of NUS members and is highly considered when making food choice.

From our survey data as shown in Figure 19, we found that food samples received the more positive response from the NUS community out of any of our other interventions. Using a Likert scale, respondents rated a statement about food samples helping them try new foods with less worry of food waste. The resulting mean from the food sample question on the Likert scale was four out of five, the agree option, indicating a demand for food samples from the NUS community. We can connect Likert scale data from our survey and our answers about taste from interviews and focus groups when developing our interventions.

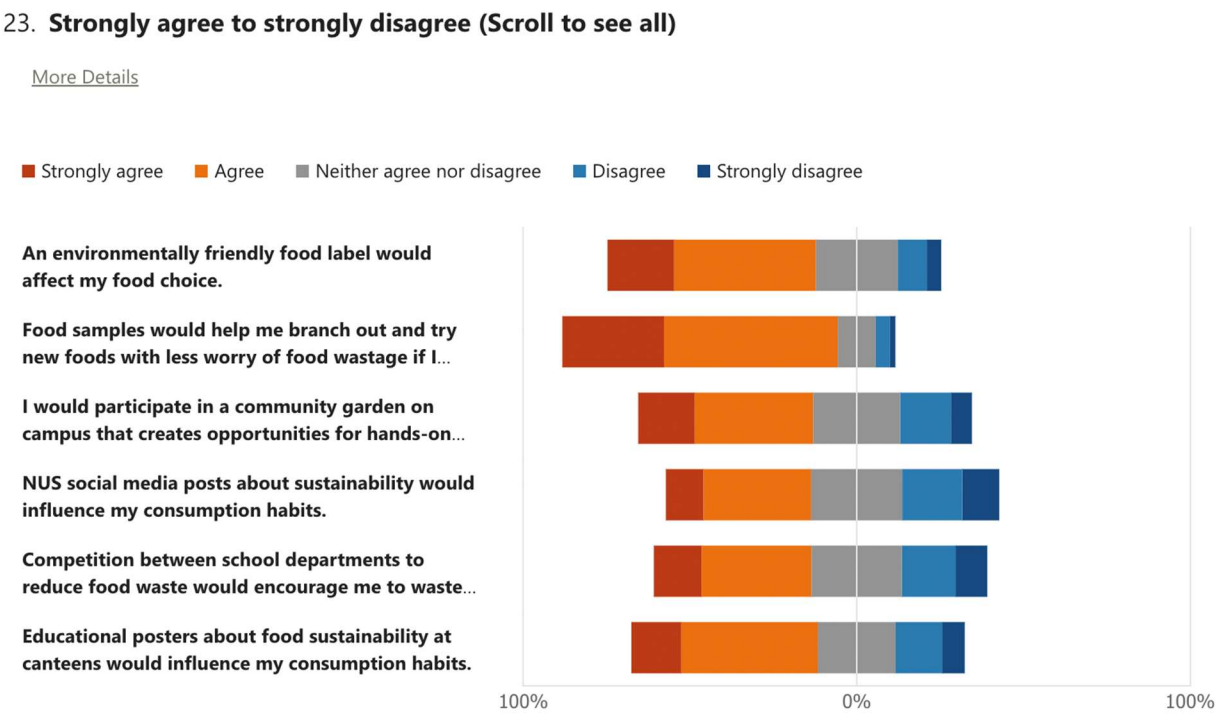

Figure 19. Survey Likert Scale

Numerous case studies have proven that the implementation of food samples onto university campuses can reduce the food waste on campus (Gunders, 2021). Using this evidence, we can use this demand for food samples to develop a recommendation addressing this food choice indicator on the NUS campus (Gunders, 2021).

4.4 Assessing Existing Sustainability Initiatives at NUS

NUS has many sustainability initiatives. However, some are more effective than others. We assessed the existing initiatives at NUS targeted at behavior change to determine what makes them successful, or unsuccessful. Evaluation of past initiatives is beneficial when developing

interventions to create behavior change on campus because we can recycle the strategies used by successful initiatives, and avoid strategies used by unsuccessful initiatives.

4.4.1 Posters

NUS has many posters strategically placed throughout the campus with large images. The posters belong to various public awareness campaigns on campus. As a result, they are intentionally placed where they want the change to happen. For instance, Figures 7 and 8 described in Section 2.6.1 that aim to create healthier consumption habits are placed outside dining spots on campus, because those locations are in the immediate vicinity of the decisions they intend to influence. The team recognized the value of the campaigns because the posters directly impacted team members' food choices. Our own choices became healthier when we ordered after viewing the posters. Viewing a poster encouraging healthier consumption habits helped us avoid junk food. Another example of posters that positively affected team members' behavior were posters in bathrooms encouraging closing the toilet lid before flushing to avoid spreading germs. Located directly above the toilet seat meant they elicited an immediate desired response to close the toilet seat before flushing. These posters worked well for us because they were located directly where the change was intended to happen. They also included big visuals to help convey their message instead of posters filled with words.

After observing canteens on the NUS campus, posters like Figures 7, and 8 encouraging healthier consumption habits are not present. These posters are present outside a food court in UTown, a section of campus. This means that people eating at canteens, different from the food court where those posters are located, are not getting the same educational benefits. After

interviewing three undergraduate students, all of them informed us that they were unaware that these posters existed. Since these posters are only located at UTown, they are not reaching a wide enough audience.

About 70% of survey respondents wanted to learn how to improve their consumption habits to be more sustainable. This makes them more susceptible to informative media such as public awareness educational posters.

4.4.2 Rice Waste Reduction

A 2021 project focused on food waste reduction by a Yale-NUS team also determined rice to be the main component of food waste at canteens. That project resulted in a poster campaign that aimed to get canteen patrons to request smaller portions of rice in both English and Chinese. The written message was reinforced by a large image of rice being served and two smaller images indicating a full bowl and a smaller 75% portion (Towards Zero Waste, 2023). Figure 20, features the poster and identifies it as sponsored by Zero Waste NUS and NUS Campus Life. Much like our findings they also deduced that a significant contributor to food waste on the NUS campus is rice. The efficacy of their project has not been tested and unfortunately, rice is still the most common food waste item. In fact, based on canteen observations, the posters are almost always ignored. Only one of our five student interviewees knew that rice customization existed at mixed rice stalls. Observations suggested that the locations of the posters play the largest role in to why they go unnoticed. In addition, food vendors do not verbally queue choice of rice level to their customers. Other factors also impeding rice level choice are communication barriers: noise level, especially during peak hours,

language barriers, glass barriers, and physical distance between most rice-serving food vendors and their customers.

Figure 20. Enhanced Menu Card Indicating Rice Level Options

4.4.3 Community Gardens

In communication with our NUS peers prior to our team's arrival in Singapore, we became aware of existing gardening interests on the NUS campus. In analyzing our survey data, we found that the mean of the Likert scale was 3.4, indicating that the NUS community would participate in a community garden on campus that creates opportunities for hands-on learning and skills. Mentioned, previously in section 2.9.3 *Community Gardens,* community gardens reap many benefits. Outside of benefiting the environment, community gardens also raise awareness and promote healthy sustainable food practices for its participants.

Upon our team's arrival on the NUS campus, we observed a desolate garden on the roof top of the Techno Edge Canteen. Professor Yen Shih-Cheng, Senior Lecturer and Director of

Engineering and Innovation Centre, explained that the garden was a roof-top community garden implemented by the school for student involvement but was in the process of being shut down and turned into a communal BBQ area due to a lack of participation. He explained that Singapore's hot weather and the garden's exposed sunny location deterred students from the community garden.

To further investigate community gardens, we discussed with our sponsor Professor Veera Sekaran. He explained that community gardens on campus have not been successful in engaging students and because of their busy schedules they cannot participate consistently. The location of the gardens has also been found to be problematic because most gardens were placed on rooftops out of sight. In corroboration with this, many students in focus groups and interviews did not know they existed. He mentioned a roof-top community garden located at UTown that still exists, however outside contractors were hired for upkeep since students were unreliable which defeats the purpose.

We initially thought community gardens would be a great implementation on the NUS campus to improve sustainable food habits. However, after analyzing why past community gardens at NUS have not taken, we have found they need very careful design and thought before any future implementation may take place.

4.4.4 Bin Design: Recycle Right

As part of a final year project in 2020 the Recycle Right Bin was born to improve recycling rates and reduce contamination. As seen in Figure 21, the final bin design featured a

display case with non-recyclable items. This display case is the key component to reducing contamination as it educates the user with 3-D visuals which have been found to be more effective than its 2-D counterparts. Also featured is a slidable opening to improve mindfulness of recycling and a transparent bin body to showcase the accumulation of recyclables. The Recycle Right bin design is now seen campus wide and in public malls with great success (Thiagarajan, 2020).

Figure 21. Features of the "Recycle Right" Bins

5. Recommendations for Sustainable Behavior Change

Based on our data analysis, findings, and research we developed strategies to encourage food consumption practices that reduce waste at the source. These interventions will thereby increase sustainability on campus and foster healthier consumption habits. In this chapter, we explain how these interventions can be implemented and why they can benefit students and faculty. Alongside these interventions, there is a baseline that can be used to test the efficacy of each.

5.1 Considering Tools from Psychology

When developing behavioral interventions, we followed best practice by referencing tips from psychology provided by Christie Manning's, "The Psychology of Sustainable Behavior" as discussed in Section 2.8.

- Social default
- Emphasize personal relevance
- Hidden information visible
- Foster mindfulness
- Create opportunities
- Balance urgency with realistic hope

The use and combination of these tips creates stronger behavioral interventions overall. We kept these tools from psychology in mind alongside our main findings from data analysis when developing our proposed interventions.

5.2 Rice Bowl Portion Displays

We recommend using true-to-size prototype rice bowls which would be present and visible on ordering counters. These rice bowl displays will include a small (100 g), regular (200 g), and large (300 g). These protype rice bowls should be placed either on counters or in visible areas when ordering food inclusive of rice. From our data analysis, we found that rice was the main contributor to food waste, highlighting a key issue that needed to be addressed on the NUS campus. Drawing on the efficacy of the NUS Recycle Right initiative outlined in section 4.4.4, we took inspiration from their 3-D display on top of recycling bins. Having a tangible object display will inspire mindfulness of portion sizing when ordering. Standardized rice portions will effectively remove the barrier of serving inconsistencies amongst rice food venders.

In conjunction we recommend a price reduction for the small portion of rice and a price increase for the large portion. We have found price to be the most effective incentive for students to reduce food waste. Many students reported that food vendors do not reduce prices when less rice is requested which disincentivizes them from asking for less despite not having the appetite for the full serving.

Similar to how cup sizes are often displayed for reference at drink stations, varying bowl sizes would indicate to a consumer visually how much rice they are truly ordering so they can make a well-informed decision. Having physical object representations of rice portions also allows for a customer to point to the size they desire, effectively removing the existing communication barriers. The efficacy of this intervention can be tested by repeating observation protocol that we conducted and comparing it to our baseline data.

5.3 Eco-labels in Stall Menus

We recommend that stalls at NUS canteens and food courts adopt eco-labels for their menus. The Nutri-grade system implemented nationwide, including the NUS campus, shows health scores for beverages to help consumers understand how healthy the beverage is. The adoption of eco-labels would be able to display how environmentally friendly food is. Since the Nutri-grade system is already implemented nationwide, implementing eco-labels on campus makes even more sense.

Menus for the stalls on campus already include chef recommendations and lower-calorie icons to help consumers decide what to order. However, through observation, no menus indicate GHG emission levels. As mentioned in section 2.2, different foods and the way they were transported emit different levels of GHG emissions. This variability shows that it is important to provide consumers with knowledge of how environmentally friendly their dish is so they can make informed decisions. The eco-labels would be on a scale of A-D, just like the Nutri-grade system, with A being the best for the environment. However, we recommend that vendors only display A and B eco labeled dishes. They are an important stakeholder and could be against displaying C or D eco labeled dishes as this could drive customers away. A benefit for vendors to introduce A and B eco labels to their stalls is that they could improve their business as it provides students reasons to order dishes they normally would not have.

We created possible prototype designs and narrowed down our list to four variations which can be found in Appendix F. At our project showcase event, we asked volunteers to vote for their favorite eco-label design. The top voted design is illustrated in Figure 22. The eco-score

key would be placed at the bottom of the menu at stalls on campus while the actual eco-label, the leaf with the letter on it, would be placed next to its menu dish.

Figure 22. Example of Eco-label designs

When connecting to Tips from Psychology, Eco-labels achieve five out of six tips. They are able to become a social default by being a campus-wide canteen and food court initiative, display hidden information such as how environmentally friendly dishes are, fosters mindfulness by making people more aware of their food choices, creates opportunities for students and faculty to alter their consumption habits to be more sustainable, and balances urgency with realistic hope as they integrate sustainability initiatives onto menus.

Data already exists at Techno Edge on the amount of each order for stalls that have set menus. The efficacy of the eco-labels can be tested by comparing the ratio of the number of orders before the eco-labels are put in place, with after. Specifically, checking if the dishes with an A or B eco-label have risen.

5.4 Food Samples at Canteens and Food Courts

We recommend incorporating food samples into the daily operations of campus canteens and food court vendors. As mentioned in section 2.9.1, food samples are effective in reducing food waste by offering consumers the opportunity to discover new foods they enjoy without the risk of food waste. Food samples offer an effective business model for vendors to gain new customers and immediate feedback on what the most favored food items are. Sampling may also incentivize food vendors to prioritize taste and continually improve recipes and cooking procedures that will garner new customers. A reoccurring concern we heard from the NUS community was that they waste much more food when taste is not up to par, and they can tell quality and freshness is often overlooked because it reflects in the taste.

Our recommendation is for NUS to focus on popular canteens and food courts on campus. These food courts and canteens have high-volume traffic of students and faculty, which would lead to more attention and awareness of the food sample initiative among consumers. To determine the frequency of food samples being provided at the NUS community, we suggest NUS try different vendor stalls on different days throughout the week to determine the best days to have food samples available. Our recommendation to food vendors is to provide eco-friendly labeled dishes like "A" and "B." By providing eco-labeled dishes to the NUS community not only reduces waste but promotes a healthier, sustainable community by reducing the food carbon footprint on the campus. We do not recommend traditional food sampling methods involving vendor employees distributing food samples. This traditional approach can be costly for vendors as they must pay employees to hand out food. Instead, food sample campaigns can be initiated in advance via posters to inform the community of the implementation of food samples and what times, days, and food stalls samples can be acquired. During non-peak hours, interested

customers can request a food sample from the vendor workers. If vendors are pleased with the results, they may consider hiring a position to distribute food samples more readily.

To test and assess the success of this strategy, tray return observations can be repeated prior to and 66 days (about 2 months) after implementation to evaluate the effectiveness of this intervention. Approximately 2 months were chosen to test efficacy because the average time to form new habits is 66 days (Frothingham, 2019). Additionally, we suggest NUS collect data from food vendors on transaction sales of eco-friendly dishes before and after the implementation to establish a baseline. If the sales data of eco-friendly dishes has increased from the baseline, we know that food samples effectively promote a more sustainable campus community. Furthermore, increasing eco-friendly dish sales would incentivize other food vendors to implement food samples into their operations.

5.5 Educational Poster Campaign at Canteens and Food Courts

We recommend NUS begin an educational poster campaign at canteens and food courts on campus, echoing efforts of its healthy consumption posters. This campaign should include posters that are primarily visual, but also include informative text in order to have a stronger effect as mentioned in 2.9.4. The purpose of the poster campaign is to inform NUS members about all our other suggestions such as considering eco-labels, choosing their rice portion size, and taking advantage of food samples. As mentioned in section 2.8.4, giving individuals the chance to pause and consider their environmental impact can foster mindfulness to help

encourage sustainable behavior change. Examples of these posters can be found in appendix K, L, and M.

We recommend that the poster campaign begins before other interventions are implemented. This is because they should first inform readers about interventions and when they are going to be implemented, so that students will be able to take advantage of them when implemented.

Location is critical. Figures 7 and 8, posters located at UTown to promote healthier consumption habits, are not present at any canteens and through analysis of our interviews and focus groups, do not reach a wide enough audience. We suggest the posters for our campaign be placed at all canteens and food courts to directly impact students and faculty when choosing what to eat. 67% of survey respondents want to learn how to improve their consumption habits to be more sustainable. This educational poster campaign is key to bring awareness for our other interventions to help create the behavioral change necessary for more sustainable consumption habits while simultaneously reducing food waste.

The educational poster campaign is a bridge for all other solutions and connects to all Christie Manning's Tips from Psychology. The placement of posters in every dining location helps make this intervention a social default. They emphasize personal relevance by conveying information that pertains to students and faculty. The posters educate people about our other interventions, making information visible. They foster mindfulness by increasing awareness about the issue, create opportunities by allowing students to take advantage of other interventions, and finally balance urgency with realistic hope by providing facts to back up why other interventions should be used.

The efficacy of these posters can be tested by comparing food waste statistics after the posters have been implemented, with data before. The eco-label aspect can be tested by comparing order history of eco-labeled dishes before and after the intervention. Another way to test the efficacy of the poster campaign is to distribute surveys to students that eat at canteens and food courts to tell whether they have felt it was effective. They foster mindfulness as they deliver facts to students about food waste and GHG emissions. The campaign creates opportunities for students to learn more and finally balances urgency with realistic hope as these solutions will not be forced onto anyone.

6. Conclusion

Our goal for this project was to decrease the consumption carbon footprint at NUS by reducing food waste at the consumption level. When establishing a baseline of food consumption habits on campus, we determined our main findings. On average 42% of plates returned at dining locations on campus included food waste consisting of mainly carbohydrates, specifically rice, followed by vegetables. Additionally, we identified that price, convenience, and taste have the most influence on the NUS community's food choices. Many survey respondents suggested wanting to learn about sustainable food choices, showing eagerness to increase their knowledge in the subject. After analyzing our data, we developed behavior change interventions for NUS to achieve our goal. These interventions include 3-D rice bowl portion displays to decrease rice waste and reduce communication barriers, eco-labels on menus to display GHG emissions of food dishes, food samples to reduce food waste and improve business for vendors, and an educational poster campaign to connect and launch all our other interventions.

Throughout our project, we laid the foundation for sustainable food consumption behavior change on the NUS campus. We faced the limitation of a time constraint as we only had seven weeks to conduct our project on site whereas behavior change takes approximately two months to implement. Even though we began the prototype design process for our interventions, future projects should continue this process by continuously designing, improving, and testing each intervention to ensure sustainable behavior change.

6.1 Recommendations for Future Research

We recommend future researchers follow the next and final two steps of the CBSM method, steps four and five. Step four is “piloting the strategy”, which in this case, would be implementing behavior interventions on the NUS campus. We suggest that interventions be kickstarted with an educational poster campaign making food sustainability information transparent and launching the other recommended behavior interventions. This way, NUS members will have sufficient time to become aware of and absorb the information displayed on the posters. This will ultimately increase the best chances of effectiveness.

Posters play a crucial role in implementing all our other interventions; due to that, we suggest that researchers continue to develop existing posters and determine where they should be installed in canteens and food courts. The implementation of rice bowl portion displays, food samples, and eco-label interventions could start with establishing contact with food vendors to implement the intervention. Further design and testing of rice bowls and eco-labels to determine final designs. We also recommend further researchers to determine the greenhouse gas emissions for meals to determine parameters for eco-label rankings.

It was brought to our attention by students and faculty that a food dining app, NUSmart Dining, exists but is underutilized and not consistently updated. This is an area for further exploration that with careful consideration, our interventions could be implemented on and serve this project's goal.

The final step of CBSM is “evaluation and assessment”, which would be testing the efficacy of behavior interventions by using the same or further developed qualitative data

collection methods utilized during this research project. After data is collected, it will be compared to the baseline data that we collected to measure food consumption habits of the NUS community.

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Appendices

Appendix A: Interview Guides (Student & Professors)

Interview Guide: NUS Students

Introduction:

- Introduce yourself
  - Explain the research project/ purpose
  - Our backgrounds
- We are from WPI, a university located in Massachusetts, USA. We are collaborating with NUS to try to improve food sustainability on campus. Our research project focuses on improving food sustainability at the National University of Singapore. The aim is to establish a baseline of food consumption habits of NUS students and faculty. Analysis of the data will result in recommendations and strategies for reducing the carbon footprint of food consumption on campus. A reduced food consumption carbon footprint contributes to greater sustainability for the NUS campus and Singapore.
  - Informed consent (ask if they're okay with being recorded)
- Do you give consent to participating in this interview?
- Are you okay with being audio recorded, or do you prefer not to be?
- Hi, can you please tell us what your role on campus is?
- (If they say, student) ask: what is your major and year?

Exploration of Consumption Habits:

- What does food sustainability mean to you?
- What factors influence your food choices when dining on campus?

Perceptions and Suggestions:

- What do you think about the interactions between food vendors and the NUS community, for example, if they are trying to rush or if communicating is hard??
- What are the main challenges in promoting sustainable consumption habits on campus?
- There are posters at canteens allowing the choice of different rice portion sizes. Do you ever use them, or have you seen anyone else use them? Do you think these posters are effective?
- If yes, do you do it or think it is effective?
- Have you noticed any poster initiatives on campus? If so, which one? Did it affect you?
- We hear that there is a community garden on the top floor of Techno Edge. However, it failed. Were you aware of this, or why it may have failed?
- Are you aware of or have you participated in any community gardens on campus? Follow-up question: Why or why not?
- In our survey, many respondents considered convenience a factor for food choice. What do you think are some examples of convenience when making food choices?

Closing:

- Thank the participant for their time and input.
- Offer any additional information or resources related to sustainability initiatives on campus.

Interview Guide: NUS Professor #1

Introduction:

- Introduce yourself
  - Explain the research project/ purpose
  - Our backgrounds
- We are from WPI, a university located in Massachusetts, USA. We are collaborating with NUS to try to improve food sustainability on campus. Our research project focuses on improving food sustainability at the National University of Singapore. The aim is to establish a baseline of food consumption habits of NUS students and faculty. Analysis of the data will result in recommendations and strategies for reducing the carbon footprint of food consumption on campus. A reduced food consumption carbon footprint contributes to greater sustainability for the NUS campus and Singapore.
  - Informed consent (ask if they're okay with being recorded)

- Do you give consent to participating in this interview?
- Are you okay with being audio recorded, or do you prefer not to be?
- Hi, can you please tell us what your role on campus is?
- (If they say, student) ask: what is your major and year?

Questions:

- How would you characterize the overall level of food sustainability awareness on campus?
- Have you seen an increase in awareness in your students about sustainability over the years? If yes, why do you think that is? If not, why not? What are the obstacles?
- Who drives food sustainability efforts on campus: student initiative, faculty initiative, administration initiative?
- Since your research is in plant development do you think having designated gardens on campus for research and educational purposes would be beneficial or utilized by the community?
- What do you think are the main challenges in promoting sustainable consumption habits on campus?
- Are you a part of any sustainability initiatives on campus? If you are, what has succeeded?

- How effective do you think Singapore is at tackling food sustainability? How effective is NUS?

Closing:

- Thank the participants for their time and input.
- Offer any additional information or resources related to sustainability initiatives on campus.

Interview Guide: NUS Professor #2

Introduction:

- Introduce yourself
  - Explain the research project/ purpose
  - Our backgrounds
- We are from WPI, a university located in Massachusetts, USA. We are collaborating with NUS to try to improve food sustainability on campus. Our research project focuses on improving food sustainability at the National University of Singapore. The aim is to establish a baseline of food consumption habits of NUS students and faculty. Analysis of the data will result in recommendations and strategies for reducing the carbon footprint of food consumption on campus. A reduced food consumption carbon footprint contributes to greater sustainability for the NUS campus and Singapore.

- Informed consent (ask if they're okay with being recorded)
    - Do you give consent to participating in this interview?
    - Are you okay with being audio recorded, or do you prefer not to be?
    - Hi, can you please tell us what your role on campus is?
    - (If they say, student) ask: what is your major and year?

Questions:

We have made some recommendations to improve food sustainability on campus so far and want to discuss them with you. What are your thoughts about each recommendation, and how feasible would these be to implement on the NUS campus?

- Rice Bowls: From our findings, we noticed that rice often gets thrown away. Currently, there is an initiative on campus where you can communicate with certain stalls to ask for less rice. However, we found this is ineffective at the moment as there is a language barrier, the canteens are loud, and not many people know that it exists. We recommend having different-sized rice bowls that students can point to when ordering to eliminate the language barrier issue, making it easier for people to order less rice. Hence, it is less likely for rice to be wasted.
- Eco-labels: *show current prototypes* About 70% of respondents from our survey stated that they want to learn how to make more environmentally friendly food choices. There is already a nutri-grade beverage system to indicate a health

rating, and menus already have chef's recommended and healthier choice symbols. We recommend putting eco-labels on the menus at canteens and food courts to indicate how environmentally friendly the dish they order is. Eco-labels would promote environmentally friendly food choices, making it less likely for foods with a high carbon footprint to be ordered.

- Food Samples: From survey respondents we asked them to vote on a Likert scale on how strongly they agreed or disagreed with our possible strategies. The top vote is for food samples. Canteens are very busy, so food samples must be implemented at non-peak hours. Students from the survey value taste and are more likely to waste food. Food samples give them a chance to try something new without any risk.
- Educational Posters: We also recommend posting educational posters at the canteens and food courts to educate people about food waste and GHG emissions so that they can make more informed food choices. There are many posters on campus, such as in posters in UTown to promote healthier eating. We also want to create posters that connect to other solutions, such as eco-labels, rice bowls, and food samples. An example would be for a poster to tell people to be on the lookout for eco-labels on the menus.

Optional questions:

- There are many campaigns to reduce GHG emissions, such as at the MRT and on the NUS campus; is there also a national agenda to reduce GHG emissions by reducing food waste at the consumption level?
- A possible recommendation is implementing community gardens on campus that have educational signs to inform readers about food sustainability. There was a community garden on the top floor of Techno Edge. However, it is getting taken down because of a lack of interest. Were you aware of it and why do you think it failed?
- Our recommendations are for the NUS canteens and food courts. In your opinion, what are the parallels between NUS canteens and food courts, and hawker centers?
- Thank you for participating in this interview. Is there anything else you would like to discuss?

Appendix B: Survey Questionnaire: NUS Faculty and Students

Survey Questionnaire

Consent Questions:

1. Do you agree to participate in this survey about food sustainability?

   Yes

   No

2. Do you purchase food on campus? (This includes canteens, dining halls, food courts, and all food and beverage)

   Yes (continue survey)

   No (exit)^

Demographic Information:

3. What is your age?
4. What is your gender?

   Female

   Male

   Other

5. What is your role on campus?

Student

Faculty

Staff

6. Where are you from?

Singapore

China

Malaysia

India

Japan

Korea

Taiwan

United States of America

Philippines

Vietnam

Other

7. If other, please specify

[Text box]

8. Do you adhere to religion-based food practices?

Yes

No

9. If yes, what religion do you practice?

Christianity

Islam

Judaism

Hinduism

Buddhism

Other

None

10. If other, please specify?

[Text box]

11. What is your ethnic background (choose all that apply)

Chinese

Malay

Indian

Japanese

Korean

European Descent

Other

12. If other, please specify?

[Text box]

13. On average, how often do you eat on campus per week?

1-2 times per week

3-4 times per week

5 or more times per week

14. On average how many times a week you eat beef?

I don’t eat beef

1-2

3-4

5-6

7+

15. On average how many times a week do you eat pork?

I don't eat pork

1-2

3-4

5-6

7+

16. What factor influence your food choices on campus? (Choose all that apply)

Price

Convenience

Health

Religion

Culture

Friend's recommendation

Taste

Time of day

Environmental Impact

Other

17. Is food waste something you are conscious of?

Yes

No

18. On average how much food do you know throw away per meal?

<1%

1-25%

25-50%

50-100%

19. What factors do you face when trying to reduce food waste on campus? (Choose all that apply)

Take out options

Portion sizes

Menu Customizability

Appetite towards the food

Smell

Appearance

Level of hunger

Taste of food

I don’t have any factors

Other

20. If other, please specify

[Text Box]

21. Are you interested in learning about how to make more environmentally friendly choices regarding food consumption?

Yes

No

22. Would you change your consumption habits to reduce carbon footprint? (Check all that apply)

Yes

No, because I care more about taste

No, because I feel my change won't make a difference

No, because I don't care

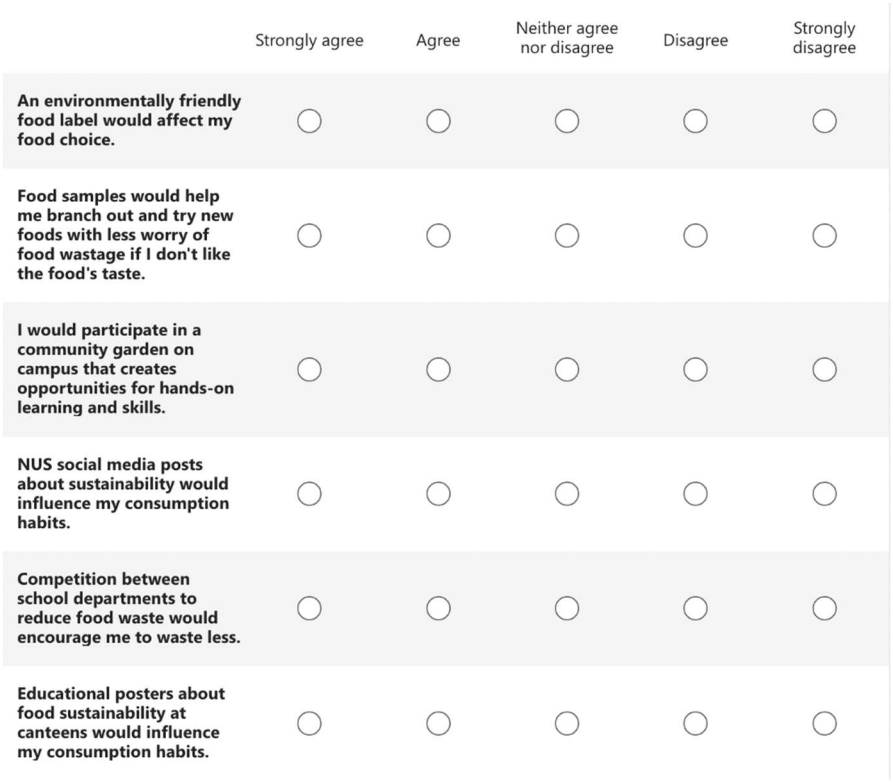
No, because I have to adhere to certain food practices

No, because I don't know how to

No, because I value convenience

No, for other reasons

23. Strongly agree to strongly disagree (Scroll to see all)



	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
An environmentally friendly food label would affect my food choice.	○	○	○	○	○
Food samples would help me branch out and try new foods with less worry of food wastage if I don't like the food's taste.	○	○	○	○	○
I would participate in a community garden on campus that creates opportunities for hands-on learning and skills.	○	○	○	○	○
NUS social media posts about sustainability would influence my consumption habits.	○	○	○	○	○
Competition between school departments to reduce food waste would encourage me to waste less.	○	○	○	○	○
Educational posters about food sustainability at canteens would influence my consumption habits.	○	○	○	○	○

24. Would you be willing to participate in a one-time focus group discussion about food sustainability at NUS? (Roughly 45 minutes)

[Text box]

25. What dates are you available? (You may select all that apply, but you will only be selected to participate in one focus group session)

Thursday 4 April, 2024 10 AM (Local students only)

Thursday 4 April, 2024 5 PM (Foreign students only)

Friday 5 April, 2024 10 AM (Foreign students only)

Friday 5 April, 2024 5 PM (Local students only)

Tuesday 9 April, 2024 10 AM (Male students only)

Tuesday 9 April, 2024 5 PM (Female students only)

Wednesday 10 April, 2024 10 AM (Female students only)

Wednesday 10 April, 2024 5 PM (Male students only)

26. If yes, what is your name?

[Text box]

27. If yes, what is your email?

[Text box]

Appendix C: Observation Protocol

Observation Protocol

Date, location, and time:

- Date is always weekday
- Canteen name, tray return type (non-halal or halal)
- Time is always 12-1 pm

Behavior and practices (Quantitative data):

- Category type/amount of food:
  - Empty plate
  - Only carbs
  - Only meat
  - Only veggies
  - Mix of types

Interactions and Engagement (Qualitative data):

- Crowdedness
- Open Stalls
- Which canteens are busier
- Popular orders
- Popular Items and Chef's Recommended at each stall
- Any other consumptions habit trends we notice

Reflection and Analysis:

- Ratios for categories
- Main data trends
- Create charts for displaying data

Appendix D: Focus Group Guide

Focus Group Guide: NUS Students/Faculty

Examples of sustainable food choices:

- ∉ Consuming Local Produce
- ∉ Reduced packaging
- ∉ Consuming plant-based food over meat
- ∉ Eating leftovers

Examples of unsustainable food choices:

- ∉ Consuming processed food
- ∉ Consuming imported food
- ∉ Wasting food

Engagement Questions

1. What is your definition of food sustainability?

2. Do you know about any ongoing NUS sustainability initiatives? How effective do you feel they have been?

3. What is the first thing you consider when looking for food on campus and why?

Exploration Questions

4. What, if anything, has influenced or elicited a change in your food behavior habits before? What did you change and why? [Are you interested in knowing what the change was? Asking might give you insights into how they understand sustainability.]

5. What challenges have you faced when trying to be more sustainable during meal times on campus?

6. We've observed that carbs such as rice, noodles, and vegetables tend to be wasted more at canteens. Why do you think that is?

7. We've also observed that women tend to waste more than men, especially carbs and vegetables. Why do you think that is?

8. Show recommendations* Why do you think the NUS community answered more positively for the top 3 recommendations?

9. If the option for portion size variation was easier to communicate, would you use it?

Exit Question

10. Thank you very much for sharing your thoughts.
Is there anything else you would like to tell us about your experience with food sustainability on campus? Is there anything else that you'd like to share with us?

Note: students and faculty in separate groups.

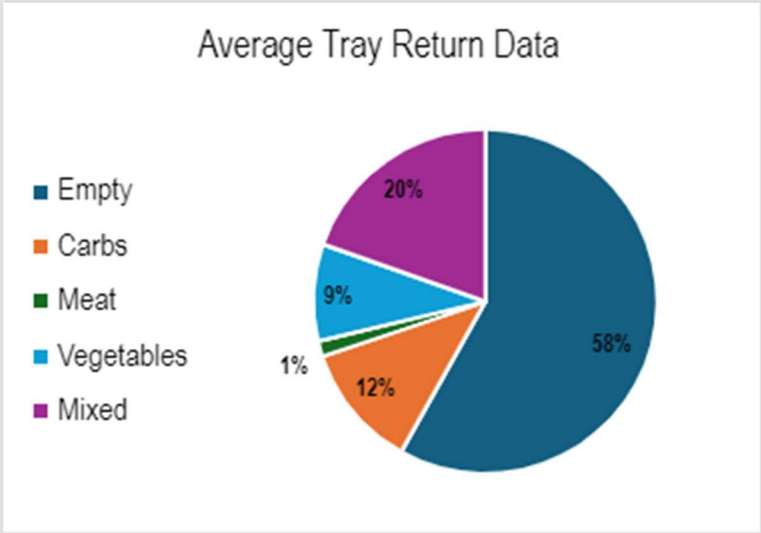
Appendix E: Timeline

Table 1: Timeline

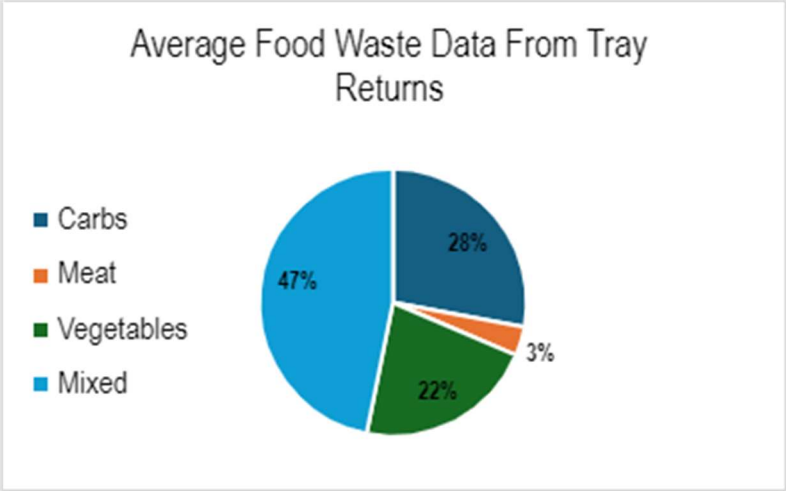
Task	Goal	Week						
		/11	/18	/25	/1	/8	/15	/22
Get NUS IRB Approval								
Observe NUS campus	Become familiar with the campus and scout out the best locations to focus on for more in-depth observations.							
Readjust goals and methods	Based on unexpected findings, goals and methods are re-adjusted and fine-tuned to suit the NUS campus.							
Finalize data collection tools	Finalize surveys, interviews, focus group questions, and observation protocols. Develop effective recruitment strategies, draft emails and PowerPoint to distribute our surveys.							
Collect Data	Interviews, surveys, focus groups data. Collect and measure baseline of behavior using the data collected							
Analyze data	Understand the attitudes and beliefs about consumption behavior at NUS. Analyze and use data to design behavior change program.							
Interpret Findings	Interpret your research findings in the context of your research objectives and existing literature. Identify key findings, implications, and recommendations for promoting sustainable consumption behavior at NUS.							
Develop strategy	Based on our findings tailor strategies for sustainable behavior change to the NUS community.							
Final proposal	Work on the final draft of the proposal and polish our work. Add finishing touches to the final presentation and practice our delivery.							
Communicate results	Share your research findings through presentation, and proposal. Consider how you can disseminate your findings to campus stakeholders, policymakers, and the broader community to inform decision-making and promote positive change.							

Appendix F: Initial Eco-label Designs

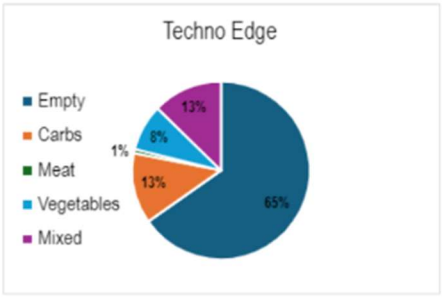
Appendix G: Average Tray Return Data

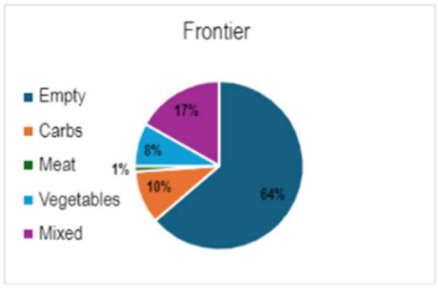


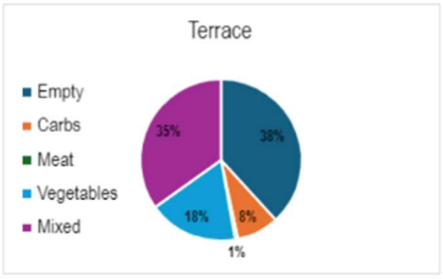
Appendix H: Average Tray Return Waste Data

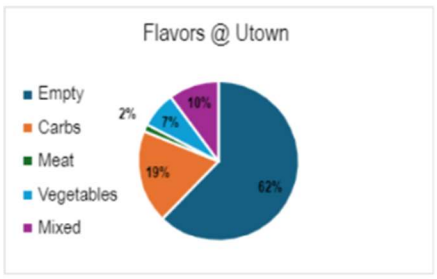


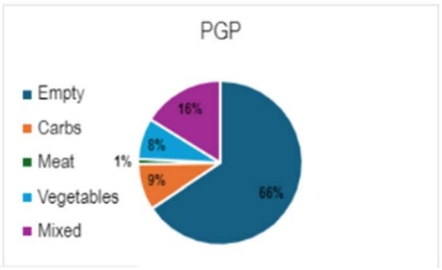
Appendix I: Specific Dining Location Data







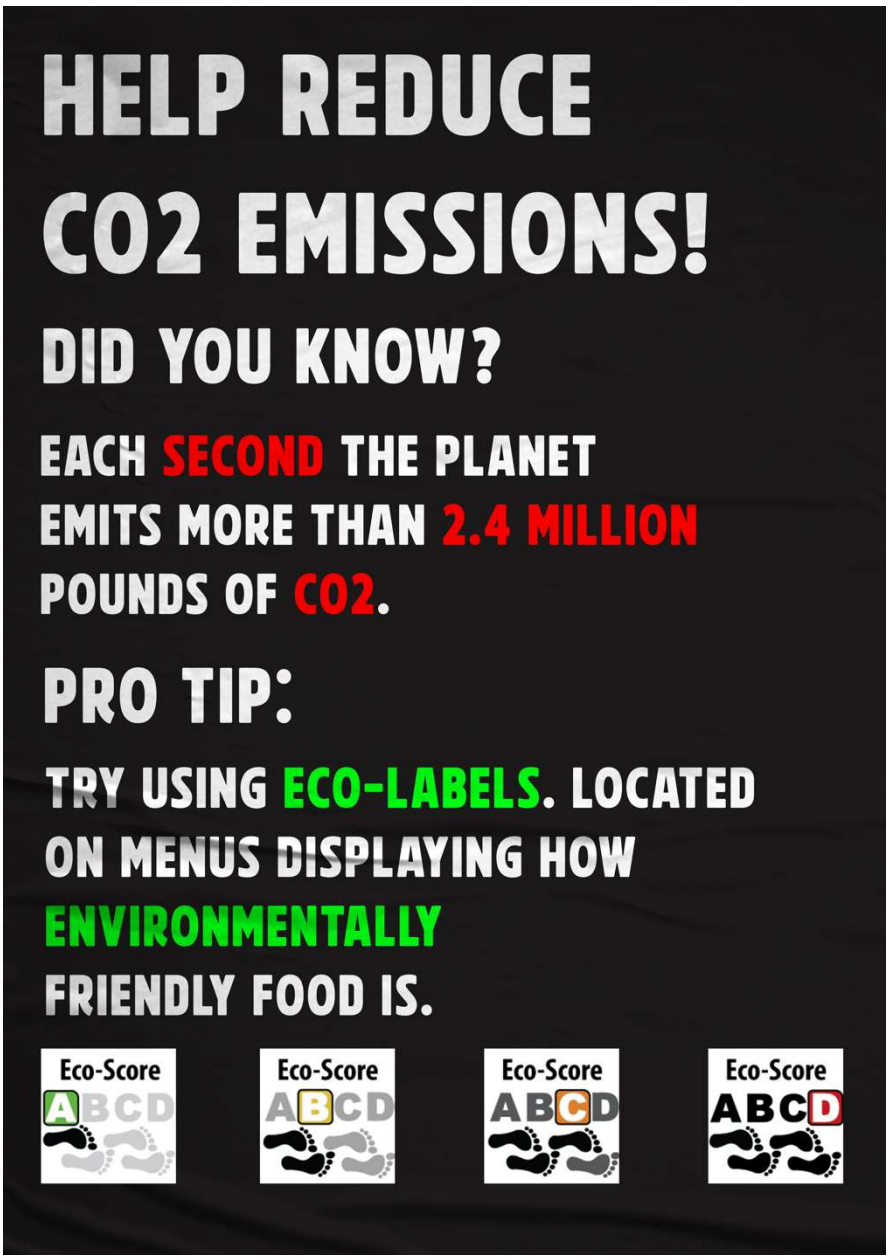




Appendix J: Specific Dining Location Waste Data

Appendix K: Poster Prototype #1

Appendix L: Poster Prototype #2



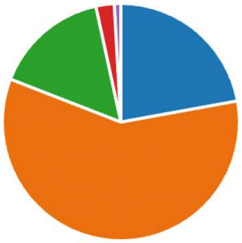
Appendix M: Poster Prototype #3

Appendix N: Data for Future Projects

14. **On average how many times a week do you eat beef?**

More Details Insights

I don't eat beef	124
1-2	329
3-4	88
5-6	14
7+	5



15. **On average how many times a week do you eat pork?**

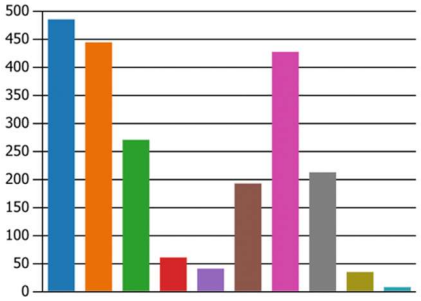
More Details Insights

I don't eat pork	86
1-2	224
3-4	184
5-6	45
7+	21

16. **What factors influence your food choices on campus? (Choose all that apply)**

More Details

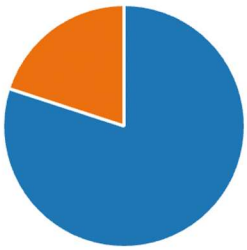
Price	486
Convenience	445
Health	271
Religion	61
Culture	41
Friend's recommendation	193
Taste	428
Time of day	213
Environmental Impact	35
Other	8



17. **Is food waste something you are conscious of?**

More Details Insights

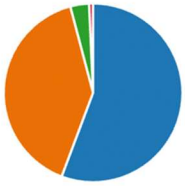
Yes	448
No	112



18. **On average how much food do you throw away per meal?**

More Details Insights

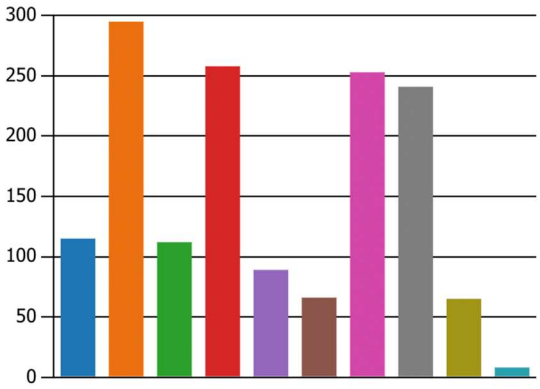
<1%	312
1-25%	225
25-50%	19
50-100%	4



19. **What factors do you face when trying to reduce food waste on campus? (Choose all that apply)**

More Details

Take out options	115
Portion sizes	295
Menu Customizability	112
Appetite towards the food	258
Smell	89
Appearance	66
Level of hunger	253
Taste of food	241
I don't have any factors	65
Other	8



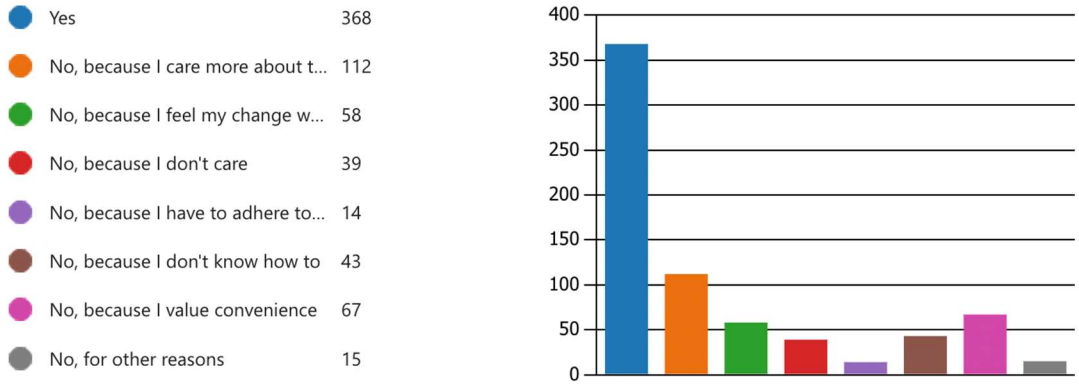
21. **Are you interested in learning about how to make more environmentally friendly choices regarding food consumption?**

More Details Insights

Yes	375
No	185

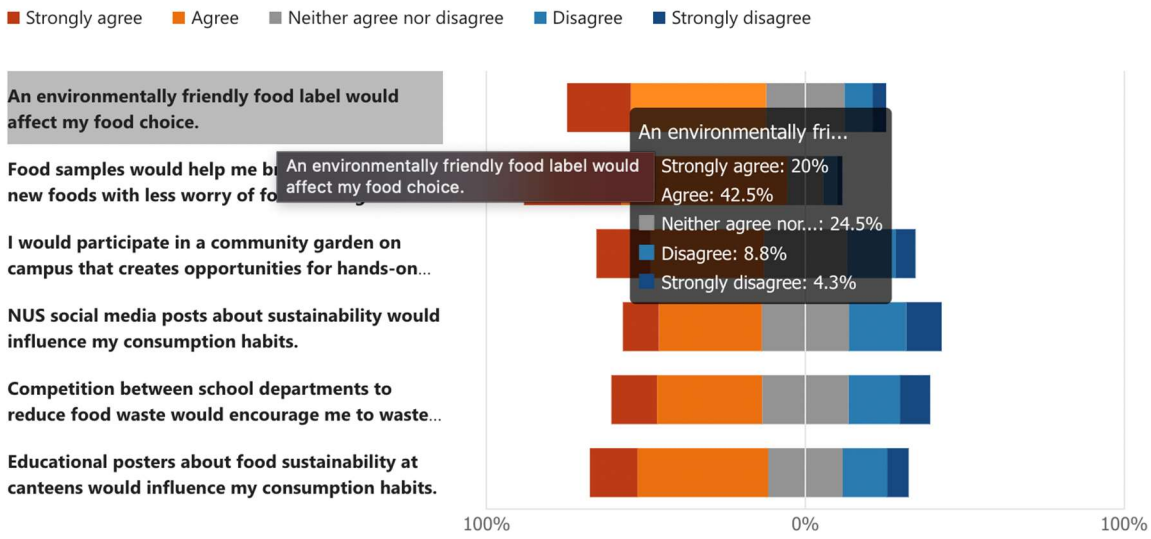
22. **Would you change your consumption habits to reduce your carbon footprint? (Check all that apply)**

More Details



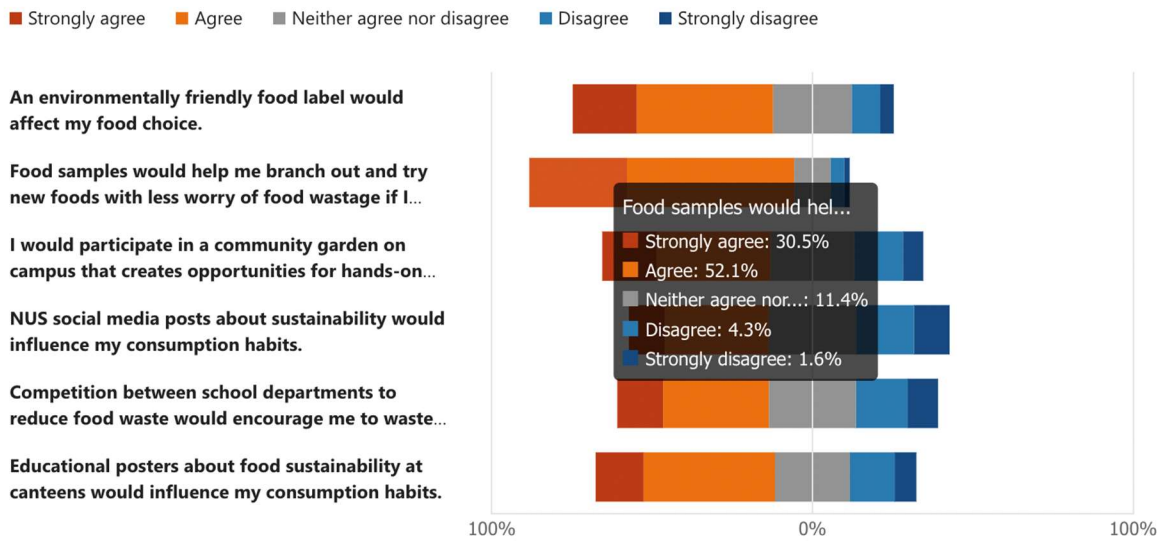
23. **Strong agree to strongly disagree (Scroll to see all)**

More Details



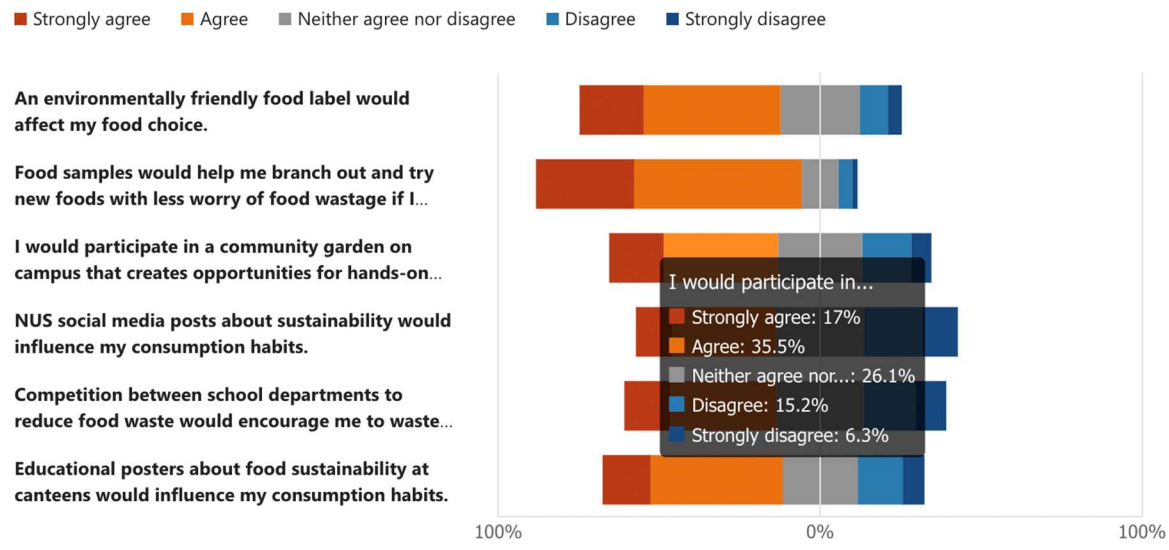
23. **Strong agree to strongly disagree (Scroll to see all)**

More Details



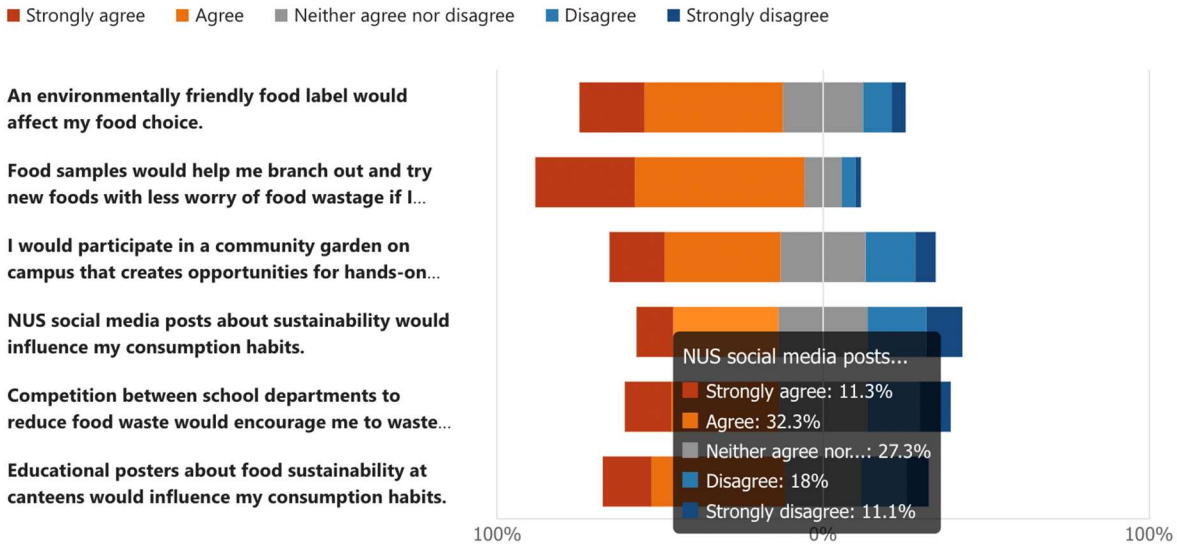
23. **Strong agree to strongly disagree (Scroll to see all)**

More Details



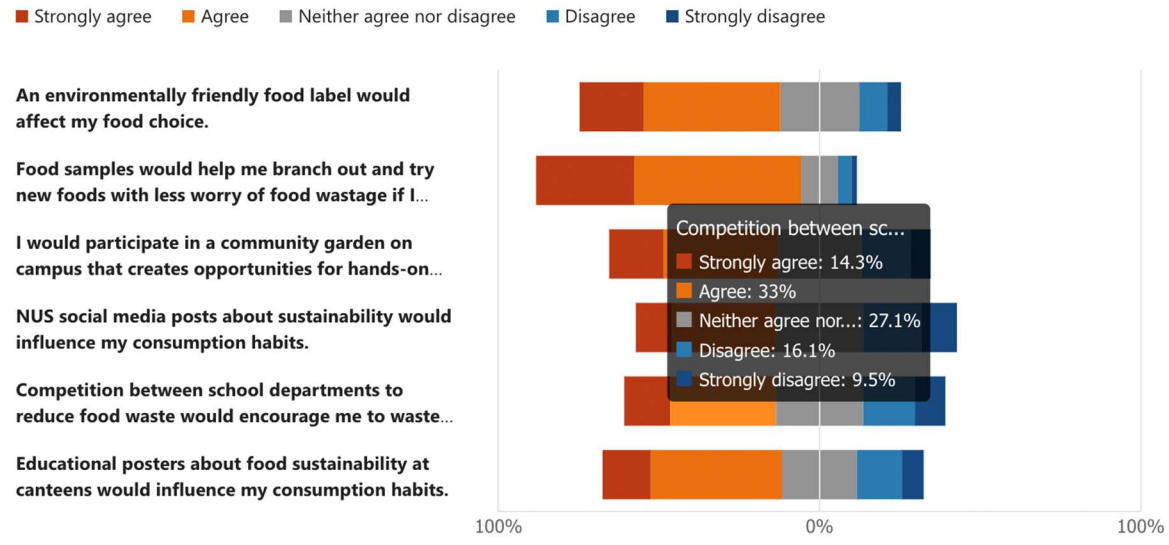
23. **Strong agree to strongly disagree (Scroll to see all)**

More Details



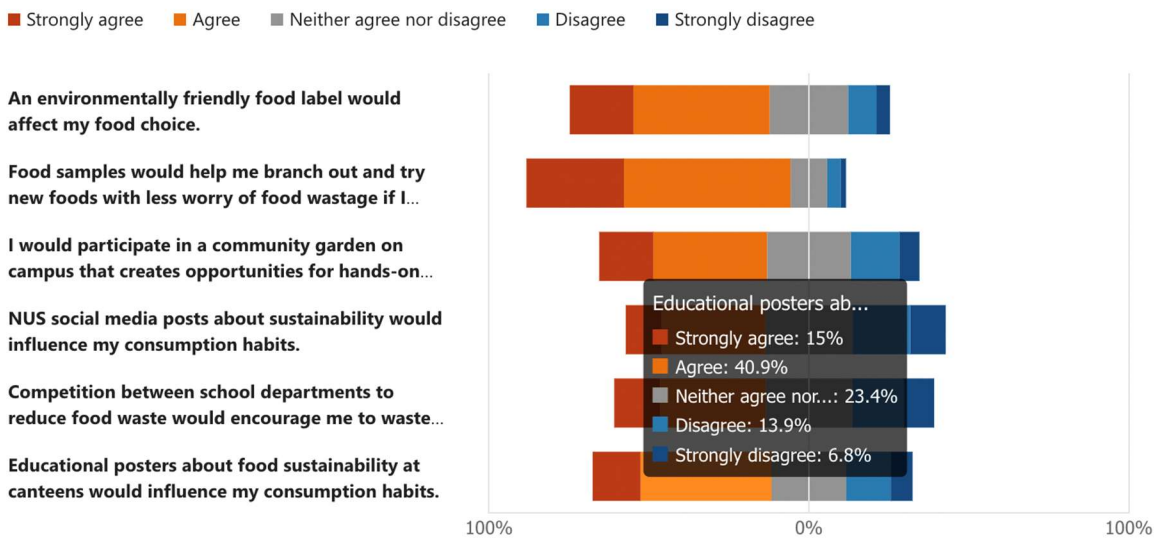
23. **Strong agree to strongly disagree (Scroll to see all)**

More Details



23. **Strong agree to strongly disagree (Scroll to see all)**

More Details



20. If other, please specify

11 Responses

1-7 | 11

ID ↑	Name	Responses
1	anonymous	Whether the food is discounted if requesting for smaller portion sizes. (Eg. a lot of stalls don't give discounts even if u ask for less rice)
2	anonymous	Idk what is meant
3	anonymous	-
4	anonymous	more of portion sizes vary. but you have to eat on campus a lot to know what the portion sizes are, to pick the right one for your hunger level that day
5	anonymous	Not exactly sure of what this question means to be honest. I opt for take away since I eat slowly. Then I can eat over time as I work and this way I reduce food waste
6	anonymous	every time i need to shout to cut my rice into half to reduce the waste cuz the rice is too much for me
7	anonymous	If it's too much food, I focus on eating the greens and protein and if I cannot finish just leave the rice. If it's a lot of leftovers I ask for takeaway and eat it later at home.

20. If other, please specify

11 Responses

8-11 | 11

ID ↑	Name	Responses
8	anonymous	how convenient it is to keep the food
9	anonymous	I don't try to reduce
10	anonymous	Time frame to eat lunch
11	anonymous	Specifically portion of rice

Appendix O: Observations Data Table

Techno Edge	None halal Tray return	Empty	Carbs	Meat	Vegetables	Mixed	Total
3/27/2024		355	70	4	46	69	544
4/1/2024		233	48	19	33	61	395
4/1/2024		346	88	4	32	70	539
4/3/2024		348	43	7	44	99	541
Frontier	None halal Tray return	**Empty**	**Carbs**	**Meat**	**Vegetables**	**Mixed**	**Total**
4/5/2024		363	58	6	47	96	570
4/8/2024		337	72	22	96	109	637
4/11/2024		287	56	7	70	115	535
4/12/2024		282	63	5	54	100	504
The Terrace	None halal Tray return	**Empty**	**Carbs**	**Meat**	**Vegetables**	**Mixed**	**Total**
4/5/2024		68	15	1	32	62	178
4/11/2024		91	26	4	18	64	203
4/12/2024		106	33	2	17	74	232
4/15/2024		84	19	1	11	53	168
PGP	Combined halal and non halal	**Empty**	**Carbs**	**Meat**	**Vegetables**	**Mixed**	**Total**
4/11/2024		130	18	2	16	32	198
15-Apr		216	46	4	7	6	279
4/16/2024		202	40	1	19	16	278
4/17/2024		128	22	4	29	48	231
Flavors (Utown)	Combined halal and non halal	**Empty**	**Carbs**	**Meat**	**Vegetables**	**Mixed**	**Total**
4/11/2024		43	13	1	5	7	69
4/12/2024		64	14	0	7	19	104
4/15/2024		42	5	0	3	10	60
4/22/2024		56	12	1	6	12	87
		Empty	**Carbs**	**Meat**	**Vegetables**	**Mixed**	**Total**
Average		189.05	38.05	4.75	29.6	63.75	317.6

Techno Edge Canteen	• We observed that women tend to throw away more food than men and we believe this is because they eat less. • We observed that carbs and veggies are thrown away the most • If the plate only contained bones or sauce we considered it empty • We observed that people don't always recycle, workers recycle for people • Some stalls have customizable rice portion sizes, but it's hard to communicate portion sizes because the canteen is loud, and language understanding
Terrace Canteen	• Customers at the terrace are more wasteful • 30-50% of plates were still covered with food • The tray return is more hidden than at other canteens • Better crowd flow and more room in this canteen • Men and women seemingly waste just as much here • Big heaps of rice, noodles, and veggies are being thrown out • Less face to face ordering of food (there's a weird blockade) and screens to order on as well • Prices are higher than other canteens.
PGP Canteen	• Seemingly men and women waste equal amounts here • Fewer people waste at this canteen • Staff educate students and faculty how to throw away their trash and waste • During peak hours very crowded • Appear to be more faculty members than other dining locations
Frontier Canteen	• Not a lot of room to walk around and do observations • Chinese stall long line, similar to every other canteen also known as mixed veg rice • Lots of NUH members • Very few Halal stalls so we didn't count them • Plates piling up at tray returns • Of the mixed dishes, most of the dishes are filled with carbs and some vegetables • The amount of carbs thrown away is much greater than the amount of vegetables
Flavours@Utown	• Significantly less volume of trays being returned • Many people are in the food court, but not all are eating, or returning at different trays return in the air-conditioned section • Disposable plastic cups are not returned • The food court appeared to be busiest towards 1 PM • People get to go boxes for the mixed rice stall